Open Market Operations and Financial Markets

Edited by
David G. Mayes
and
Jan Toporowski

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The last 15 years have been the most dramatic for changes to the concept and practice of central banking. This book lies at the heart of how central banks manage to influence the economy and financial markets, exploring how central banks work, how they have changed and how they are likely to change in the future. The contributors bring together a unique combination of practical experience from around the world, including chapters from Japan, USA, Australia and the Euro area.

Over recent years a new consensus has appeared over what monetary policy is and how it should be implemented. This volume takes a critical look at that consensus and argues that some of its foundations are weak. It considers the changing role of open market operations and the consequence of forcing markets to 'need' the central bank through required reserves. There is a detailed study of the US and an exploration of how the Bank of Japan had to innovate to try to continue to have an influence when interest rates were zero, as well as detailed attention to countries across Europe.

The issues discussed within this volume are applicable to all countries with an active monetary policy, whatever their stage of economic development. As such the book will be useful to academics working in the area of banking, monetary economics and finance as well as professionals working with central banks across the world.

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Routledge International Studies in Money and Banking

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Routledge
Taylor & Francis Group

LONDON AND NEW YORK

EUROJÄRJESTELMÄ
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Preface

This book arises from a fortunate coincidence of interests among the Bank of Finland, SUERF (Société Universitaire Européene des Recherches Financières) and the editors and contributors to this book on a topic of current debate. The Bank of Finland has between three and five visiting research scholars in its Monetary Policy and Research Department at any one time. They work on one or other of the Bank's three main research themes: modelling monetary policy, the future of financial services and the transition economies – primarily the Russian Federation and China – usually in close co-operation with staff in the Bank who are involved in research at the time. Jan Toporowski of the School of Oriental and African Studies in London, one of these research scholars in 2005, devoted his time in the Bank to various aspects of open markets operations and the implementation of monetary policy.

The implementation of monetary policy had tended to receive much less attention in the literature than the formulation of monetary policy, yet it forms an essential part of any effective policy regime. The framework for policy has been evolving rapidly round the world in recent years, particularly with the rise of inflation targeting. This has had consequent implications for methods of implementation, with an increasing focus on the setting of short rates of interest over which the central bank has some control. The creation of a major new monetary institution, the European Central Bank, and the development and evolution of its approach to the implementation of policy have added to the renewed interest. The Bank of England has also changed its procedures, moving towards the European system. Many issues of debate remain, however. One is simply the balance between allowing market forces to operate and generate signals on the one hand and the enforcement of the central bank's wishes over pressure on the macro-economy on the other. A second is that, as markets develop and become more efficient, the need for central bank money in the system may decline. It may therefore be necessary for methods of implementation to evolve further. The Bank of Japan, for example, has found that it has needed to make major changes to its operations in the face of deflation. A third and increasing interest is the relationship between the central bank's monetary policy operations in the pursuit of price stability and their impact on financial stability, which is normally also on of the central bank's objectives. This is more than enough to justify a new book on the topic.

The Bank also organises several academic conferences during the year, to exchange ideas on its current areas of work directly with a wide international network of experts. In the main these conferences are organised in collaboration with a particular foreign organisation or network. On this occasion the partner was SUERF, of which the Bank is a corporate sponsor and with whom it has worked on a number of occasions before. SUERF offers two particular advantages to this relationship in addition to the obvious expertise in the chosen topics. First of all, it is a network that combines financial economists in the public, academic and professional sectors. It therefore provides a much wider forum for discussion than is normally the case. Second, it has a widely spread membership internationally, so it is possible to bring a substantial range of experience to the table.

Hence, as part of the research programme associated with Jan Toporowski's visit a joint conference was organised in Helsinki on the topic of Open Market Operations and Financial Markets. David Mayes, who had been working with Jan Toporowski over a number of years, was the main collaborator in both the organisation of the conference and the production of this book, which contains revised versions of most of the papers in the conference, following their external review. The first two chapters explore the main issues underlying the research programme, while the remainder of the book offers views from other perspectives, and evidence from how various regimes operate round the world. Franco Bruni participated in the scientific committee designing the programme and selecting the papers on behalf of SUERF, and Morten Balling is responsible for SUERF publications.

All the contributors have written on their own behalf and the views they express should not be ascribed to the organisations with which they are or were associated. Similarly the Bank of Finland and SUERF have acted to promote the discussion rather than support any of the particular views that have been expressed. Indeed the point was to encourage the expression of a range of views, also an important reason for having the independent research scholars come to work in the bank, in addition to be able to benefit from the depth of their experience and expertise. The organisers have been pleased by the result and it is planned to hold more of these joint conferences on a bi-annual basis in future and to publish the resulting papers.

1   Introduction

David Mayes and Jan Toporowski

The arrival of the 'New Consensus' as the guiding doctrine for monetary policy has coincided with a renewal of interest in the ways in which that monetary policy is implemented. Such a coincidence is not really surprising. It is obvious that the replacement of one guiding doctrine, laying out the effects of monetary policy on an economy, by another doctrine is not just decided by policy considerations, but also usually involves some re-examination of the way in which monetary policy is implemented. The practical operation of a guiding doctrine of the past is usually re-examined to show that not just administrative failures are responsible for the flaws in previous monetary policy. At the same time central bankers, operating in financial markets, need clear procedures for the implementation of the new policy. The last change of monetary regime, the switch to controls of monetary aggregates during the 1970s, was also anticipated by the critique of monetary operations from Milton Friedman and guidelines for the operation of new policy from William Poole (Friedman 1960; Poole 1970). The monetary procedures for the previous regime of active, Keynesian monetary policies after the collapse of the gold standard, and procedural errors in gold standard operations, had been clearly laid out by Hawtrey and Keynes himself (Hawtrey 1932; Keynes 1930/1971, 1945).

Similarly, the embrace by policy-makers of a 'New Consensus in Monetary Policy', the view that a central bank should set the short-term (overnight) rate of interest by regard to some target for future inflation, has also been associated with critiques of monetary policy procedures under the previous regime targeting monetary aggregates (e.g., Bindseil 2004b). Indeed, such discussion of their operating procedures has been invited by central bankers as a way of clarifying their obligations. For example, in a recent speech to Lombard Street Research, the Bank of England's Executive Director for Markets, and member of the Bank's Monetary Policy Committee, Paul Tucker urged further research in this direction: 'The overall historical picture is not especially coherent. I suggest that the question of whether desirably or even optimally, there might be some mapping from monetary regimes to operating frameworks warrants research by the academic community' (Tucker 2004, p. 372). Tucker refers to the Bank's procedures as its 'operating system', an intriguing example of the influence of technology on the language of economics.

The operating target of New Consensus policy-making is the overnight rate of interest, as opposed to the money supply in the previous doctrine. The new system is a major and welcomed simplification in economic modelling, since the relationship between the interest rates that are the independent variables in models of the monetary transmission mechanism and the money supply, while elegant in theory, always proved troublesome in practice. Charles Goodhart has remarked in the past on the tendency of the money supply to elude control, and the Volcker experiment (1979–1982) in stabilising the monetary base also succeeded in destabilising the interest rates through which monetary policy was supposed to be transmitted to the rest of the economy. Since changes in the money supply were supposed, in any case, to operate through the rate of interest (the IS component of macroeconomic models, from which the Phillips Curve was derived), it makes sense where possible to control that rate of interest directly. This inevitably raises the question of how market interest rates can be influenced, and the role of open market operations in that system of control.

Central banks have relatively little direct control of interest rates. Operations in the money market, where overnight interest rates are set, require the co-operation of counter-party banks. In the case of the longer-term rates that are crucial for the monetary policy transmission mechanism, the influence of central banks is even more tenuous. Even the Bank of England's Bank Rate under the gold standard, which is sometimes referred to by partisans of the 'New Consensus' as the golden age of interest rate targeting (e.g., Bindseil 2004b: 10–16; Tucker 2004, Appendix 3; Woodford 2003: 93–4), regularly lagged behind money market rates. Indeed, once it became clear that money market interest rates, rather than the amount of base money, were the targets of central bank monetary operations, the practical need to concentrate money market rates around the central bank's preferred rate became a key factor in changing central bank operating procedures, both in the Euro-zone and in the U.K. The setting of an official discount or lending rate may of course have a significant 'signalling' effect in the money markets. But, without operations in the money markets, such signalling may have only a marginal impact on interest rates in those markets (Friedman 1999).

Central bank operations in the money markets may be conducted through open market operations, or through the use of standing facilities, sometimes also called the discount window. The previous monetarist, monetary policy regime undoubtedly favoured the use of open market operations. In part this was a legacy of the 1930s, when open market operations seemed to offer a direct way of counteracting a catastrophic credit contraction (Hawtrey 1932; Simons 1946). This preference for conducting monetary policy through open market operations was encouraged in recent central bank practice through the influence of Simons's most prominent student, Milton Friedman. Even prior to the monetarist regime, open market operations were a favoured way of implementing policy. For example, in the early 1980s the Bank of England described its monetary operations as:

> …setting, and periodic variation, of an official discount or lending rate, which, when necessary, is "made effective" by open market operations in

the money market. "Making Bank rate effective" means restraining a decline in market rates from an unchanged Bank rate, or bringing them up to a newly established and higher Bank rate; it is accomplished by limiting the availability of cash to the banking system so as to "force the market into the Bank" to borrow at the somewhat penal rate of Bank rate.

(Coleby 1983, p. 213)

Under the monetarist regime, the conduct of monetary policy operations was supposed even to exclude standing facilities, or discount window operations. As an authoritative paper by Goodfriend and King on U.S. Federal Reserve policy argued 'the discount window is unnecessary for monetary policy… Open market operations are sufficient for the execution of monetary policy. It follows that unsterilized discount window lending is redundant as a monetary policy tool'. This was followed by a cautionary note: 'Nevertheless, over the years the Federal Reserve has employed unsterilized discount window lending extensively, together with discount rate adjustments, in the execution of monetary policy. Though it remains puzzling, use of the discount window this way seems to be connected with the use of secrecy or ambiguity in monetary policy' (Goodfriend and King 1988; see also Schwartz 1992). In fact, the diversity of banks in the different regions of the Federal Reserve system has traditionally been a factor in the use of the discount window in the USA.

In a somewhat confessional (for a central banker) aside the Bank of England's Executive Director for Markets admitted: 'With no deposit facility… the OMO rate was a natural way to express policy and we slipped into thinking of it as how we actually implemented policy too. That was a fallacy' (Tucker 2004).

The 'New Consensus' view of monetary policy has reversed the accepted view on the relative importance of open market operations and standing facilities. If standing facilities are available to participants in the money market, then the standing deposit and borrowing rates form a 'corridor' between which the market rate will fluctuate. *How* it will fluctuate depends on the amount of reserves that banks need on any one day; the amount and frequency of open market operations; and the credit activities of banks. For convenience the latter is sometimes modelled as a stochastic variable, e.g. in Davies (1998). If minimum reserves are required to be held at the end of every day, and that minimum is sufficiently large in relation to the daily fluctuation in credit activities, then, without accommodating open market operations, the overnight rate in the money market will tend to the upper and lower bounds of the corridor. One way of moderating this drift to the margins is to allow banks to average their reserve requirements over a maintenance period. In that case, the overnight rate will fluctuate between the deposit and lending rate, but will tend to end up on one of the corridor margins at the end of the maintenance period. The new arrangements for implementing monetary policy by the Bank of England envisage averaging with a wide corridor (100 basis points on either side of the official rate), to discourage use of standing facilities on a daily basis, but a narrower corridor (25 basis points on either side of the official rate) on the final day of the reserve maintenance period (Clews 2005, p. 211).

Thus, in the operational framework for the 'New Consensus' monetary policy, open market operations become redundant for the purpose of keeping the overnight interest rate close to the official interest rate. For example, the leading theoretician of the 'new consensus' Michael Woodford has argued that even with the zero reserve requirement that is implied by his assumption of a 'pure credit' economy, all that is required to keep the overnight money market rate at the official rate is for the central bank to offer a deposit facility at the official rate (Woodford 2003: 32–33). However, this is because the deposit facility he envisages would only provide a risk-free asset to the banking system, giving the money market a benchmark rate of interest on such assets. In the 'pure credit' economy that he envisages, all autonomous movements in banks' currency would be accommodated in 'complete markets'. Hence not only the absence of reserve requirements, but also the reduction of the banking system's autonomous reserve requirements for payments purposes to zero, would eliminate the need for open market operations.

However, Ulrich Bindseil has recently raised another issue that has not been discussed in the academic literature, although it appears among the practical considerations that have been advanced in the establishment or reform of central bank operating procedures (e.g., Bank of England 2004a). This is the degree to which open market operations that deprive the banking system of reserves in order to induce the borrowing of reserves from the central bank thereby cause the central bank effectively to replace the activities of the money market ('bringing the market into the bank'). His argument is that 'open market operations should ensure that the recourse to standing facilities is not structural, but covers only non-anticipated probabilistic needs… Today, the essential argument advanced for open market operations is that they do not, in contrast to standing facilities offered at market rates, dry up the short-term inter-bank money market' (Bindseil 2004b: 144 and 177). His concern is to minimise the tendency of commercial banks to draw routinely on standing facilities. Unchecked, this may turn the central bank into a giro-clearing system for the banks, as the German Reichsbank was before the First World War. In such giro-clearing all autonomous movements in currency and reserves end up as book-keeping transfers in the central bank's balance sheet. The current view is that such routine drawing on standing facilities would require central banks to price the riskiness of lending to individual banks on a routine day-to-day basis, something that they would prefer the money market to do (Clews 2005). This is an aspect of central banks' operations in money markets that has not been adequately discussed in the academic literature.

The reduced scope of open market operations is reflected in the reduction of the Bank of England's operations from two or three each day, to one each week, plus another operation on the last day of each maintenance period, although additional open market operations will be undertaken to prevent a build-up of reserves that would render the banking system independent of the central bank's official rate (Clews 2005). In the 'New Consensus', in which monetary aggregates are no longer supposed to matter, but monetary policy is conducted by movements in the official rate of interest, the new function of open market operations is not a

monetary one, in the sense that the scale of these operations is unrelated to the rate of interest that the central bank seeks to enforce in the money markets, or to the monetary policy stance that the central bank is adopting, i.e. the trend in interest rates that the central bank seeks to indicate to the financial markets. The function of open market operations in the new consensus is to prevent settlement banks from 'forcing the money markets into the bank' by using remunerated standing facilities as a form of cash management service. Monetary 'shocks' are now supposed to be modelled as changes in interest rates, possibly in exchange rates, rather than as unexpected increases or decreases in the money supply, that may be offset by open market operations. Similarly, the monetary transmission mechanism is activated by changes in interest rates, rather than injections of money through open market operations.

The changed scope and significance of open market operations in the New Consensus monetary policy therefore raise important questions of theory, policy and modelling. In 2004, the Bank of Finland, together with SUERF, took the initiative of calling a conference to discuss these questions. The conference took place in Helsinki in September 2005. We were fortunate in being able to secure the participation of a wide range of experts from central banks, the academic milieu, and commercial banking and finance. The papers in this volume therefore represent a selection of those papers, enlarged and improved by the discussions at the conference.

The structure and argument of the rest of the book

The twelve chapters that follow fall into three groups. The first, containing chapters by David Laidler, Bill Allen, Ulrich Bindseil and Flemming Würtz, Jens Forssbæck and Lars Oxelheim, Laurent Clerc and Maud Thuaudet, and Noemi Levy Orlik and Jan Toporowski, lays out the ingredients of the 'New Consensus' and what it implies. The second group, with papers by Dan Thornton, Beata Bierut and Michal Kempa, looks much more closely at what the new consensus implies for the behaviour of monetary policy implementation and in particular explores its limits. The remaining group considers wider questions, with Sheila Dow, Matthias Klaes and Alberto Montagnoli exploring the nature of signalling in implementing monetary policy, Xinsheng Lu and Francis In the impact of OMOs on financial markets and, finally, Takero Doi, Toshihio Ihori and Kiyoshi Mitsui the interaction with fiscal policy and public debt in face of the threat of deflation.

While there is a larger share of papers on the Eurosystem, the chapters explicitly cover the situation in the United States, Japan, the UK, smaller EU countries, Australia and emerging markets, with a particular focus on Mexico, so as to cover a wide spectrum of experience and regimes.

The flavour of the early chapters is to look beyond the 'new consensus' into what open market operations could be in different circumstances and into where thinking on the subject appears to be going. They form a group, each contributing to the overall understanding. The initial purpose is to set out what the new consensus

constitutes and build on it from there. Put crudely, what we see is a shift from a focus on quantities in the money market directly influenced by the central bank to a focus on a rate of interest. The essence of the system is in effect a simple three-equation model. Aggregate demand in the economy is affected, inter alia, by the rate of interest. Inflation is a function of expectations, some specific factors and the gap between aggregate demand and some measure of sustainable supply – the gap being labelled the output gap. Central banks seek to control inflation by setting interest rates in such a way that future inflation is likely to remain within acceptable levels.

David Laidler's chapter, which follows, seeks to embed these views in the literature of monetary economics. In many ways his chapter offers a critique of Michael Woodford's (2003) book, 'Interest and Prices: Foundations of a Theory of Monetary Policy', that has done so much in developing a consensus model that has a proper foundation in economic theory. However, he provides a fascinating account of how thinking in monetary economics has developed over the last 75 years or so and how that development has interacted with the monetary policies that central banks have sought to implement.

The key message in his analysis is that, attractive and elegant though the Woodford framework is, it is lacking in some of the core elements necessary to provide a helpful basis for policy making. His 'cashless' economy removes the role of money as a means of exchange and assumes away the problems of what will happen if markets do not clear. Traditional theory at least offers a buffer stock role for money in enabling people to correct for all the various errors they make in pricing and in interpreting information.

The interest rate route also appears to offer a problem when the lower bound of a zero nominal rate is reached in the face of deflation. Here, traditional theory suggests using open market operations to flood the market till the point that the economy does turn round – a point that Nakaso returns to in discussing the very last chapter in the book on the case of the quantitative easing in Japan. Laidler remarks with some irony that perhaps 'the seemingly serious limits imposed on the powers of orthodox monetary policy by the nominal interest rate's zero lower bound is not so much a property of the real world as of monetary policy models that focus too exclusively on interest rates'. A monetary policy that simply focuses on the new consensus and does not bear regard for the function of monetary quantities would tend to miss out on the times of difficulty when 'open market operations should be promoted from the technical fringes of monetary policy to its very centre'.

Allen turns the focus on its head by arguing that the technical facets of modern open market operations can have clear macroeconomic and microeconomic consequences that need to be explicitly addressed. Hence it is important to step back from technical objectives, such as achieving a particular short rate of interest and consider whether the point of such actions might, for example, be better achieved by having a little flexibility. Without price signals, banks may pay only limited attention to cash-flow management and spreads may be narrowed, with consequences for macroeconomic management. It seems odd, for example, that some central banks provide free intraday credit, yet credit has a price in the overnight

market for a similar fraction of a day. Similarly, allowing commercial banks to average their reserve holdings at the central bank over a predetermined period to achieve a given minimum requirement (subject to never running into overdraft at the end of any day) in order to keep short run interest rates smooth is likely, in Allen's view, to limit market activity and accord unequal competitive advantage to the banks. While the market needs to be orderly, great smoothness in short interest rates has no particular macroeconomic implications and may allow inefficiencies, such as a bank with problems being able to get through to end of the (maintenance) period before the problem becomes apparent.

The two principal avenues of open market operations through the central bank buying or selling short-term securities and through overnight collateralised lending and borrowing facilities form the heart of much of the debate in the rest of the book. While central banks may be able to manipulate short rates it depends very much how much the market agrees with their assessment as to how much those rates will be transmitted along the yield curve and affect real activity and inflation. Allen's work thus provides a basis on which many of the subsequent arguments are built.

Bindseil and Würtz, whose chapter immediately follows, is a case in point. It considers the relative roles of the two forms of operation – open market operations and standing facilities in achieving the desired short-term interest rates and keeping them stable. It begins with a robust critique of the Reserve Position Doctrine in the Federal Reserve over period from the 1920s to the 1990s. Gavin, in his comment, focuses on this aspect of the chapter, which is not surprising as he works for the Federal Reserve System. The authors come out in favour of the standing facility end of the spectrum, preferring stability in interest rates over a more 'vivid' interbank market, as they put it. The flavour of their remarks is thus in contrast to Allen, who puts a stronger weight on the importance of a market to ensure the removal of distortions – but a market in which the commercial banks are not particularly priviledged. As Gavin also remarks in his comment, exposing banks to the interbank market means that there will be a greater element of discipline in their risk-taking than would be the case from automatic access to the central bank's standing facilities.

The chapter considers a number of further aspects of the structure of open market operations over which the central banks has to take decisions: over the maturity and frequency of operations; whether they should be outright or reverse operations; whether they should be fixed or variable-rate tenders. The authors are obviously influenced quite heavily by what the ECB actually does and by the unfortunate experiences it had early on, with under- and over-bidding, when it tried to control both prices and quantities. In tendering, therefore, the better systems involve either fixing the quantity in the operation and allowing the rate to vary or fixing the rate and allowing the quantity to meet the demand. The authors are more inclined to the latter. If nothing else it avoids the risk of people thinking that variations in the rate reflect a policy signal by the central bank.

This issue of avoiding unintended signalling lies at the heart of the next chapter by Clerc and Thuaudet. They argue that implementation should be organised so

that market variations, whether in prices or quantities, should not be taken as signals outside the transparent communication relating to the decision-making committee's periodic meetings. Their chapter considers how the major changes in financial markets and the structure of the international economy have impacted on market operations and how changes in the operational instruments themselves have contributed to the ability to implement monetary policy decisions. Although they write from the perspective of a Eurosystem central bank they cover changes in the US, Australia, New Zealand, Canada, the UK, Sweden and Japan as well, providing a useful information source in its own right. In addition to documenting the trend towards standing facilities discussed by Bindseil and Würtz, they explore, for example, how the increasing range of permissible collateral and the trend to repos rather than outright operations helps limit problems of credit risk and liquidity in the market. A point which they emphasise is that the level of today's overnight rate has little impact on the economy. Hence manipulations in it one way or the other have little importance in themselves. What affects the market is the message the central bank can give about the path of overnight rates over an extended period. That will affect the shape of the yield curve, the general cost of finance and hence real activity and inflation in the way intended.

They also explore the role of reserve requirements, which are less used outside the euro area. A key facet, which they raise, reflects the institutional detail. Because of its international structure the Eurosystem implements monetary policy in a decentralised manner. It therefore requires a system that can be robust to this level of variety in assets and bank behaviour. Interestingly enough, unlike Bindseil and Würtz they argue that the corridor between the standing facilities should be wide enough that the banks do not normally have recourse to them so that the market actually operates and the opportunity for manipulation is reduced.

The historical development in the chapter raises some issues about the ability of central banks to influence the market adequately for implementing monetary policy. As the discussant points out in his comments, the fear that a run-down in government debt might have an adverse effect on liquidity has been answered by the willingness of central banks to accept a much wider range of collateral, without adverse consequences. Given the worries these days about the rate of increase of such debt, these concerns look strangely out of date. More apposite is the concern that the central bank is becoming rather small compared with size of the market as a whole and that the market might be able to get by without it, or at least that the role it plays is sufficiently marginal that it has only limited effect on the price.

The next chapter in this initial group by Forssbæck and Oxelheim extends the coverage to a much wider group of smaller countries. Here their interest is in the relationship between the central bank's monetary policy operations and the development of the money market. The group of small West European countries they choose to look at – Austria, Belgium, Denmark, Finland, Greece, Ireland, the Netherlands, Norway, Portugal, Sweden and Switzerland – are all the countries that had their own monetary policy in the 1980s and 1990s. Thus they include seven that are currently members of the euro area, two that are members of the

EU but not the euro area and two that are members of neither. Of the omitted countries, Luxembourg and Iceland, only Iceland could have been studied because Luxembourg was part of the Belgium-Luxembourg economic union.

Over the period, monetary policy operations were not the only factor to have a considerable impact on financial markets, as a result of the major process of financial liberalisation, reregulation and internationalisation that took place. However, the primary picture is one of heterogeneity. Although it appears to be the case that those countries that stayed with exchange-rate targeting saw more limited development in money markets than those that switched or substantially changed regimes, there are exceptions. The tables in the chapter provide a unique documentation of the monetary policy regimes and changes in the money markets in these countries in a comparative framework, which alone justifies the work. However, the authors go further in exploring the instruments that these central banks with small markets have used, such as issuing their own paper because of the lack of deep markets. They appraise the main drivers for change and the sources and effects of fluctuations in liquidity. While one might have expected that as markets developed and monetary policy operation became more sophisticated liquidity fluctuations would have fallen, there are several counter examples. The authors therefore seek the causes or exogenous factors that are most important, which turn out to be net foreign assets and net lending to the government. While the former should tend to follow the extent of openness of the economy, the latter in many respects reflects the rather weak separation of roles in macroeconomic adjustment which characterised several countries (Denmark, Norway and Sweden, in particular).

Although both active and passive factors have affected development, what is perhaps surprising is how little homogeneity in behaviour there is by the end of the period in 2000, given the drive towards the euro area and a common monetary policy. The euro area countries show just as much variation as the others. Thus while there may be common trends and clear development over the period, heterogeneity remains.

Finally, the discussion is completed in a chapter by Noemi Levy Orlik and Jan Toporowski, which considers the position of the emerging markets, primarily in Latin America, with a special focus on Mexico. Here it is necessary to go beyond the new consensus to get an understanding of the implementation of monetary policy and the role of open market operations. These countries have faced some strong challenges to an anti-inflationary monetary policy, not least from government actions. The countries have tended to run structural deficits on the balance of payments and have strong underlying inflationary pressure. The structural deficits can exist because of an inflow of foreign investment to exploit the opportunities that the low levels of domestic saving cannot meet. A pure inflation-targeting strategy would lead to substantial fluctuations in the exchange rate, with consequential variations in the net inflow of capital thereby exacerbating the impact on real economic growth compared with more closed and more developed economies. The appropriate way to handle a deficit depends on the relative importance of the income and price effects. A focus on prices might imply that a depreciation was required to restore competitiveness, while a focus on income would suggest an

increase in interest rates to reduce demand pressure. However, the latter would draw in further funds and appreciate the exchange rate. This has therefore led many of the countries to focus more on the exchange rate as an intermediate target to smooth external price variation rather than on domestic inflation.

A variety of non-market methods have been used to try to offset inflationary pressures when the role of the interest rate has been reduced, ranging from reserve ratios to the issue of special government bonds that banks find attractive to hold. As with the ECB the intention has been to try to keep the banking system short of liquidity so that it has to make use of the central bank's facilities. However, the onset of financial deepening and widening has made it increasingly difficult to apply these non-market techniques successfully. Put another way round, if the domestic currency does not look attractive then these countries will tend to dollarize and there is a limit to how much the authorities can push the banks into holding domestic currency instruments. The fluctuations in the foreign inflows that result have also meant that the autonomous factors in bank's balance sheets have fluctuated, necessitating more extensive and varied open market operations to handle the fluctuations in liquidity and keep financial markets stable. Taken together, therefore, although the Latin American central banks have used similar instruments to the more advanced countries, their monetary policy has been less countercyclical. Interest rates and the output gap tend to be uncorrelated, thus removing one of the basic tenets of the Woodford model. Thus in practice a rather wider view than the New Consensus is required.

The following group of chapters concentrate on specific issues, led by Dan Thornton, who provides the chapter on the US experience. As a result of an empirical exercise using daily data on the Trading Desk's operations in New York he concludes that although the operating procedure for implementing monetary policy was followed during the period 1984 to 1996, these open market operations seemed to have only a limited effect on liquidity in the market. In 1994 the Fed became much more explicit in announcing the aims of policy with respect to interest rates, thereby removing the signalling role of the open market operations themselves. This change does seem to coincide with a change in behaviour by the Desk but not as striking as might perhaps be expected. Without the need to signal the Desk can be more responsive to the short-run needs of the market.

The remaining two chapters in this part of the book, by Beata Bierut and Michal Kempa, are theoretical in character. Bierut is concerned with the optimal frequency of OMOs, while Kempa is concerned with the relationship between the structure of OMOs and their impact on the volatility of the market. The two chapters are thus related. Bierut in effect offers a comparison of the US and euro area regimes, as smoothing is better achieved by frequent operations as in the US rather than by the weekly operations in the euro area. However, this lower frequency is matched by the nature of the reserve requirements, where averaging and co-ordinated ends to the maintenance period also have a smoothing effect. The final outcome therefore depends on the combination of frequency of OMOs and reserve requirements rather than on one or other unconditionally. Ulrike Neyer, the discussant, suggests that the model is to some extent rather dependent on some particular assumptions

that can be relaxed and the model simplified. This gives a more straightforward intuition.

Kempa finds the same result for frequency of operations but points out that if maintenance periods are staggered across banks it is then possible to economise on liquidity, which otherwise can require the operations to be substantial. The width of the band between the two standing facilities also affects the ability to smooth interest rates and some countries outside the euro area find more frequent operations within a narrow band effective. Targeting the individual liquidity needs of the banks works somewhat better then targeting a market aggregate. Thus irrespective of whether the central bank's concern is in line with Bindseil and Würtz to impose considerable smoothing on the market or in line with Allen to make sure that the central bank's hand is not so heavy as to impede the operation of the market and emergence of market signals, a careful design of the system can reduce unwanted volatility. However, as Alain Durré, the discussant, points out, how readily one might target the individual banks depends on how many of them there are that are participating in the operations. If, as in the euro area, the number admitted is large then perhaps targeting the aggregate is the only practical route to follow.

The chapters have concentrated on OMOs as a means of implementing monetary policy, but in practice this is usually enhanced by signalling or 'open mouth operations'. Dow, Klaes and Montagnoli address this in the following chapter. They focus on two aspects of the need to signal, the first relating to the uncertainty of the economic outlook as such and the second related to the uncertainty felt by the central bank with respect to the setting of policy. The UK provides a rather good laboratory for exploring these forms of uncertainty, as the structure of the system requires considerable transparency and a carefully crafted Inflation Report from the members of the MPC. The uncertainties therefore need to be spelt out if the predictability and credibility of policy is to be maintained. In so far as central banks use a single model or modelling system, then they find it somewhat easier to quantify the consequences of uncertainty. However, even without such a specific basis, the MPC has found it possible to communicate an element of uncertainty through the fan charts it regularly publishes. The exact meaning of such fan charts varies among the central banks that use them. The variance tends to reflect past forecasting performance while the skew reflects the balance of risks. In the main such assessments should be made of the contributions to the forward-looking picture rather than to its outcome directly, which seems to describe the approach of the Bank of England, rather than say that of the Bank of Norway.

The authors' approach is considerably more novel as they plan to apply discourse analysis to Inflation Reports and the MPC minutes from which they hope to judge the extent of the different types of uncertainty from the frequency of reference to them in the text. Cobham (2006) has applied a similar approach to these reports in assessing the MPC's views on the position of the exchange rate.

The final two chapters extend our coverage of the world to Australia and Japan. In the study of Australia, Xinsheng Lu and Francis In look in detail at how open

market operations affect not just interest rates but also the spot and futures markets for foreign exchange. One of the key issues for monetary policy in a small open economy is that interest rate decisions have an impact not simply on the yield curve but on the nominal and hence the real exchange rate. These consequential shifts in the exchange rate at low frequency can form a major part of the process of maintaining price stability. A rise in relative interest rates, which is intended to dampen inflation, will start to attract short-term foreign capital (carry trade) and will drive the exchange rate up and hence import prices down. Since many imports will be consumer goods these reductions will feed fairly directly into the price level. The extent of these fluctuations can, however, be troublesome, as they may concentrate the impact of monetary policy on the traded sector to the extent that it causes structural costs in a way that would not be the case if the pressure were spread more evenly across the economy. This appears to be the case in New Zealand, where economic cycles have been out of phase with the rest of the world and hence offering substantial interest differentials – over 6% with Japan at the time of writing for example.

Lu and In, however, look at high-frequency data, with daily observations on outright transactions over the period February 2000 to June 2004, when there were over 1,100 open market operations in Australia. It is immediately clear that OMOs play a role in smoothing exchange-rate fluctuations. Furthermore, from the effect on futures markets, it appears that both the market and the Reserve Bank have a forward-looking approach to cash needs. This is balanced by the lag structure of the impact, which implies that it takes a few days for markets to digest the implications of the Reserve Bank's actions. Lastly, it appears that the impact is asymmetric. The Reserve Bank OMOs thus have a clear impact not simply on the cash rate but on the yield curve and current and future exchanges rates.

We conclude with the discussion of Japan, since that country has been exploring the problems of how the central bank can have an influence on monetary conditions when nominal short-term interest rates have reached zero. Doi, Ihori and Mitsui approach this from the direction of the government's debt policy. Japan has embarked on a massive attempt to counter deflation by expanding public expenditure, financed by borrowing. The rate of increase has been so great that clearly it is not sustainable in its current form and the question arises as to how it will be paid for in the future. The inflation tax appears an unreliable approach and some formal programme of debt-reduction targets, reflecting the maturity profile of the debt, will be required. Understanding these issues requires the use of models using a number of generations, as the time horizons for repayment, given the size of the debt, are long. The authors consider how the existence of the different interest groups affects the choice of the optimal structure for debt replacement.

Nakaso in his comment, however, focuses directly on the problems that the Bank of Japan has had in trying to run a monetary policy that will contribute to the solution of the problems without placing all the burden on fiscal policy under zero interest rates. He thus considers how the quantitative easing policy is expected to

work in trying to get the banks to take more liquidity even though the cost is zero. Interestingly, the policy was initially characterised by considerable under-bidding. More recently, as banks' expectations of future growth have begun to rise, this cheap source of funds has become more attractive. Thus, ironically, as the facility is taken up, so the chances of its being ended increase, as the ability to return to conventional monetary policy at positive interest rates increases.

2 Monetary policy and its theoretical foundations*

David Laidler

Stocks of assets and the yields they bear have usually been recognized as playing interdependent roles in monetary policy's transmission mechanism but there has often been disagreement about matters of emphasis. In the last decade or so, there has been a growing tendency, particularly on the part of policy makers, to stress yields and downplay stocks, and this way of looking at things has recently received a major theoretical boost from Michael Woodford's masterly (2003) monograph *Interest and Prices*.

Woodford's work is important not just because it provides a particularly thorough set of analytical foundations for the framework that nowadays routinely underpins the day to day conduct of monetary policy in many central banks – the *standard model* as I term it here – but more critically because it proposes that the theoretical fundamentals of policy-relevant monetary analysis are best grounded in a model of a *cashless economy*, one in which stocks of monetary assets play no essential role. Open market operations, the topic of this book, involve transactions in stocks of financial assets, and such a theoretical approach would necessarily downgrade their policy-significance; so this book is timely, because it presents an opportunity to examine Woodford's advice from both a theoretical and a practical standpoint.

In Woodford's model, central bank money is the economy's unit of account, and the critical policy variable under that same central bank's control is the rate of interest on loans denominated in it. He acknowledges that, in the world as it is, central banks might use open market operations in overnight loans to control that interest rate, but he also looks forward to the time – which has already more or less arrived in some jurisdictions – where the critical variable for monetary policy is the corridor between the rates of interest at which the central bank itself borrows and lends to the market. He therefore treats open market operations aimed at keeping the overnight rate in its chosen corridor as an inessential technical detail, of interest to those who actually implement policy, but not to those who seek to understand how it affects the economy.

Similarly, though Woodford agrees that there do exist frictions in real-world economies that give rise to a determinate demand for stocks of their means of exchange, he also argues that the interaction of the stocks supplied and demanded

of them has trivial effects on other variables and may safely be neglected. Hence, he is quite comfortable with a theoretical foundation for monetary policy that ignores money's means of exchange role altogether, as well as the behaviour of inventories of money to which this role gives rise. This chapter argues that to abstract from these factors is to deprive monetary economics of a significant part of its policy relevance. It will touch on open market operations as and when their role in monetary policy processes is relevant to the argument, but its main concern is, nevertheless, the broader context of the theories of money that must always lie in the background when questions about monetary policy are discussed.

In what follows, I first of all briefly discuss why a monetary policy framework that emphasizes interest rates has become standard in recent years, and why so many economists have been persuaded simultaneously to downgrade the importance of monetary aggregates. Then I describe Woodford's particular contribution to these developments, and contrast it with a more traditional approach to the theory of money that stresses its means of exchange role. Here, I suggest that, though there are difficulties aplenty with the latter, Woodford's cashless simplification of the monetary economy presents problems of its own, both for monetary theory *per se*, and for the discussion of currently relevant monetary policy questions. I conclude that the best theoretical basis for monetary policy at present is one marked by wary eclecticism.

What went wrong with monetarism

This is not the first time that the importance of monetary aggregates has been downgraded to essentially zero by important economists. It is a well-known paradox that the work of John Maynard Keynes on what he thought of as a 'monetary theory of production' set in motion developments that culminated in the 'Radcliffe view' of monetary policy. This view, as expressed by Richard Sayers, had it that monetary policy works through rates of interest and the availability of credit and hence was better conducted by directly influencing these variables than by trying to influence the quantity of money. It also embraced the opinion, as expressed for example by Richard Kahn in 1959 that 'The velocity of circulation… is an entirely bogus concept . . an effect and not a cause' of 'variations in the level of economic activity and prices'.[1]

Coupled with the view that inflation was largely a matter of sociological cost-push rather than monetary forces, opinions like these (though not always so extremely held) dominated the design of monetary policy in the 1960s and early 1970s, which in due course generated the inflation that would discredit them. Thus was the scene set for so-called monetarist anti-inflation regimes that gave pride of place to the rate of money growth. These relied on the view that, rather than being a 'mere statistic', velocity was a well-determined structural parameter, derived from an equation in which the economy's demand for money was a 'stable function of a few arguments'.[2] As everyone remembers all too clearly – particularly those who

were involved in the efforts of various central banks to implement them – these did not work very well either. Monetarist views were not totally discredited by the experience, for inflation did turn out to be mainly a matter of monetary policy and it was brought under control. However, demand for money functions turned out to be less stable than expected and certainly too fragile to serve as a fulcrum for the conduct of day to day monetary policy.

In due course, therefore, money growth targeting gave way to more or less formal inflation-targeting regimes. The transition here was often a rough one, but central banks now seem to have learned how to make inflation-targeting work. This change did not involve any immediate and fundamental revision of their operating procedures, however. Most proponents of money growth targeting had argued for its implementation by way of control of the monetary base, which would have tended to give open market operations a more central role in the day by day conduct of monetary policy than they in fact occupied, but this debate was lost. Central banks instead tried to control money growth by manipulating short-term interest rates, and when they turned to aiming at inflation directly, they continued to rely on short-term interest rates as their policy instrument.[3]

Though demand for money instability played an important role here, a more fundamental problem was that central banks' efforts to control money growth were based on a model of the determination of the money supply that was incompatible with the theory of monetary policy upon which the case for such a regime rested in the first place. This case had it that money growth affected inflation through its influence on nominal aggregate demand, and was supported by a large literature documenting long and variable time lags between changes in money growth and their ultimate effects on output and prices.[4] When central banks implemented money growth targeting, however, they did so by using estimated demand for money functions to forecast the demand for money, given the current and forecast behaviour of prices and output, and then set interest rates to bring the quantity of money demanded into line with their targets. In this scheme of things, money growth is a lagging, not a leading, variable. So, while the theory that justified money growth targeting treated money as *actively determining* the future behaviour of output and prices, it was put into practice by treating money as *passively reacting* to their current and past behaviour: small wonder that policy regimes based on such a massive contradiction went wrong.

These practical failures were not the only reason for the downgrading of monetary aggregates as a centrepiece for policy, however. Theoretical developments also played their part. Monetarism evolved into New-classical economics in the 1970s, with the 'money-supply-surprise' model of the business cycle as its centrepiece, and its academic exponents paid no more attention to well-established evidence on the temporal ordering of money supply, output and price-level fluctuations than did policy makers. This model's aggregate supply side had output moving in response to mis-perceived price level variations and it was therefore grossly inconsistent with the fact that output systematically leads inflation over the cycle. When real business cycle theory gave up the idea that monetary impulses were an important source of shocks to the economy, this was, in some measure,

an attempt to preserve New-classical assumptions of clearing markets and rational expectations in the face of this awkward fact.[5]

Disappointments about the stability of empirical demand for money functions also led to a search for 'sound micro-foundations' for models of the demand for money. Samuelson's (1958) overlapping generations model was much favoured for this purpose for a while, and in this framework money is a pure store of value. It was not difficult to construct versions of it in which other stores of value are perfect substitutes for money and then to show, for example, that, in such circumstances, changes in its quantity, including those brought about by open market operations, can have no effect on anything. The search theoretic alternative to the overlapping generations model as a micro-foundation for monetary theory did, and does, have the all-important merit of taking money's means of exchange role seriously, but for a long time it remained (some would say it still does remain) wedded to models so remote from any actual economy that not even their most ardent supporters could claim any policy relevance for them. In short, these approaches to the micro-foundations of money offered no immediately useful theoretical insights for policy makers.

Nor was any way out of this impasse to be found in cash-in-advance set-ups. These either assume a constant velocity of circulation, or predict one inversely related to the rate of interest in the cash-or-credit variation on them first proposed by Svensson (1985), and traditional models of the demand for money that had already proved inadequate for policy purposes had been able to get much closer to the facts than this. In such a theoretical vacuum, it is hardly surprising that researchers at central banks, having bid 'a not-so-fond farewell' to the LM curve – to borrow Benjamin Friedman's (2004a) phrase – continued to refine their own in-house approaches to monetary policy to the point at which it is now possible to talk about a standard model in which any role for monetary aggregates is simply by-passed.[6]

The standard monetary policy model

Three basic building blocks make up this standard monetary policy model. The first of these – some form of IS curve – links the level of aggregate demand for goods and services to the rate of interest; the second – some form of expectations-augmented Phillips curve – links the rate of inflation to the 'gap' between aggregate demand and some long-run equilibrium level of aggregate supply; while the third is a central-bank policy reaction function – a Taylor rule – linking the rate of interest set by policy makers to actual or forecast inflation, and often to the so-called output gap as well.

An enormous literature has tried to fill in the details of this broad framework One way of reading Woodford's *Interest and Prices* is as just another, particularly careful, variation among many on this theme, but to do that is to sell both the book's ambition and accomplishment seriously short. At each step in the construction of his basic model, and in each extension of it, the choices that Woodford makes turn the finished product into a work well calculated both to bridge crucial gaps

in the literature to which it contributes, and to provide a basis for future work as well. Woodford's book attempts, that is to say, to define the foundations of a new research agenda in monetary economics, just as, in their own ways, did Wicksell's *Interest and Prices* (1898/1936) whose title it self-consciously borrows, Keynes' *General Theory* (1936) and Patinkin's *Money, Interest and Prices* (1956). Each one of these addressed issues with which their authors' contemporaries were also grappling and, with a judicious mix of ideas already in the literature and original insights, found just the right simplifications to enable old problems to be clarified and new ones to be formulated.[7]

Woodford's over-riding aim is to provide micro-economic fundamentals for today's standard monetary policy framework, as a means of insulating the latter from Lucas-critique related errors, to be sure, but more broadly as a means of finally eliminating the chasm that opened up between pure monetary theory and policy modelling after the abandonment of the monetarist experiment. The basic simplification that he deploys towards this end is, as Bennett McCallum (2005) has ironically noted, to eliminate *Money* from *Money, Interest and Prices*.[8] Central banks had already taken this step because of practical problems in implementing policy, but Woodford (2005a) defends it as a means of by-passing the as yet unsolved, and in his view probably insoluble, theoretical problem of providing a sound micro-foundation for monetary policy in a model that takes money's means of exchange function seriously. His cashless economy embodies the bold hypothesis that, in the world for which policy is made nowadays, the frictions that give rise to demands for stocks of various monetary aggregates are sufficiently trivial to warrant ignoring them altogether, and he is willing to have his work stand or fall by the usefulness of the resulting models.[9]

No variable is more central to monetary policy these days than the *output gap*, and in Woodford's model it is represented by the difference between aggregate demand (and hence actual output, for markets always clear in his model) and the level of output that would prevail were consumers' forward looking maximizing choices about the allocation of their consumption over time in harmony with what its production sector would provide along its equilibrium growth path. Thus, a concept long embedded in the policy literature as a useful holdover from the Phillips curves of the 1960s and 1970s, is, in Woodford's model, firmly grounded in the micro analysis that forms the basis of real business cycle theory. And once the output gap is conceived of in these terms, a corresponding *interest rate gap* follows, because there is a *neutral* value of the real rate of interest that will rule when the economy is on its equilibrium growth path. Monetary policy is thus seen to have its impact on the economy by creating deviations of the actual real rate from this value. And it is, of course, straightforward to deploy the Fisher effect in order to re-express these relationships in terms of the nominal interest rate.

In his treatment of the output gap, Woodford thus not only connects theoretical fundamentals to policy modelling, but also, within pure theory, the New-classical and New-Keynesian traditions. Overlapping price contracts in the style of Calvo (1983) represent a further New-Keynesian element in his basic model, needed to slow the response of the overall price-level to demand shocks and hence

to produce the empirically appropriate ordering of output and inflation responses to monetary policy. The basic model is then completed by attributing rational expectations to the agents inhabiting its private sector and by having policy makers use a rule of the type investigated by Taylor (1993) as they try to achieve a target inflation rate.

The resulting model yields two key results for monetary policy. The first is that the critical variable that policy must control is not the level of the nominal interest rate but the gap between that rate's actual value and its neutral level, itself an endogenous variable. The second is that, in responding to changes in inflation, the authorities should move that gap by more than those changes; the rationale here being that what is required of policy is to offset the influence of the change in inflation on the inflation expectations that underlie the nominal value of the neutral rate, as well as the change in its real component that is associated with the shock to demand that moved inflation in the first place. Given a rule of this type, Woodford shows – here, even more so than McCallum (2005), I am willing to take his word for it – that his basic model will generate a stable equilibrium inflation rate that agents are able to learn about and use as an anchor for the very inflation expectations that support the equilibrium in question.[10]

Woodford analyses one extension of his model that introduces frictions of a type necessary to create a demand for money, and another to deal with some of the complications that are created by permitting investment to influence the time path of the economy's capital stock. He shows that neither modification makes any essential difference to the basic model's properties and, in later work (Woodford 2005a), he also demonstrates that the construction of an open economy version of the system, with a determinate time path for the exchange rate, is also feasible. In short, he goes to considerable pains to show that his fundamental results are robust to just the kind of complications that a policy maker might want him to deal with.

Scarcity and money

Markets always clear in Woodford's basic model, and when he brings money into it, he does so by introducing certain frictions into its operations. There is nothing here to set this model apart from a great deal of recent work but they are symptoms of a very odd – Rogers (2005) would say totally wrongheaded – approach to providing sound micro-foundations for a theory of monetary policy.

We routinely instil into our students the lesson that scarcity requires economic agents to make choices but we are all too often less careful about drawing their attention to a second implication of scarcity: namely, that if choices about the use of the economy's endowments are to be left up to individuals in a multi-agent economy, then a structure of property rights and a system that facilitates their orderly and voluntary exchange are needed to co-ordinate these choices. If, of course, we required that every application of the theory of the allocative and distributive functions of a market economy be grounded in an explicit discussion

of the property law and the mechanisms of exchange that characterize it, economic analysis would become too cumbersome to use. It is just as well that, for many purposes, we can take the existence of well-established property rights for granted and can also adopt the fiction that their voluntary exchange is presided over by an auctioneer who always sets prices at their market clearing values and then ensures that buyers and sellers find one another without costly search. But this usually useful simplification does not work for all purposes and, in particular, it cannot work for studying the fundamentals of money.

To assume that markets always clear is to assume that agents' choices are always fully co-ordinated by the market and that the economy's mechanisms of exchange never break down. But the monetary system is an essential component of those mechanisms and though the monetary systems we encounter in the real world might always work this way, then again they sometimes might not. Either way, however, this outcome should be a prediction of the theory of money that we use to analyse them, not an assumption upon which that theory is based. A micro-economics that assumes that money always and everywhere successfully performs its means of exchange function cannot, as a matter of simple logic, provide a proper basis for studying how and whether it does so. That is surely why, when economists have tried to find micro-foundations for a theory of money while maintaining market clearing assumptions, they have ended up treating it as a pure store of value – the over-lapping generations model – a unit of account – Woodford's cashless economy – or by imposing apparently arbitrary exogenous restrictions on the market's working – a cash in advance constraint or Woodford's 'frictions' – and it is also why the outcome of such attempts is always unsatisfactory.[11]

Furthermore, a theory of money adequate for policy purposes must provide guidance when things go wrong, and a theory that has markets always clearing can only deal with the consequences of mistaken information. If it also attributes rational expectations to agents, it can only deal with the consequences of errors that, *ex ante* at least, are random. On these assumptions, co-ordination failures, which, as Leijonhuvfud (1981) demonstrated, provided the monetary economics of the inter-war and the early post-World War II era with much of its subject matter, do not happen and therefore cannot be studied. Now if we had an alternative fully worked-out theory of the fundamentals of monetary exchange, we could simply stop the discussion at this stage by directing attention to it, but we do not. Woodford (2005a) is right to argue that there is still far too much work about along these lines that is contrived and divorced from reality for it to offer any early promise of providing a useful micro-foundation for policy analysis.[12] He is, however, wrong to agree with, for example, Wallace (2005) that until it does so, the more traditional models of money that underpinned the monetarist experiment must be altogether shunned.

Traditional monetary theory

The very idea that there exists a set of fundamentals which, once discovered, will prevent capable logicians who understand them from making false propositions

about the economy's response to policy measures (among other disturbances) is unscientific.[13] Even if such fundamentals existed, and even if we did understand them, we would have no way of empirically verifying either fact. Of course we should always be trying to derive policy-relevant results from premises of greater and greater generality, whose empirical implications have been tested against an ever wider range of evidence; but no matter how far we carry this process, we shall always remain open to the risk that our theory will let us down at a crucial juncture. To argue that traditional monetary theory exposes us to such a risk, then, is to not argue for abandoning it but for attempting to improve it, even as we continue to use it, albeit always with a sceptical eye on the outcome.

As we have seen, moreover, the fundamentals of monetary exchange exist in the same intellectual stratum as those of property rights. It is surely inconsistent to insist that the ability to derive the institutions of monetary exchange from deeper postulates is a prerequisite for taking notice of their existence in policy analysis, while simultaneously taking property rights for granted when we study the consequences of trade in them for questions about allocation, growth, distribution and so on. It would be intellectually satisfying to be able to make such tight connections in either case, and probably it would sometimes be very helpful too, but until we can do so, we do have to get on with our economics. Woodford has chosen to investigate the policy implications of a cashless economy as his way forward, and he is explicit (2005b) about being willing to have his results judged by their empirical relevance and policy usefulness. A more traditional approach should surely be judged on the same criteria.

That more traditional way of dealing with monetary questions requires only the briefest of sketches.[14] It starts from the proposition that, in an economy co-ordinated by monetary exchange, where the same item usually serves as both means of exchange and unit of account, economic agents face serious problems of collecting the information required to make certain critical decisions. The prices at which they can trade need to be discovered and/or, particularly in the case of firms, they need to be set and transmitted to potential customers. Both activities use real resources, including time and effort. The configuration of the marginal costs and benefits associated with them will usually lead to the amount of information that it is optimal to collect being less than all that is potentially available in the market-place, so that this traditional theory has trouble accommodating rational – as opposed to merely unbiased – expectations. That configuration will also lead to prices being changed, not continuously as the economy evolves, but at discrete intervals that may be unco-ordinated across markets. For individual agents therefore, errors, small and sometimes not so small, are likely to be frequent, and they can partially protect themselves from their adverse consequences by holding inventories – buffer stocks – of the economy's means of exchange.

The cheaper it is to hold money, moreover, the fewer resources will agents devote to price-setting and information-generating activities. Money holding may thus, broadly speaking, be said to economize on 'shopping time' – to borrow McCallum and Goodfriend's (1987) useful phrase – and resources devoted to it have alternative uses in gathering market information and making pricing

decisions. The quantity of money demanded, the amount of information used in making decisions and the economy's degree of price stickiness are thus jointly determined endogenous variables, and the terms of the trade-offs among them, and hence the stability of the behaviour to which they give rise, are likely to depend upon deeper characteristics of the economy's mechanisms of exchange. Because we do not know nearly enough about the latter, the qualms of economists such as Wallace (2005) and Woodford (2005a) about the unthinking application of traditional analysis to policy need to be taken very seriously; but we should not ignore its implications altogether.

Traditional analysis tells us, for example, that there exists, at the level of the economy as a whole, a demand for money function with certain generic characteristics: a unit elasticity of demand with respect to the general price level, a positive elasticity with respect to some such scale variable as real income and/or wealth, a negative elasticity with respect to the opportunity cost of holding money (or costs in systems where more than one margin is relevant), and perhaps a positive one with respect to some measure of the value of the time and trouble saved by holding money. Empirical evidence largely confirms these predictions and, even if the parameters of empirical demand for money functions are not stable enough to bear the weight of day to day monetary policy, they are more than well enough determined to refute any idea that velocity is a 'mere statistic'. These parameters are also of orders of magnitude that imply that a necessary and sufficient condition for inflation to persist at a noticeable rate for any period is money supply growth significantly in excess of that of real output.[15] As an empirical matter, moreover, money growth is not merely correlated with inflation. It leads inflation, with variations in output occurring in the interval between changes in these two variables. Traditional monetary theory, moreover, explains why this should be so.

In the case of changes in money growth generated when governments vary the extent to which they finance their spending by borrowing from the central bank, the pace at which new nominal money is forced into circulation also changes, creating a discrepancy between the time path of the amount of it that must be held, and that of the amount which the private sector is willing to hold. A discrepancy is created between the own rate of return on money and those on other financial and real assets, and this in turn impinges upon the private sector's demand for other financial assets and upon its spending on goods and services, as agents attempt to return their money holdings to their desired time path. With the government choosing the rate at which new nominal money is injected into the system, however, this last step cannot be accomplished by an economy-wide correction in the time path of nominal balances. Adjustment ultimately takes the form of a variation in the inflation rate, which is itself the aggregate consequence of individual prices responding to variations in spending on specific goods, both durable and non-durable, and services too.

Matters work in just the same way when variations in money growth arise not from transactions between the banking system and the government, but between that system and private borrowers. This is even so when the initiative to such transactions is taken by borrowers rather than the banks, which is typically the

case when monetary policy is conducted by controlling a short-term interest rate. Agents who vary their borrowing from commercial banks seldom do so in order to adjust the time path of the stock of money they hold, but to vary their acquisitions of new nominal balances to spend; and those with whom they then transact in the markets for goods services and financial assets find the time path of their cash balances deviating from what was planned just as surely as do those who transact with government in exchange for money newly created for that purpose.[16]

It is true that, in a sophisticated monetary system, one way open to individual agents to vary their money holdings, particularly narrow transactions-related money, is by transacting with a bank, either increasing or decreasing debt, or holdings of less liquid bank liabilities, thus varying the amount of narrow money in circulation. Money creation and destruction in the presence of a modern banking system is not the same simple process as when the mythical helicopter is involved, because, in this case, there is no unique asset that can be readily identified as 'money', the size of whose stock is determined completely exogenously to the decisions of non-bank agents. Nor, however, as I argued at length in Laidler (2004b), is the quantity of money whether narrowly or broadly defined simply the result of the banking system's passive response to variations in those agents' demands for money-to-hold (except in theoretically limiting cases of dubious empirical relevance). It is rather the consequence of their interactions with the banking system, not just in the market for that system's monetary liabilities, but in the markets for its non-monetary liabilities too, not to mention the market for bank credit.

The standard model of monetary policy and Woodford's basic model of the cashless economy both bypass the analysis of these complex interactions and posit a direct link between the interest rate that the central bank sets and the volume of private sector spending, and perhaps in quiet times under an already well-established inflation-targeting regime, it does no real harm to think of policy in such terms. The movements in short-term interest rates on which these models focus act as proxies for those in the wide variety of other yields, including implicit own rates of return on money and on stocks of durable goods, that the traditional approach suggests are also important, and perhaps they tell policy makers enough to keep their actions on track. But there are other questions in monetary policy than how to hit an inflation target in a tranquil environment. In dealing with them, analysis of money's means of exchange role, and of the interactions among supplies and demands for inventories of financial assets to which that role gives rise, has a lot to say that is useful.

Choosing a policy regime

The very existence of inflation-targeting regimes in a number of places is itself the outcome of policy choices. Such a monetary order is one among many that have been either tried or proposed in the past, but it has not yet been universally adopted and alternatives to it are either in place or on the menu in many places, even in the financially advanced economies to which Woodford's theorizing seems

most immediately relevant. The least we can ask from a theoretical foundation for monetary policy is that it should offer some guidance about these matters, and there is much to be said in favour of the traditional approach here when it is compared to the cashless economy.

It is only five years since the Euro emerged as a fully fledged currency in the European Union, and even now, there are important members of the Union, including three 'old European' countries, who still face the choice between adopting it or keeping their own currencies, while in Canada and Mexico there are vocal and influential domestic lobbies that would replace those countries' domestic currencies with the US dollar as a means of establishing a common currency for the NAFTA as a whole.[17] The cashless economy model is silent about the effects of the number of currencies circulating in a market on the transmission of price information – the question of transparency – and on the resources eaten up in trade across monetary boundaries – the question of transactions costs – but both issues loom large in these debates. The model's assumption that markets always clear, furthermore, distracts attention from important political questions about the effects of monetary policy on their functioning when political and monetary boundaries no longer coincide with one another. In short, the economics of the cashless economy offers us very little help with some very important, and highly relevant, policy choices.

These competing orders are by no means the only ones that we might want to discuss, moreover. Forty years ago, for example, the mainstream choice was a monetary order firmly based on a national currency, with the central bank's principal task being to support the elected government's fiscal policy. When the latter was expansionary, as it often was, the effects of keeping interest rates low so as not to interfere with its effects led to central banks collecting seigniorage on behalf of the political authorities. Monetary policy of this sort in the US in the 1960s and early 1970s, albeit complicated by the need to finance the Vietnam war, was an important source of the inflation that would eventually destroy the Bretton Woods system.[18] Indeed, for as long as governments have found themselves short of revenue, they have looked to seigniorage, and it is hard to think of any significant inflationary episode in recorded history that was not underlain by monetary expansion driven by fiscal requirements, and of any successful monetary stabilization that was not supported by budgetary reforms. There is, that is to say, much wisdom in Thomas Sargent's wry variation on a theme of Milton Friedman, that 'inflation is always and everywhere a fiscal phenomenon'. In a cashless economy, however, there is no stock of real balances on which an inflation tax can be levied, and a theory of monetary policy based on that model does not even permit us to see the point of Sargent's joke.

Though seigniorage is a trivial source of current revenue in modern inflation-targeting economies, we still need to pay attention to these matters. Sargent and Wallace's (1988) 'Unpleasant Monetarist Arithmetic', derived from a very specific model of how expectations about a future inflation tax, resulting from current bond-financed deficits, can affect an economy's current behaviour. It was far-fetched, but was nevertheless based on an important and valid insight

about the fundamental inter-connectedness of fiscal and monetary policy through the government's budget constraint. Canada after 1991 provides an example of inflation-targeting as close to Woodford's ideal of such a regime as one could reasonably get, and from the outset inflation targets were achieved – even over-achieved at first. Nevertheless, as Laidler and Robson (2004: 106–111) show, long-term inflation expectations remained stubbornly high until early 1995, and the economy's real performance was disappointing too. It is hard to believe that the Canadian Federal Government's 1995 budget, which finally put a high and rising public debt-to-GDP ratio onto a sustained downward path, did not have something to do with the sharp fall in long-term inflation expectations and the more or less simultaneous improvement in the economy's real performance that began the following year. Or, to give another example, the fact that the European Central Bank is forbidden to finance the expenditures of member governments, and is not doing so at present, does not eliminate concerns that this arrangement might prove politically unsustainable in the future under the weight of the debt that some of those governments are accumulating – the Stability and Growth Pact notwithstanding.

In short, though the cashless economy provides a theoretical foundation for analysing and designing policy for one particular kind of monetary policy regime, it needs help from a more traditional approach when the properties of that regime are compared to those of others and also when the inter-connectedness of monetary and fiscal policy within such a regime are considered.[19]

Financial stability

A similar conclusion holds when we turn to questions about financial stability and the responsibilities of central banks for maintaining it, a policy issue that is, incidentally, central to present-day discussions about the place of open market operations in monetary policy.

Asset markets seem less likely to be unstable when low inflation is firmly in place but there are examples of problems arising when the overall inflationary climate is benign – the United States' 'Great Contraction' of the early 1930s, Japan's collapsing 'bubble economy' in the early 1990s, to mention only two. The instability in question seems to involve not just financial markets but those for real assets too and seems to arise in specific sectors – real estate for example. It is not surprising, then, that the monetary aggregates seem to provide less-reliable early warnings of trouble than does bank lending for the acquisition of particular assets. Even so, such credit indicators can still herald trouble that has economy-wide repercussions if it gets out of hand: an erosion of banking system capital, widespread depressed expectations about profit opportunities; downward pressure on interest rates; and even generalized real stagnation. All of this leads to two questions. Should inflation-targeting regimes be complicated by adding the avoidance of asset-market bubbles to their goals? And, regardless of the answer here, what should be done after a bubble that has got out of hand bursts?

The cashless economy model can, as Woodford has shown, accommodate questions about the allocation of investment across sectors of the economy. So it ought to be able throw light on the central issues that must face any central bank that wishes to control exuberance in a particular sector: namely, how can monetary policy, which is inherently economy-wide in its impact, be used to address problems in a particular sector without risking unhappy repercussions elsewhere? And if it cannot, how are the gains and losses of such measures to be traded off against one another? There are limits to what this model can do here at present, however, because it pays scant attention to the fact that investment affects not only the current level of aggregate demand in the economy but also the future size and structure of an imperfectly malleable capital stock.

Here, as I argued in Laidler (2003), the debate seems to need guidance not only from traditional monetary models, but also from those in the Austrian, Swedish not to mention Robertsonian and Kaleckian traditions that focus on inter-temporal co-ordination failures. Given the neo-Wicksellian nature of Woodford's cashless economy model, it may well be susceptible to extensions along these lines.[20] Perhaps, though, it would have to give up the twin assumptions of rational expectations and clearing markets to accommodate them. Debates about financial instability make frequent references to accumulated imbalances in portfolios of real and financial assets, and it is hard to give meaning to such phenomena in an economy in which the only disappointments arise from random errors in expectations.

Similarly, the cashless economy model's capacity to deal with problems associated with the real stagnation that sometimes follows the bursting of an asset market bubble is unduly restricted. It forces this phenomenon to be looked at through the lens of the market-neutral interest rate distinction and, given that stagnation is associated with a very low value of the latter, it sees a basic difficulty in the fact that there is a zero lower bound to the nominal market rate that prevents it being lowered far enough to promote recovery. Hence it points to the desirability of measures designed to raise inflation expectations in any chronically depressed economy. This is surely valid as far as it goes, but a more traditional approach would point to the desirability of also giving some thought to the interaction of the supply and demand for money.

Times when markets for goods and services, not to mention financial assets, appear to be working badly are likely to see an unusually high demand for money, and those very same conditions also make the private sector particularly unwilling to borrow from the banking system, a reluctance that inhibits the creation of the very money needed to satisfy this demand, let alone over-satisfy it to the point of inducing a renewal of expenditure. In short, as I have noted in Laidler (2005), at such times the traditional approach would lead us to diagnose what Ralph Hawtrey (e.g. 1932) called a 'credit deadlock', and then to prescribe open market operations on whatever scale was needed to break it and promote recovery. Friedman and Schwartz (1963) recommended just such measures in hindsight as a cure for the great US contraction of 1930–3, as did a number of contemporary commentators, including Hawtrey himself and some of his associates, notably Lauchlin Currie (1934); and, in 1932, the Fed. did in fact undertake large-scale

open market operations for a few months. The Bank of Japan also belatedly implemented such a policy – which it called *quantitative easing* – beginning in 2001, on a very large scale for about 18 months, and more timidly thereafter. In the US case, the data can be read as suggesting that greater vigour might have provoked a more decisive response in economic activity in 1932–3, and, in the case of Japan, it now appears that a hesitant recovery has in fact been under way since 2002.

Perhaps then, the seemingly serious limit imposed on the powers of orthodox monetary policy by the nominal interest rate's zero lower bound is not so much a property of the real world as of monetary policy models that focus too exclusively on interest rates and neglect the interaction of the supply and demand for money, and the scope for open market operations to shift the supply in question. In depression, just as in inflationary conditions, changes in money growth do seem to precede changes in output, which in turn do seem to precede changes in inflation, and the traditional approach to monetary economics tells us why this should be the case, We should ignore neither these facts nor the theory that seems to explain them.

The attractions of eclecticism

Much has been said in this chapter about the limits of Woodford's cashless economy model as a theoretical foundation for monetary policy. It has been argued: that no model which assumes markets always to clear can provide a suitable microeconomic basis for the theory of money; that the cashless economy is therefore better regarded as a useful but regime-specific simplification, particularly relevant to inflation-targeting economies; and that the menu of policy questions to be discussed does not have to be much broadened beyond such a regime before the cashless model finds that it needs help from the very analysis that it seeks to by-pass.

Thus, though we should warmly welcome the extra rigour that Woodford's cashless economy brings to the standard monetary policy model that has proved so useful to inflation targeters in recent years, we should not let it distract us from certain older truths: namely, that excessive money growth is necessary and sufficient for significant inflation and seems to be a leading indicator thereof, that it is often associated with loose fiscal policies, and that the latter can therefore have a deleterious effect on economic performance by way of their influence on longer-term inflation expectations. Central banks that rely on the standard model to design their ongoing policies will find Woodford's work extremely helpful, but the behaviour of money still requires their attention, whether informally as, for example, in the case of the Bank of Canada, or formally as, for example, in the case of the European Central Bank. For the same reasons, a wary eye needs to be kept on fiscal policy too.[21]

Furthermore, the analytic usefulness and popularity of the assumptions of clearing markets and rational expectations notwithstanding, the co-ordinating mechanisms of real-world economies do sometimes seem to break down, more

often than not in inflationary environments, but sometimes even when the price-level is stable. Theoretical models that cannot encompass such failures cannot be trusted to illuminate them, and their implication that cutting short-term interest rates to zero exhausts the central bank's armoury in dealing with the stagnation that sometimes follows them is misleading. Traditional theory suggests that it is precisely in such circumstances that open market operations should be promoted from the technical fringes of monetary policy to its very centre, and surely it is right here.

Even so, it has not been claimed that we should feel comfortable with a more traditional approach to the theory of monetary policy, or that its exponents have nothing useful to learn from Woodford: quite the contrary. Here, I would single out two areas of particular interest, namely his treatment of the output-gap interest-rate-gap inter-relationships and of Taylor-style policy reaction functions.

Today's standard policy model evolved from an IS-LM system without the LM curve, while the more traditional approach continued to pay attention to that relationship. But both approaches have long utilized some sort of expectations-augmented Phillips curve to link aggregate demand to inflation, so both give an important place to the output gap in monetary policy's transmission mechanism. Even the crudest IS curve, moreover, when combined with the idea that there is a 'full-employment' level of output, invites a mapping from the output gap to an interest-rate gap. Exponents of the traditional approach thus have much to learn from Woodford's careful grounding of these concepts and of the linkages between them in the same micro-foundations that inform real-business cycle theory, not to mention his further linking of the Taylor rule to these same micro-foundations: this despite the difficulties that his approach is bound to encounter as it disaggregates over sectors, so that the values of the economy's capital stock and neutral interest rate become variables that depend upon the structure of relative prices, and hence upon the interest rate set by the central bank.

There is room for fertilization in the opposite direction too. One of the less attractive features of Woodford's basic model is its reliance on Calvo contracts to generate price stickiness. The duration of these is fixed regardless of the rate of inflation the economy is generating. It should be possible to incorporate the insights yielded by traditional analysis about the role of information and transaction costs in generating price stickiness and of how agents' willingness to incur these is likely to vary as the opportunity cost of holding money varies with inflation into an extended version of Woodford's framework. Such an extension would render its treatment of price stickiness less arbitrary and also enable questions about long-run inflation-output tradeoffs to be further investigated. Since, however, this extension would also require explicit analysis of the effects of inflation on the demand for money, it might also show that this relationship is more relevant to policy analysis than Woodford initially suggests.

Such a conclusion would, of course, begin to compromise the idea of the cashless economy as a sufficient basis for the theory of monetary policy, while simultaneously strengthening the claims of a more traditional approach, but it still leaves too much that is tentative for anyone's comfort. But if we are not at present quite

sure how, or even whether, the various threads of contemporary monetary theory can eventually be woven together, it should also be reiterated that we probably never will be. The threads in question will change over time as the subject, not to mention the monetary systems it seeks to understand, evolves. Some of them are always likely to be loose, and we should never ignore any of them that appear to support useful policy insights. Sceptical eclecticism, even to the point of utilizing apparently unrelated, even inconsistent, ideas to come to grips with different problems, currently seems to put monetary policy at less risk of error than single-minded devotion to any particular model, and it is likely to continue to do so in future.

Notes

* Keynote address delivered at the 2005 SUERF – Bank of Finland Conference on 'Open Market Operations and the Financial Markets', Helsinki, September 22, 2005. The author is Scholar in Residence at the C. D. Howe Institute and Professor Emeritus at the University of Western Ontario. He is grateful to his discussant, Jan Toporowski, as well as to Perry Mehrling, Colin Rogers and Dan Thornton for helpful comments on an earlier draft.

1 As quoted in Laidler (2004a, 14 [1989]: 333), a paper in which a fuller discussion of the Radcliffe view, and of the evidence upon which it was based, is to be found.

2 The phrase is Milton Friedman's (1956). It is worth noting that Friedman's own main effort to give it empirical content (1959) used business-cycle average data, a far cry from the monthly and quarterly observations that were used when the demand for money function began to be used for guiding policy. How claims to stability came to be uncritically stretched so far would be well worth studying.

3 This is not to say that there was no evolution in the conduct of monetary policy. Nowadays its centrepiece is the interest rate on overnight loans of central bank deposits. At one time the rate of interest on short-term government debt, for example, 3-month treasury bills, was the critical variable. But the evolution here had nothing to do with abandoning money-growth targeting.

4 And variations in money growth still lead output and inflation. To generalize, narrow aggregates seem to display a longer lead than broader aggregates, an observation that is consistent with their being closer to initial policy impulses, whose effects then ripple through portfolios as they simultaneously influence expenditure patterns. For recent evidence on the leading indicator status of very narrow (base) money, see Nelson (2003), and for a powerful statement of the case that, such evidence notwithstanding, it is broad aggregates that have the greater strategic importance, see Congden (2005). The issues raised by these papers require more attention than there is space to give them in this chapter.

5 It was only in 1996 that Robert E. Lucas himself acknowledged the difficulty created by this fact for the model which he had pioneered.

6 As Daniel Thornton has pointed out to me, it is often hard to discern even the outlines of this model in the minutes (where these are published) of meetings at which interest-rate decisions are actually taken by central banks. Nevertheless, it does seem to inform a great deal of the research work that underlies those decisions.

7 Wicksell's self appointed task was to adapt the quantity theory of money to the facts of a monetary system still based on gold but increasingly dominated by deposit banking, and to provide a guide as to how that system could shed its dependence on specie convertibility; Keynes's tackled problems of co-ordinating saving and investment in a

monetary economy, showed why the rate of interest might not be up to this task and how this failure could lead to unemployment; and Patinkin's concern was to provide a foundation in maximizing microeconomic theory for the conventional macroeconomic model that, by the 1950s, had emerged from Keynes's work to dominate the conduct of policy.

 8 And, it must sadly be noted that, perhaps inadvertently, Woodford (2003) includes neither *Money, Interest and Prices* in his bibliography, nor Patinkin's name in his index.

 9 Woodford is not the first economist to suggest that monetary theory should proceed along such lines. As Perry Mehrling (2005) has reminded us, Fischer Black had been there before him, but where Black's work seemed to run quite counter to contemporary policy practice, Woodford's now blends seamlessly into it.

10 The practical problems of implementing Woodford's recommendations that stem from the difficulty of actually measuring the output gap and estimating the neutral value of the interest rate are worth mentioning here. So far these have not led inflation targeters into serious policy mistakes but one wonders just how long their luck will hold out.

11 That money's most fundamental function is the means of exchange is attested to by the fact that, when monetary systems break down under hyper-inflationary pressures, local currency is replaced by some other money (typically the US dollar) first of all as a store of value, then as a unit of account and only finally as a means of exchange. See Heymann and Leijonhufvud (1995).

12 Recent formalizations in terms of search theory of ideas that go back at least to Carl Menger (1892), and indeed to Adam Smith (1776, Book 1: 4) and beyond, have nevertheless made considerable progress. They began with model economies with three commodities, in which isolated agents, endowed with a single indivisible unit of one of them, meet at random, and in which indirect exchange can be shown to arise (Kiyotaki and Wright, 1989). Now we have systems in which institutions that look very much like deposit-taking banks can emerge (He *et al.* 2005). It should also be noted that the less technical Austrian tradition begun by Menger also continues to flourish as a distinct entity. See Selgin and White (2002), for example.

13 For far more thorough methodological critiques of Woodford's approach than are offered here, see Hoover (2005) and Rogers (2005), both of which have surely influenced this chapter more significantly than one brief footnote might indicate.

14 Rabin's (2004) account of the broad approach I have in mind here deserves more attention than it seems to be getting. Though often associated with so-called *Post-Keynesian* economics (eg. Rogers, 2005), the idea that an economy characterized by monetary exchange is fundamentally different from a Walrasian system is also to be found in Monetarist literature. For a recent example, see Daniel Thornton (2000). My own earlier expositions of some of the implications of this idea are to be found in Laidler (1997, 8 [1974], 13 [1984] and 14 [1988]).

15 The critical parameters here are, of course, the price level and real income – more generally scale variable – elasticities of demand for money. A recent meta-analysis of estimates of the latter parameters by Knell and Stix (2005) shows that they display considerable variation across countries and some variability across aggregates too – broader aggregates have higher elasticities of demand than narrow – but leaves little doubt that they represent an aspect of the economy's structure rather than some coincidental statistical artifact.

16 Some would argue that the impact of money created to finance government expenditure is greater than that created by private borrowing, because the first represents a net increase in private sector wealth, while the second is offset by an increase in private sector indebtedness to the banking system. This, however, is to overlook the effect on the value of the banking system's equity of a simultaneous increase in its interest-bearing assets and non-interest-bearing liabilities. This result was firmly established in

the debate that followed the publication of Pesek and Saving (1967) – see for example Laidler (1997, 4 [1969]) – and rests on reasoning similar to that which later figured in the debate about the 'Ricardian equivalence' of debt- and tax-financed government expenditure.

17 Sweden and the UK are domestic inflation targeters which successfully deploy versions of the 'standard model', while Denmark maintains a fixed exchange rate on the Euro. Meanwhile the European Central Bank pursues 'price stability' – an asymmetric inflation target that stresses an upper bound – using 'two pillars', one a version of the 'standard' model and the other a 'reference value' for broad money growth. Canada and Mexico are domestic inflation targeters, while there are serious proposals for the US, currently constrained by law to pursue both inflation and employment goals, to do likewise.

18 The link between US budget deficits and money creation under the Bretton Woods system was complicated by the fact that monetization of US debt acquired through current account surpluses was carried out by member countries of the system, rather than by the Fed. itself. Similar forces seem to be at work now, and threaten to undermine the stability of the Bretton Woods-like system of fixed exchange rates on the US dollar that has developed among South East Asian countries.

19 Woodford (2003) does not analyse fiscal policy except as an influence on aggregate demand. His cashless model does not permit consideration of its potentially direct effect on monetary policy through the government budget constraint.

20 The connections between Wicksell and Woodford are perhaps more tenuous than a quick reading of the latter would suggest, as Boianowsky and Trautwein (forthcoming) have noted. Let is be clear however that, as Woodford (2005b) has explicitly noted, he did not make strong claims in this regard in the first place. A discussion of recent developments in the Austrian-style macroeconomics alluded to here is beyond the scope of this chapter. The interested reader is referred to Garrison's important and stimulating monograph (2001).

21 On the ECB's policy framework, and the role of money therein, see Issing (2004). Engert and Selody (1998) provide a compelling exposition of the Bank of Canada's views, which have much influenced this chapter, on the need to deploy 'competing paradigms' in the analysis and formulation of monetary policy.

Comment on Laidler

Jan Toporowski

There are few economists who could have given such a stylish and perceptive analysis of current monetary theory and policy as David Laidler has. If I pick out particular insights, there is a risk of losing the consistency in the chapter, based on the position on monetary theory and policy that David Laidler has maintained over years. His response to adverse and inconvenient argument and empirical evidence, by extending his scholarship and the sophistication of his analysis, is an example to us all.

The insights that I found especially apt are, for example, his comment on the theoretical inconsistency of central banks' monetary policy in the past: namely that the theoretical justification for the management of monetary aggregate(s) is based on the lagged *future* effect that such aggregates have on inflation via changes in nominal aggregate demand; while central banks implemented monetary policy to bring the *current* demand for money in line with current targets. His dismissal of any 'set of fundamentals which, once discovered, will prevent capable logicians who understand them from making false propositions about the economy's response to policy measures' echoes the work of another of our authors, Sheila Dow, and is a salutary reminder that economic theory is about putting forward arguments rather than incontrovertible 'fundamentals'. (There is more than one reason why we should avoid fundamentalism in this day and age!) The injunction to read more Austrian and Swedish monetary theory is well taken by this particular devotee of German credit-cycle theories, but our reading should include, besides the 'inter-temporal co-ordination failures' of abstracted and representative agents, the operations of the firms and the financial and monetary institutions whose decisions dominate market outcomes.

As a scholar of the Polish economist Michal Kalecki, I am especially pleased to find in David Laidler's text a remark that among other limitations of general equilibrium models of the kind currently popular in monetary theory is their very attenuated view of business investment, which 'not only affects the current level of aggregate demand in the economy but also the future size and structure of an imperfectly malleable capital stock'. So inflation and economic instability may not 'always and everywhere be a monetary phenomenon' and may even have monetary and financial consequences beyond the reach of monetary policy. I shall say more on this later.

Laidler is not the only monetary theorist to find Michael Woodford's rationale for an interest rate (as opposed to monetary aggregate) policy targeting inflation magnificent in its ambition and conception, but flawed in its delivery. Wicksell himself devoted far more attention to the mechanics of economic disequilibrium than do latter-day 'neo-Wicksellians'. The contrivance of Calvo pricing (allowing only a certain proportion of prices in any one period to adjust to make supply and demand equal) is not only arbitrary and *ad hoc*, as Laidler points out. It is also a poor substitute for the examination of cumulative economic processes that Wicksell pioneered. The elimination of random errors in expectations would still leave the enlightened agents at the mercy of such cumulative processes. We flatter ourselves that we control our assets and liabilities when, to a great extent, at least in the short term, they control us. And, even if we are so bohemian, wealthy or (economically) irrational that we disregard our assets and liabilities in our economic decision-making, they are certainly crucial to the decision-making of the firms on which the progress of our economies depend.

If we expand the microeconomic foundations of monetary analysis beyond their shallow and attenuated limits in the primitive (albeit bond-financed) New Classical household economy, we have to consider how the decisions of firms are influenced by their balance sheets. The following considerations are not too dissimilar to the credit-counterparts approach to money that David Laidler will recall from the 1970s, but with an interesting, Kaleckian twist. By definition, (incidentally, I am aware that many economists find arguments based on flow of funds identities circular; however, such identities do at least have the merit of helping to avoid some of the grosser flights of creative accounting) saving (i.e. the net acquisition of monetary and financial assets) in an economy in a given period (S) is equal to the sum of firms' gross capital expenditures (I); plus the fiscal deficit ($G - T$); plus the current account surplus ($X - M$):

$$S \equiv I + (G - T) + (X - M).$$

We can further divide up saving into the net acquisition of monetary and financial assets by households (S_h) and the net acquisition of monetary and financial assets by firms (S_f),

$$S \equiv S_h + S_f.$$

Substituting and re-arranging gives an equation for the net saving of firms:

$$S_f \equiv I + (G - T) + (X - M) - S_h.$$

This net acquisition of claims on monetary and financial institutions by firms is in effect the profits that they retain after payment of interest, taxes and dividends. These retained profits accumulate into the 'free' (i.e. unencumbered by financial liabilities) reserves that not only largely determine firms' credit-ratings, but are also the margin of safety that allows firms to engage in capital spending or corporate

acquisitions more freely. In general equilibrium or in accounting or Keynesian identities, no direction of causation may be inferred. But in practice, we, and firms, do not determine our incomes from day to day (an inconsistency in the New Classical view of the world) but we do control our expenditure decisions. In the short run at least the net cash flow of firms is determined by their capital expenditure, the fiscal deficit and the trade surplus, and is offset by household saving.

Let us suppose that the government budget and the current account are balanced. In that situation, the net cash flow of firms is equal to their capital expenditure minus household saving. Supposing in this situation firms' investment were to fall below the level of household saving (or household saving rise above capital expenditures). The retained profits of firms would become negative. While this could be accommodated for a while by borrowing or drawing on reserves, a more sustainable response would be to postpone investment. This reduction in capital expenditures would, in the past, have set off a cumulative contraction of the economy until falling income finally reduced household saving below the level of capital expenditures. (This reduction in household saving is somewhat more difficult to engineer if incomes are relatively unequally distributed, or a large middle class exists whose incomes, and saving, are relatively immune to fluctuations in firms' capital expenditures. See Steindl (1982).) Today, the more fiscally active (U.S. and U.K.) governments can stabilize consumption at the cost of high fiscal deficits. But there is little sign that this can reverse the decline in capital expenditures of firms, so that the counterpart of high fiscal deficits is current account deficits, and continuing weakness in firms' cash flows rather than higher spending on productive capacity. The US and the UK are also rather unusual in having recently had negative net household saving. But even that is a floor below which firms capital expenditures should not fall, and the capital expenditures of firms in Britain and the US are not among the highest of the OECD countries.

This Steindl/Kalecki 'inelasticity of saving' has important monetary and financial consequences. If their corporate customers have weak balance sheets, then banks that lend to them will import that weakness into their own balance sheets. If prices are forced to adjust downwards, then Fisher-style debt deflation increases the real value of corporate liabilities. The banking system can be kept liquid by open market operations, of the kind recommended by Hawtrey, or those pursued with variable success by the Bank of Japan since 2001. Such policies were an important factor in the relative absence of bank failure in Europe (apart from Kreditanstalt in 1931) during the Great Depression. But, keeping the banking system liquid leads to a freezing of the debt liabilities of the corporate sector. Eventually this can lead to Minsky-style cumulative debt deflation, unless securities' markets can be inflated, to refinance bank debt, before a fall in securities' prices allows companies to buy in depreciated debts. For the neo-Wicksellians, negative real interest rates can only be reversed by stimulating inflationary expectations in our household production units financing themselves in perfectly liquid capital markets. In practice cash flow is the key to the liquidity of businesses, and even the inflationary expectations of 'agents'.

Let me conclude with two remarks.

I would like to have heard more about the mechanisms whereby, in a system of free international capital movements, the conservative refusal of a central bank to monetize its government's debt may be frustrated by the possibility that other central banks will naturally monetize foreign government debt. This seems to me an insight that is especially relevant to the topic of our conference and to the current US fiscal reflation of the East Asian economies.

Finally, David Laidler's call for 'sceptical eclecticism, even to the point of utilizing apparently unrelated, even inconsistent, ideas to come to grips with different problems', is to be welcomed. While as thinkers and academics we have in our writings to put forward consistent arguments, central banks have to consider the widest range of arguments if, as David suggests, they are to minimize the risk of error in monetary policy. It is better for an economist to be derided as 'two-handed' for putting forward all considerations relevant to a policy decision, than to avoid controversy by hiding behind a consistent, but simplified, model. The losers from avoiding controversy can only be economists themselves. When Goodfriend and King averred that 'virtually all economists agree that there is an important role for public authority in managing the nation's high-powered money' (Goodfriend and King 1988), the comforting consensus that they expressed meant that it was more then a decade *after* central banks had started their retreat from monetary aggregate management before economists wedded to that consensus realized that central bankers were doing something else. One needs to be something of a historian of economic thought to appreciate this, and few could have put forward such an appreciation with the elegance and scholarship of our speaker.

3   The scope and significance of open-market operations

*William A. Allen**

Open-market operations are the means by which central banks enforce their policies. However well-informed and wise the deliberations of central bank boards and monetary policy committees may be, their importance derives from the central bank's power to impose their decisions. A central bank that was just 'an army with only a signal corps', as Friedman (1999) put it, would be unable to withstand competition from similarly equipped private armies.

Open-market operations were developed in Britain in the nineteenth century and early twentieth century, at a time when the gold standard was in operation. It is interesting to recall that open-market operations were not a logically necessary part of the gold standard. In the pure theory of the gold standard, the domestic supply of money was determined by the supply of gold, and changes in money supply were largely determined by international gold flows. In that theory, there was no necessary role for central banking, or for discretionary monetary policy. Open-market operations were nevertheless developed precisely in order to moderate the automatic functioning of the gold standard. Central banks used open-market operations to raise interest rates when they wanted to protect their gold reserves, in order to prevent the monetary contraction that would have occurred if a gold outflow had been allowed to take place.[1]

This chapter discusses three related aspects of the microeconomics of open-market operations. One is how tightly short-term interest rates should be controlled in those countries where they are the operating instrument of monetary policy. The second is the provision by central banks of intra-day credit in payment systems, which is a relatively new kind of open-market operation. The third issue is reserve averaging. The justification for discussing these microeconomic issues is that, in something as important as open-market operations, microeconomic decisions can have macroeconomic consequences.

Objectives of open-market operations

Open-market operations have in different places and at different times served different immediate macroeconomic objectives.[2]

One type of immediate objective is to manage the quantity of central bank money available to the commercial banking industry and the economy. This was the early objective of the financial operations of the Federal Reserve system (indeed it is why the Federal Reserve was set up), and it has been the objective of those central banks which have adopted monetary base control as an operating technique, notably the Federal Reserve in 1979–82.[3] It has also been the objective of the Bank of Japan since it embraced 'quantitative easing' in 2001 in the attempt to stimulate economic activity and overcome deflation.

Even where the central bank implements monetary policy by controlling short-term interest rates, as is the case in most countries, open-market operations still have some quantity-related objectives. One such objective is to enable commercial banks to economize on their holdings of central bank money. In the absence of any open-market operations, the cash-flow of the commercial banking system would be heavily influenced by the flows of funds between the commercial banks and the central bank. Such flows can be very large, and they typically have a pronounced seasonal component. For example, they include flows of banknotes, which respond to fluctuations in public demand, which in turn has a pronounced seasonal component; and, in countries where the central bank acts as banker to the government, they include tax payments and government disbursements. Those flows would probably cause temporary and largely predictable fluctuations in short-term interest rates, but not in interest rates for maturities longer than the period of the cycles in the flows of funds. By offsetting such flows, open-market operations can both greatly reduce the average size of the clearing balances at the central bank that commercial banks need to maintain, and stabilize short-term interest rates.

Interest rate control

The other type of immediate objective, which has been and currently is much more widespread, is to manage short-term interest rates. The main objective of this chapter is to discuss how such management is best achieved.

When a central bank board or monetary policy committee makes a decision about interest rates, it presumably has in mind that it is making a decision about the cost of borrowing and the money reward for deferring spending. It is then the responsibility of those responsible for implementing monetary policy to translate that decision into actions in financial markets, by managing the central bank's affairs in such a way that market prices are consistent with the board's decision.

As a preliminary, it is useful to begin this section with a sketch of the technique which is increasingly widely used to implement monetary policy through control of short-term interest rates. The details differ from country to country, but the broad structure described here is used by many central banks, including the Federal Reserve and the European Central Bank. It will be also be used by the Bank of England, when its plans to reform its operations have been implemented.[4]

The operations are of two kinds:

- Open-market operations proper, in which the central bank takes the initiative in buying (usually) or selling (occasionally) short-term securities in order to relieve a shortage of central bank money in the banking system, or to absorb a surplus of central bank money in the banking system.[5] These operations are normally conducted at the interest rate decided by the central bank board, or at a rate close to it. Their maturity is normally longer than overnight, but the open-market operations typically mature before the next interest rate policy decision becomes effective.
- Overnight collateralized lending (and in some countries also borrowing) operations conducted by the central bank at the initiative of the commercial banks under 'standing facilities'. These facilities enable the commercial banks to get overnight funds from the central bank when they are not readily available in the market.[6] The lending facilities are normally available at a fixed interest rate margin above the policy rate; likewise, the borrowing facilities (if any) are available at a fixed margin below the policy interest rate. The lending and borrowing rates establish a band, or corridor, within which market rates for overnight loans can fluctuate (see Figure 3.1).

Overnight lending and deposit-taking are sometimes regarded as something separate from open-market operations. However, for the purposes of this chapter, I regard both types of operation as part of the totality of open-market operations.

Maturity

One aspect of the issue is the precise maturity of the short-term interest rates that the central bank thinks it is managing. It is clearly much easier for a central bank to
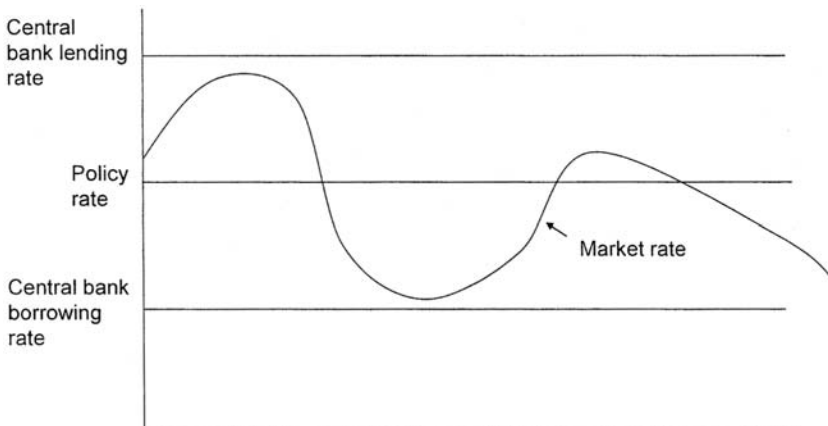
Figure 3.1 The interest-rate band.

control overnight interest rates than long-term bond yields. The reason is that for a central bank to control long-term bond yields would probably involve it in very large-scale transactions, and very large amounts of financial risk. Interest rates beyond the overnight maturity depend on market expectations of future overnight interest rates, as well as a range of other factors (some of which are described in the next section). By controlling a longer-than-overnight interest rate, a central bank would be implicitly endorsing or rejecting a market expectation about future overnight rates, and would stand to lose money, and appear foolish, if the expectations that it endorsed were falsified. That might be thought an unnecessary risk for a central bank to take.

In most current circumstances, central banks choose to control overnight rates, since it is by far the simplest and least risky technique available to them. Some of them (e.g. the European Central Bank and, in its planned future operations, the Bank of England) aim in addition to control rates at slightly longer maturities, up to the date of the next interest-rate decision meeting. It is left to market forces to determine rates at longer maturities, but the central bank recognizes that market forces will be influenced by expectations about future short-term interest-rate decisions by the central bank, as well as by expectations about the behaviour of the economy.

In this division of labour, the central bank determines overnight rates while the market determines longer-term rates. The impact of monetary policy on the economy depends on both short- and long-term interest rates. Thus financial markets in a sense participate anonymously in the formation of monetary policy through their effect on longer-term interest rates: this is part of what is often called the 'transmission mechanism' of monetary policy. But the word 'mechanism' is ill-chosen, since the process is not merely mechanical, and the role of financial markets is not just to translate the central bank's view of the economy into the yield curve and other asset prices. Financial markets will not always be guided by the same analysis as the central bank. If the market believes that the central bank's analysis of the economic outlook is mistaken, it can and will express that view in determining the behaviour of longer-term interest rates, and the result is likely to be a yield curve which appears to be inconsistent with the central bank's stated view of the economic outlook. This market power can be regarded as a check on the power of central banks[7].

Other specifics of the loan: credit risk and liquidity

An important microeconomic issue is exactly which market interest rate is supposed to be in line with the decision of the central bank board. Any market interest rate is specific to the particular circumstances of the loan of which it is the price – for example to the times at which the loan was contracted, at which the funds were extended, and at which they were scheduled to be repaid; to the nature of the loan instrument (e.g. interest-bearing security, discount security, non-tradable deposit); to the identity and creditworthiness of the borrower; to the liquidity of the market for the security in question (if the loan is securitized); to whether there

is any collateral for the loan and if so, what it is; and perhaps to other factors as well.

I have already discussed maturity issues. Central banks typically try to simplify their task by specifying that they will deal only in transferable debts issued by issuers of high credit quality. In favourable conditions, this strategy has a number of attractions:

- The central bank takes relatively little credit risk and therefore does not need to undertake very detailed credit analysis.
- In many countries, the market for high-quality short-term debt is broad and liquid, so that the central bank's purchases may not distort the market too greatly, and the short-term interest rates that affect the economy are likely to be close to the rates on which the central bank board has decided.

It is common for the vast majority of central bank open-market operations to be in domestic currency-denominated government securities, bought in sale and repurchase transactions (repos), since they generally have low credit risk and relatively broad markets (see below).

Even if the central bank confines its purchases to securitized debt of high credit quality, such instruments are not homogeneous. For example, even within the class of government securities, some issues are often in short supply in the repo market (perhaps because they appear to be overpriced and market makers have short positions, which they will have created by borrowing from investors, or because they are for some reason mainly owned by investors who, for whatever reason, are unwilling to lend them). Those issues are often more expensive to borrow than others, and the central bank is unlikely to receive them in its open-market operations.

The interest-rate band

Another microeconomic issue arises from the trade-off that the central bank faces in specifying what assets it will buy, outright or on repo, in its open-market operations. If it wants the class of eligible assets to be as nearly homogeneous as possible, it will specify the criteria for eligibility quite tightly. However, if it does so, the resulting class of assets will be relatively narrow, and its influence on interest rates on other assets will be weaker. A trade-off exists and needs to be taken into account; central banks cannot expect to be able to achieve complete homogeneity in the class of assets that they buy.

If the assets that the central bank buys are not homogeneous, their market prices cannot be expected to be the same all the time. To put the same point a different way, if the central bank is willing to buy different assets at the same price, then it is in effect offering the market a free option as to which assets within the eligible class to sell, and it can expect to end up holding the lowest-quality assets within the class. Another example of non-homogeneity within the class of government securities is that the issuers may not all be the same. The European Central Bank

is willing to buy (on repo) the euro-denominated securities of all twelve national governments of the euro area in its open-market operations. It buys them all at the same price, regardless of whether the issuing government has an 'excessive deficit' (as defined in the Maastricht Treaty) and regardless of any other aspect of creditworthiness. However, it is clear that the creditworthiness of the twelve governments is not uniform. The ECB does not publish the breakdown of its holdings of euro-area government securities by nationality of issuer, but it would be surprising if the distribution were unrelated to the relative creditworthiness of the issuers.[8]

If the central bank wants to be able to control the average quality of its assets, it needs the facility to discriminate in its pricing between assets with different characteristics. Thus the inevitable non-homogeneity of eligible assets is one reason why the central bank needs to maintain short-term interest rates within a band, rather than at a single point. It is, however, not the only reason.

Another reason is related to the cash-flow management of commercial banks. It was noted above that open-market operations directed at an interest-rate objective can additionally enable commercial banks to economize on liquidity, because open-market operations can offset the cash flows between the commercial banking system and the central bank. This offsetting is usually based on the central bank's forecasts of its own cash flow, which, in countries where the central bank provides banking services to the national government, are in turn largely based on the cash flow forecasts of the ministry of finance. The forecasts are, however, like all forecasts, not perfect, and the offsetting provided by means of open-market operations undertaken at the central bank's initiative is therefore likely to be incomplete. If the central bank maintains a relatively narrow overnight interest-rate band, by providing standing facilities for borrowing and depositing at rates relatively close to its target interest rate, then it is in effect giving commercial banks the opportunity to manage their cash flow relatively cheaply by using the central bank to smooth out fluctuations in its cash flow.

By the same token, if the central bank maintains a relatively narrow overnight interest-rate band, it constrains the rewards available to those market participants who try to anticipate cash flows between the central bank and the commercial banks, and position themselves to profit from them. By maintaining a relatively narrow band, the central bank in effect provides a relatively low-cost cash-flow management service to commercial banks, and squeezes out potential competitors from the private sector. This involves a moral hazard, because if commercial banks are confident that their cash flow management can be carried out relatively cheaply by transacting with the central bank, provided they have adequate eligible collateral, they will devote less effort to forecasting their own cash flows. Such a development is not likely to be conducive to the prudent management of the bank.

How wide or narrow the official interest-rate band should be is a matter of policy judgment, in which stability in short-term interest rates must be traded off against self-reliance in commercial bank cash-flow management (there may be other factors as well, for example the desire to have liquid and well-functioning

financial markets). In other words, there is a potential conflict between the macroeconomic objectives of monetary policy, which presumably require an interest rate level as close as possible to the level chosen by the central bank board, and the microeconomic objectives of financial stability, which require commercial banks to have incentives to take care of their own affairs and not pass off responsibilities to the public sector.

Intra-day credit

Traditional open-market operations involve loans or deposits with a maturity of at least a day. Until the 1990s, the information technology to make real-time intra-day payments, and monitor intra-day credit exposures, did not exist. In practice, there were unmeasured (but presumably very large), unmanaged and unsecured intra-day credit exposures within national banking systems.

Now that the necessary information technology does exist, central banks have persuaded commercial banks to measure and manage their intra-day credit exposures to each other by means of Real-Time Gross Settlement (RTGS) systems, in which all large-value inter-bank payments are settled immediately and irrevocably. Such RTGS systems require extensive credit facilities, since the sequencing of large-value payments is inherently unpredictable and commercial banks can easily find that their readily available assets are temporarily exhausted if they encounter a bunching of large out-payments.[9]

Many central banks provide intra-day credit to enable commercial banks to ride out fluctuations in intra-day payment flows. It is a strict rule that the credit has to be repaid by the end of the day;[10] nevertheless, central banks provide intra-day credit for at least one of the same reasons for which they undertake traditional open-market operations: namely to enable the commercial banks to economize on liquid assets. Central banks have made no attempt to manage the supply of intra-day credit in a manner analogous to monetary base control, and none seems likely to do so in the foreseeable future: central banks behave like interest-rate setters in providing intra-day credit. Figure 3.2 illustrates schematically how central bank intra-day credit works.

The Federal Reserve provides unsecured credit to commercial banks up to a bank-specific net debit cap at a marginal interest rate charge of 36 basis points levied on the average amount outstanding.[11] Net suppliers of intra-day credit are not remunerated. In the United Kingdom, the Bank of England supplies unlimited credit, at no interest charge, against specified collateral.[12] In Japan, too, the central bank supplies unlimited intra-day credit against collateral at no interest charge.[13]

Within most central banks, intra-day credit is the responsibility of the payment system department and the banking operations department, and not of the department responsible for implementing monetary policy.[14] Nevertheless, some of the issues surrounding the provision of intra-day credit are the same as those surrounding traditional open-market operations. If commercial banks are to have an
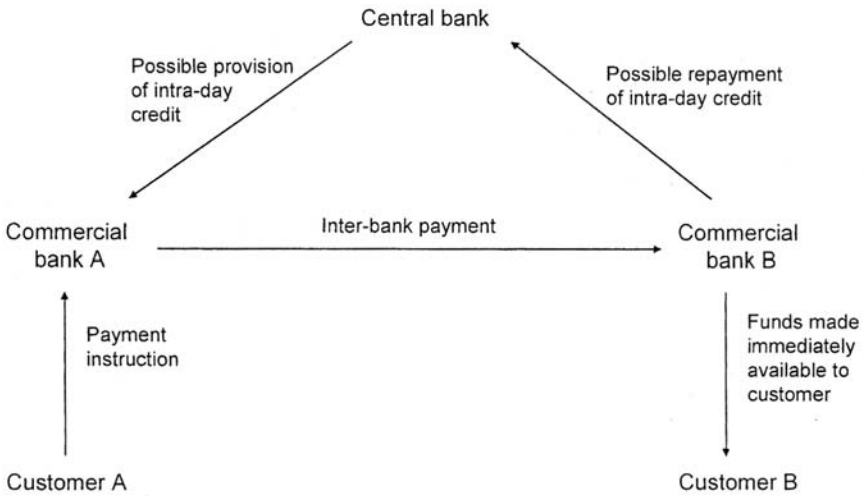
Figure 3.2 Central bank intra-day credit. The flows illustrated in the diagram are generated by a large real-time payment from customer A of commercial bank A to customer B of commercial bank B. If the consequent payment from commercial bank A to commercial bank B exceeds commercial bank A's credit balance with the central bank, then the central bank extends intra-day credit to commercial bank A (against collateral transferred to the central bank). The payment from commercial bank A is received immediately by commercial bank B (and made available to customer B for immediate use). If, at the time of receipt, commercial bank B has intra-day credit from the central bank outstanding, it will use the payment it has received from A to repay some or all of the credit (and get collateral returned to it).

incentive to manage their payment flows, there needs to be some cost attached to taking intra-day credit from the central bank; and there needs to be some benefit attached to being a provider of intra-day liquidity. In countries where there is no charge for intra-day credit from the central bank, and no remuneration for intra-day lending to the central bank, the central bank is providing free intra-day intermediation among financial institutions. Not surprisingly, in the United Kingdom at least, the central bank is a counterparty to all intra-day credit transactions.

There is a powerful argument, as a matter of microeconomics, for the central bank charging a non-zero interest rate for intra-day lending. It would also be possible for the central bank to accept intra-day deposits from commercial banks at a non-zero interest rate, which would be lower than its intra-day lending rate. Such changes would create an incentive for commercial banks to find ways of economising on intra-day credit, and to trade with each other in intra-day loans. Thus it would help to create the conditions in which a commercial market in intra-day credit could develop. It is not obvious how large an intra-day interest rate band would have to be for a market actually to emerge: that would depend on

the costs of developing the market infrastructure and the costs of participating in it. Those costs will probably fall over time as technology improves. A policy of introducing an interest rate band should not be judged a failure if no commercial market emerged immediately: it might become economic to develop a market only later when better technology has brought the costs down. But it is clear that, while central banks lend and borrow at the same interest rate, commercial banks have no incentive to economize on intra-day credit, and no market will ever develop.[15]

At the macroeconomic level, in countries where the central bank provides intra-day credit, there is no relationship between the interest rate (if any) charged for intra-day credit, which is determined by convention and rarely changed, and the rate charged for inter-day credit – i.e. for credit provided for maturities of one or more days.[16] The inter-day rate is something that the central bank regularly reviews and might change as a matter of monetary policy, whereas the intra-day rate is not subject to regular review and is not regarded as a monetary policy issue. However, there is no reason in principle why there should be any such disjunction between inter-day and intra-day interest rates. The marginal productivity of capital is not any less between 9.00 am and 9.00 pm than it is between 9.00 pm and 9.00 am the next day. The fact that such a disjunction persists appears to be no more than a relic of a technologically less-advanced era.

Reserve averaging

Reserve requirements imposed by central banks oblige commercial banks to hold a minimum amount of funds in their current accounts with the central bank. Reserve averaging means that the requirement applies to their average balance over a period (the reserve maintenance period), rather than to the balance at the close of business each day. The period over which reserves can be averaged may be chosen so as to coincide with the period between monetary policy decisions. Thus the Bank of England's future plans for open-market operations envisage reserve maintenance periods of roughly a month, beginning and ending on days when the Monetary Policy Committee announces an interest rate decision. On individual days within the period, commercial banks may have a current account balance below the required average, provided that they compensate by having balances above the required average on other days.

The issue of reserve averaging can be separated conceptually from the issue of whether reserve requirements are desirable. The reason is that it would be possible in principle for a central bank to impose no reserve requirement – that is, a reserve requirement of zero – while at the same time allowing averaging by permitting commercial banks to run overdrafts in their current accounts with the central bank on some days, provided they compensated with positive balances on other days.

Typically, however, even in countries with positive reserve requirements, commercial banks are not permitted to have overdrafts with the central bank on any individual day,[17] though they do have access to overnight borrowing facilities,

at some rate of interest above the policy rate which the central bank is attempting to impose on the economy. That proviso apart, commercial banks need to pay close attention to their cash flow only once in each reserve maintenance period, on the last day.

In some ways, in a structure of this kind, the reserve maintenance period takes the place of the business day in what might be called traditional structures, in which commercial banks are required to meet the reserve requirement each day (if the reserve requirement is zero, the requirement is simply for the commercial banks to have their current accounts in credit at the close of business each day). A year has twelve periods (if the reserve maintenance periods last a month each), instead of 250-odd periods of one business day. Overnight lending within the reserve maintenance period is the analogue of intra-day lending in the traditional model.

Reserve averaging has important microeconomic effects on inter-bank borrowing and lending. Because commercial banks are not obliged to meet any particular minimum target for their current account balances at the end of each day, and can carry over any surplus on their current account balances for future use, their need to borrow from and lend to other market participants is greatly reduced. Thus there is likely to be much less market trading in short-maturity assets than where commercial banks do have to meet a daily target, and interest rates are likely to be more stable, because banks can, in effect, borrow funds from or lend funds to themselves to be used on later dates in the reserve management period, as well as from and to other market participants.[18] Indeed, one of the Bank of England's main objectives in introducing reserve averaging has been to induce greater stability in short-dated interest rates. Of course, reserve averaging does not deliver greater overnight interest-rate stability on the last day of the reserve maintenance period, when the commercial banks face a hard funding constraint.

There are, however, potential microeconomic drawbacks to reserve averaging. One of them is that the commercial banks face a hard funding constraint, i.e. the need to get their current balances up to the minimum, only once each maintenance period. If a commercial bank has an undiagnosed financial problem, this might permit the problem to go undetected for longer than if reserve averaging were not allowed.[19] Another is that commercial banks have a powerful advantage over other participants in the short-dated money market, as they alone have the facility, at low cost, not to balance their books at the close of business each day. It is not realistic to expect that competition among commercial banks will be powerful enough to induce them to extend the equivalent of reserve averaging to their customers. Thus reserve averaging is likely to reinforce the market power of commercial banks in the short-term money market.

At the same time, it is not clear that the objective of stable overnight interest rates is anything of great macroeconomic value. Plainly, it is a desirable objective for the short-dated money market to function smoothly and efficiently, and stable prices could in principle be a sign that it is doing so. However, if stable prices are achieved only by means of the contrivance of reserve averaging, the result is likely to be subdued market activity and limited and unequal competition. In that case

stable prices would be an indication not that fluctuations in supply and demand were being balanced by efficient market-makers, but rather that fluctuations in supply and demand were being suppressed by regulatory contrivance.

Concluding remarks

Not all central banks implement monetary policy by managing short-term interest rates, but most do so. Obviously, they are concerned to meet their responsibility to enforce the level of rates that the central bank decision-making body has chosen.

The theme of this chapter is that short-dated interest rates guide microeconomic resource allocation within the financial system, as well as macroeconomic resource allocation in the economy at large. If the central bank controls interest rates too tightly in an excess of macroeconomic zeal, there is a risk that the price signals that would otherwise guide microeconomic resource allocation will be suppressed. There is a risk of resources being misallocated, for example if commercial banks are induced to devote insufficient attention to cash flow management, or if central bank procedures cause credit spreads to be narrower than otherwise, or if the short-term money market comes to be dominated by a small number of large banks. Such resource misallocation could over time do serious damage to the financial system; and a malfunctioning financial system can have adverse macroeconomic consequences. There needs to be a trade-off between precision of interest-rate control and allowing market forces to work in the financial system.

Notes

* I am very grateful to Franco Bruni, Charles Goodhart, Richhild Moessner, Geoffrey Wood and participants in the Bank of Finland/SUERF conference on open-market operations on 22–23 September, 2005, for very useful comments on earlier versions of the paper. Needless to say, they are absolved from blame for remaining errors of fact or interpretation.

1 See chapter 2 of Meltzer (2003) and chapter 3 of Sayers (1976).

2 For a comprehensive historical survey, see Bindseil (2004a).

3 It is fascinating to read the account by Lindsey *et al*. (2005) of the debate in the Federal Reserve leading up to the adoption of a variant of monetary base control in 1979. The account is based on the transcripts of meetings of the Federal Open Market Committee. The FOMC was persuaded that, with inflation and inflationary expectations rising, monetary policy needed to be tightened sharply. It had to decide between a large discretionary increase in interest rates and the introduction of some form of monetary base control. It chose the latter, not because of any theoretical conviction but mainly because monetary base control left the determination of short-term interest rates ostensibly to the market, even though the FOMC planned to manage the supply of base money in a way that would cause short-term interest rates to rise. FOMC members were anxious not to have to bear the political burden of having decided explicitly on a high and unpopular level of interest rates.

4 For an account of the reforms, see Clews (2005).

5 The demand for central bank money can safely be regarded as being interest-inelastic in the short run of up to a month or so. Thus it makes sense to speak of a shortage or a surplus of central bank money without regard to interest-rate levels. This inelasticity also means that it would technically possible for the central bank to impose more or less any level of short-term interest rates that it chose.

6 Of course, if the open-market operations have been perfectly conducted, then there ought to be exactly enough central bank money in the banking system to satisfy the commercial banks' needs. However, the central bank may have mis-estimated the initial shortage (or surplus) of funds in the system, and therefore undertaken the wrong amount of open-market operations, or one or more of the commercial banks may have mis-perceived their own need for central bank money. Or individual market participants may be playing market games in which they contrive to become the only borrower in the overnight money market and seek to dictate terms to those with surplus funds which they wish to lend. In those circumstances, a central bank standing deposit facility gives the lenders an alternative outlet for their surplus funds. See Allen (2004).

7 See, however, Morris and Shin (2005), who argue convincingly that the published forecasts of central banks have a disproportionate effect on market expectations about the behaviour of the economy, so that the market's check on central bank power is not very effective.

8 ECB Executive Board members have defended the ECB's policy, noting that the amount of collateral that commercial banks have to provide depends on the market price of the securities they provide, so that if they provide securities of low credit quality, they have to provide a relatively large nominal amount (see Issing (2005) and Papademos (2005)). However, this is not a complete answer to the point. The ECB accepts the securities issued by relatively low-quality issuers among euro-area governments at the market's valuation, even though it clearly thinks the market's valuation is too high. More fundamentally, the ECB says that it is not responsible for enforcing fiscal discipline. Maybe not, but the ECB is, on its own reckoning, taking financial risks by going along with a market view of creditworthiness which it plainly thinks is seriously mistaken; and the ECB is obviously responsible for its own finances.

9 Not all RTGS systems use intra-day credit. For example in Finland, the BoF-RTGS system makes payments in real time, but only when there are sufficient funds on the sending bank's account at the Bank of Finland. If there are insufficient funds, the payment order is put in a queue, and the system periodically attempts to execute all outstanding payment orders in a single operation. This means that payments are not guaranteed to be settled immediately. Systems offering immediate settlement require intra-day credit. For an account of the Finnish RTGS system, see chapter 6 of Iivarinen *et al*. (2003).

10 This means that there are substantial penalties if the rule is broken.

11 Commercial banks can get additional intra-day credit, beyond the net debit cap, if they provide collateral. See Federal Reserve Board (2001).

12 See section 3.2.5 and 3.2.6 of the United Kingdom section of Basel Committee on Payment and Settlement Systems (2003).

13 See section D of Bank of Japan (2001).

14 In the euro area, the division of responsibilities is even deeper. National central banks are responsible for payment systems, and decide whether and if so on what terms they will provide intra-day credit, whereas the European Central Bank is responsible for traditional open-market operations.

15 A plausible explanation for the existence of zero interest-rate bands is that they were a concession made by central banks in the negotiations over the introduction of RTGS, in which, in general, the central banks had to persuade the commercial banks to abandon previous risky deferred net settlement systems in favour of RTGS. However, the commercial banks should be equally happy with an arrangement involving

a non-zero band, in which the spread revenues are directly or indirectly distributed to them.

16 In Japan, the rates that the central bank charges for intra-day and inter-day credit are currently the same – they are both zero – but the fact that they are the same is no more than a coincidence.

17 What this statement means is that overdrafts either carry a severe interest rate penalty, or earn for the borrower the disapproval of the central bank, or both.

18 For evidence that overnight interest rates are more stable in countries where the central bank allows reserve averaging, see Tucker (2004).

19 The severity of this drawback is, however, mitigated in countries where commercial banks' current balances are not allowed to go below zero at the close of business on any individual day.

Monetary policy and the allocation of resources: Comment on Allen

Franco Bruni

Open Market Operations (OMOs) are macroeconomic instruments having several microeconomic aspects relevant for the allocation of resources within and outside the market for central banks' liquidity. Allen stresses the relevance of OMOs for resource allocation while analysing three of their main technical features: the way they involve the control of interest rates, the intra-day 'open market' credit required by real-time gross interbank payment systems and the relationship of OMOs with reserve averaging.

Interest rate targeting

Allen's main analytical point on the issue of interest-rate control is about the width of the targeted interest-rate band: the narrower the band the more monetary policy can rely on stable rates; but a narrower band constitutes a smaller incentive for banks to improve their cash-flow management fruitfully competing with other money market operators. The trade-off should be managed taking into account also the fact that the size of the band must be sufficient to allow OMOs a suitably diversified pricing of non-homogeneous eligible assets.

The problem of dealing with non-homogeneous eligible assets has two main dimensions. The first refers to differences in assets' maturities, the second to differences in default and liquidity risks. There are obvious connections between the two dimensions.

On different maturities Allen supports the orthodox view that OMOs should not, in principle, target rates beyond the very short term. Aiming at longer-term rates looks like an abuse of the central bank's market power to constrain possible diverging expectations by the markets on the future course of policy-determined short rates. I tend to agree but I submit that the optimal strategy of the central bank, to signal its medium-term policy analysis and stance, can sometimes require a certain dose of intervention on medium–long-term rates: what might appear as abuse of market power could turn out to be a valuable commitment technology. In the latter case, time-inconsistency must be costly in terms of reputation: which means that OMOs ambitions to influence the term structure of interest rates directly should be announced in a transparent way and remain an exception.

On the issue of differently risky assets Allen stresses the fact that an insufficiently diversified pricing provides borrowers with an incentive to pass lowest-quality assets to the central bank. This opaque risk-subsidization can in fact damage the allocation of financial and real resources. A special problem arises with government bonds in the euro area where the ECB has never been proactive in discriminating between instruments issued by countries with very large differences in external indebtedness. To defend this behaviour the central bank brings two main arguments: that it bears no responsibility for the fiscal discipline of euro-area countries and that, as OMOs take place at market prices, which should incorporate any risk premium arising from excessive indebtedness, the quantity of collateral needed to back a given amount of borrowed liquidity is indirectly influenced by the markets' assessment of differences in sovereign risks. Allen's main counterargument is that, if the market price of government securities is wrong, the ECB ends up unduly taking financial risk.

In my opinion, stating that the market price is 'wrong' can be considered a rather vague expression, until one contrasts the small spreads currently prevailing on government bonds issued by the most indebted countries of the euro area with the strong preoccupation that the ECB keeps expressing on the lack of respect for the Stability Pact: either the preoccupation is excessive or ECB's risk assessments are significantly higher than the markets'. Moreover I think that the ECB's argument based on market prices could hide a tricky logic loop: market-neutral OMOs greatly enhance the substitutability between government securities of differently indebted countries and discourage forward-looking speculation by market specialists. The result is a narrowing of the spreads that the ECB accepts as a basis to determine the quantity of collateral needed to obtain liquidity using differently risky eligible assets. In other words: the availability of a very elastic supply of market-neutral OMOs tends to distort market prices. Suppose, instead, that the markets feared a more judgmental pricing by such a large, powerful, informed operator as the ECB: the spreads would open up much more in accord with the central bank's judgment.

Payment systems, reserve requirements, OMOs and forced stabilization of short-term rates

Real-time gross settlement payment systems trade-off lower systemic risk with higher liquidity needs. Allen correctly considers the intra-day credit triggered by the payment system equivalent to OMOs. He thinks that when this credit is provided free (which does not happen everywhere), two allocation problems follow: the price of intra-day liquidity gets disconnected from the stance of monetary policy on the overnight rate; and there is no incentive to develop a private market for intra-day credit.

If we look at the case of the payment system of the euro area the picture is in fact one of implicit and free OMOs. In the ECB website one can read that: 'Liquidity is widely available in TARGET. Minimum reserve holdings are

available for settlement purposes during the day and the Eurosystem provides unlimited (collateralized) intraday credit free of interest to its counterparts'.

I agree with Allen that intra-day liquidity services should be extended at a price: the cost of average daily balances (to be included in the monetary base) should be connected with monetary policy's overnight rates. I am more sceptical than Allen on the possibility of developing a private market for very-short-term liquidity: under a certain maturity, liquidity services look like a low-value-added public good; and there is a danger of monopoly in privatizing its production. Profit incentives, to be sure, could help to obtain the appropriate rate of technological improvement in the provision of these services; but, to this end, a benchmarking process by the ECB can perhaps be sufficient.

Compulsory reserve requirements averaging is aimed at stabilizing short-term interest rates, except on the last day of the maintenance period. But Allen points at two allocation problems that could derive from reserve averaging: an unlevel playing field between commercial banks and other money-market participants that have end-of-business-day balancing constraints, and a questionable social value of the stability of overnight interest rates when it is not caused by a better matching of payment flows. In my opinion Allen's criticism of the regulatory contrivance of averaging does not recognise that reserve requirement payments obligations are artificial and superimposed on normal money management affairs, only of the banking system, for (more or less valid) monetary policy reasons. Averaging can also be considered a compensation of the banks for this extra burden. Averaging also acts as an incentive to a forward-looking and sophisticated cash-flow forecast and management by commercial banks: this incentive effect clearly resulted, for instance, from the introduction of averaging in the pre-euro Italian monetary policy framework.

The issue of forced stabilization of short term rates – caused by reserve averaging or by other aspects of the monetary policy framework – deserves special consideration. I think this artificially engineered stabilization is damaging if it tends to neutralise the role of expected changes in monetary policy: when this tentative neutralization takes place it is equivalent to subtracting the central bank's credibility from the judgment of the market. In the case of the euro area changes to the reserve maintenance period were introduced in March 2004 together with a change in the maturity of the main refinancing OMOs. These were positive changes. But during the whole reform process the ECB confirmed, in my opinion, the suspicion of being excessively hostile towards short-term interest-rate instability. In fact, before the reform, the problem consisted in markets betting (with refinancing operations) on possible monetary policy changes during the maintenance period. I submit that a credible central bank should not fear this type of betting: on the contrary, it should be interested in the information that can be derived from the betting. Moreover, the worst episodes of over/under-bidding, that triggered the reform of the monetary policy framework, had been caused by a true anti-market monster that had been used for a long time since the introduction of the euro: namely the fixed-rate tenders with discretionary allotment of a fixed amount of liquidity. The adoption of this monster, which was an effort to control

both prices and quantities during the learning period of a freshly created market, had also been motivated by the fears of excessive instability of short-term interest rates on the newly introduced currency.

Risk-free rates and spreads

Let me conclude my comments on Allen's stimulating paper with a much more general point on the relationship between monetary policy and the allocation of resources. Suppose OMOs (including standing facilities) are the only monetary policy instrument available (which happens in a flexible interest-rate context with no central bank financing of the government) to implement interest rate decisions, taken by the central bank using a Taylor-type interest-rate rule, in the framework of a strategy targeting price stability. Are OMOs a purely technical step or, in their complex implementation within a complex strategy, do they share some responsibility for the consequences of monetary policy on the allocation of resources?

Note that the paper by Allen begins by recalling that OMOs were invented during the gold standard, to improve the functioning of the excessively rigid monetary policy rule of the time. Their origin is not that of a neutral instrument zealously servicing a fixed rule! How should we look at them now? This is not the right place for developing a well-argued answer to this question. But I would like to comment briefly on a particular issue within the wider problem. OMOs can have a role in implementing a policy which: (i) pegs the risk-free rate at a level which turns out to be too low in a medium–long-term perspective (a too low intercept of the Taylor rule); and (ii) decreases the role of interest rates in rationing credit risks, thus favouring the flattening of risk spreads on securities and, indirectly, on loans as well. In other words: OMOs, by dealing with financial instruments of different types and maturities, can be a pro-active agent of a monetary policy that favours excessive liquidity and a mis-pricing of risks.

I think the literature does not devote sufficient attention to the relationship between (i) and (ii), i.e. between two variables on which OMOs' rules and organization exert a substantial influence: the level of the policy-determined risk-free rate and the size of the spreads on risky assets. Consider the simplest possible theoretical scheme from which such a relationship can result. Let i be the risk-free rate and r the equilibrium rate on risky assets with probability of default p and loss-given-default (in percentage of capital plus interest) L. Suppose there is pure competition between risk-neutral intermediaries that, as a consequence of asymmetric information and opacity, are able to borrow at rates that are driven much more by the risk-free rate than by the risks incurred in their lending; for simplicity consider the extreme case where i is their borrowing cost. The following relationship will result:

$$(1 + i) = (1 - p)(1 + r) + p(1 - L)(1 + r) \text{ or}$$

$$r - i = (1 + i)[pL/(1 - pL)].$$

The spread is thus positively related to the level of the risk-free rate and the derivative of the spread with respect to p and L is also increasing with i . A low-interest-rate policy favours a flattening of spreads (is this the 'low carrying cost' effect which is sometimes cited without further analytical elaboration?) and a decrease in their sensitivity to credit risk. To the extent that OMOs deal with both risk-free and risky securities, they are responsible for both the level of i and for the spread: OMOs supporting excessively low rates and spreads can thus generate the wrong incentives for the quality of investments and, in general, for the allocation of resources and the sustainable non-inflationary rate of long-term growth.

Are too flat maturity and risk spreads not a problem of world-wide monetary policies of recent years, a problem that is also at the roots of dangerous assets-price bubbles? Is this problem not due also to the prevailing theoretical and policy paradigms, which show an excessive separation between models, issues and discussions of monetary policy and models, issues and discussions related to the optimization of resource allocation over both time and space? After all, the only link between monetary policy and resource allocation currently recognized by orthodox thinking is the principle, often stressed by the ECB, that the best contribution of monetary policy to long-term growth is the supply-side effect of credibly pursued price stability.

The links between monetary policy and the allocation of resources should be explored further and deeper by academic research and by the analysis of experienced policy-makers, perhaps with the help of some re-reading of old, classical economists. The reason I like Allen's paper is that it puts valuable emphasis on these general links, even if it is dutifully confined to dealing with some rather specific technicalities of OMOs.

4 Open market operations – their role and specification today

*Ulrich Bindseil and Flemming Würtz**

Although used by central banks in the nineteenth century, open market operations were only explicitly praised as a supposedly superior tool of central bank policy in the early 1920s. This 'discovery' of open market operations occurred in tandem with the rise of reserve position doctrine and the dismissal of the traditional steering of short-term interest rates mainly through setting of the discount rate. The idea of a purely quantitative transmission mechanism and the associated supremacy of open market operations survived, until recently, in particular amongst US academics. Only the unambiguous return to interest rate steering by the Fed in the 1990s and the appearance of new academic impulses as exemplified by Taylor (1993) and Woodford (2003), who put no emphasis on monetary quantities as operational targets of monetary policy, seem to have also put into question the belief in the supremacy of open market operations and in the evil of standing facilities. Nevertheless, undergraduate text books still continue to devote ample space to the money multiplier, which makes so little sense under the new consensus.

This chapter revisits the role and specification of open market operations after the fall of the reserve position doctrine and the return to explicit short-term interest rate steering by central banks. The next section provides a short summary of the rise and fall of the reserve position doctrine, and in particular of the associated evolution of the perceived role of open market operations. It is followed by a section defining and distinguishing 'open market operations' and 'standing facilities' more precisely and providing a short classification of monetary policy implementation approaches into 'open market operations based' and 'standing facilities based' ones. It highlights a kind of continuum between the two types of operation and between the two types of approach. Given the unambiguous return to short-term interest rate steering, a simple model is used to argue that standing facility based approaches may appear more efficient than the relatively complicated open market based approaches, which are applied by most central banks today.

The next section finds that other factors not captured in the stylized model, such as the functioning of the interbank market and/or the central banks' balance sheet management should also, in principle, not prevent future moves by central banks

towards more standing facility based approaches. Still, in the absence of more recent practical experience with these approaches, more detailed analysis than that presented in this chapter will probably be needed for central banks to move more radically away from the open market operations based approaches, which have after all turned out to be sufficiently effective in steering short-term interest rates.

Since central banks are thus likely to maintain an important role for open market operations, at least over the coming few years, there is a section that tries to provide a few elements of a normative theory of the specification of open market operations, including such features as maturity, frequency, auction technique and the decision between outright and reverse operations. The last section concludes.

Some history of thought in the twentieth century

An interpretation of the evolution of twentieth century doctrine on monetary policy implementation is put forward in Bindseil (2004a,b). For key episodes, see also, for instance, Goodfriend (2003) – on the early years of the Fed – and Goodhart (2004) – on the 1980s in the Bank of England. This section contains only a brief summary of the debate.

Today, there appears to be no dispute about what a central bank decision on monetary policy means: setting the level of short-term market interest rates that the central bank will aim at in its day-to-day operations during the period until the next meeting of the central bank's decision-making body. At these meetings, the level of short-term interest rates is decided on the basis of some economic model, or looser conjecture, which links short-term interest rates to relevant macroeconomic variables and the final objective(s) of the central bank. There was also little doubt on the meaning before 1920. Central bank policy meant first of all control of short-term interest rates, mainly via the setting of the discount rate, as exemplified by Thornton (1802), Bagehot (1873) and Wicksell (1898/1936) – but consider also the lengthy debates that led to this conclusion as summarized in King (1936). In between, namely between around 1920 and the end of the 1980s, the 'reserve position doctrine' (RPD; coined by Meigs 1962) dominated at least in the US, according to which a central bank should, via open market operation, steer some reserve concept, which would impact primarily via the money multiplier on monetary aggregates and ultimate goals.

As has been well-documented (e.g. Friedman and Schwartz 1963; Meltzer 2003), in its first years the Federal Reserve System suffered from a series of shortcomings, namely excessive Government influence, excess influence of commercial banks, excess decentralization and lack of experience. In addition, it was immediately confronted to a major challenge, namely the Government's wish to finance the First World War at low interest rates. The combination of issues meant the Fed failed to raise interest rates so as to maintain price stability. The economic impact of this too loose monetary policy was substantial: the wholesale price index increased from 1914 to 1920 by 150%, and then it declined in the following phase

of restrictive policy (beginning in November 1919) again within two years by around 35%, the latter development being associated with a decline in real GDP of more than 20% (see e.g. Meltzer 2003).

What makes the episode extraordinary in the case of the Fed and distinguishes it from other national monetary histories of the First World War and the early 1920s was the ex post rationalization given to it, namely that the reasons for the inflation in the first six years of the Fed had not been the failure of the monetary authorities to hike short-term interest rates, *but excessive borrowing by the banks through the discount window, i.e. it was not rates that were the problem but quantities*. This switch of paradigm seems to have taken place quite clearly around 1920, with discussion after this date highlighting consistently the quantity dimension. Two main events seem to explain 1920 for the switch; namely (i) the resented need for a smokescreen after the start of the tightening of monetary policy in November 1919 and its substantial negative impact on economic activity, and (ii) an academic event, namely the invention of the money multiplier by the American C.A. Philipps (1920).

According to Goodfriend (2003) 'it is no exaggeration to say that the Fed was traumatized by its first use of interest rate policy… After its unhappy experience managing transparent discount rate policy geared to the gold standard in the early 1920s, the Fed set out to rethink its operating procedures…' and borrowed reserves targeting was invented. Again, according to Goodfriend (2003):

> *Borrowed reserves targeting allowed the Fed to manage short-term interest rates much as before, but less visibly. It appeared to loosen the link between market rates and the discount rate and enabled the Fed to talk about interest rate policy in terms of borrowed reserves rather than short-term interest rates.*
>
> Goodfriend (2003)

After this denial of previously undisputed monetary policy logic, the Fed for some reason did not really manage to return to normality regarding its operational target for 70 years. In the early 1920s, we find Fed officials rationalizing more and more why interest rates are secondary and quantities are more relevant as the operational target. Open market operations became the key official monetary policy instrument. Open market operations, by injecting free bank reserves, were supposed to trigger credit and monetary expansion via the money multiplier. Right from the beginning, an inherent element of RPD was the view that recourse to discount borrowing was potentially evil, as the inflation up till 1919 had been attributed to excessive recourse to the discount window. To rationalize the failure to hike rates during the First World War, it was necessary to argue that raising the level of the discount rate would not have been sufficient to limit monetary expansion, and that therefore, non-price disincentives – mainly moral suasion – were necessary to discourage use of the discount facility. This new approach went so far that discount rates were from then onwards kept below market rates, sufficiently to make clear that moral suasion and burdensome administrative procedures indeed became *necessary* to prevent banks from making use of the facility. Both

Keynes (1930/1971) and the monetarist school supported the innovative approach of the Fed.

While the Fed only returned to an unambiguous steering of short-term interest rates in the 1990s, the Bank of England, for example, never adopted RPD. Why? Although the UK had gone through as bad an inflation as the US during the war, and both went through deflation in the 1920s to restore the pre-war gold standard, the two central banks in 1920 could not have been more different. The Bank of England had a well-elaborated money market technique in 1920, derived from a century of experience. It had a fair degree of independence from the Government, and was not decentralized as the Fed (Sayers 1976). It also completely lacked the transparency to which the Fed was committed from its very start, implying that it did not need to rationalize anything through theory, i.e. it did not also need to rationalize failure through fallacious theory, as the Fed was tempted to do in the early 1920s. Governor Montagu Norman (1919–1944) was probably personally instrumental in keeping RPD from the Bank. Being an experienced conservative banker and financial markets expert, he had little sympathy for the new ideas, which had apparently been designed to sell central banking to academics, the Government and the public.

While the Fed had returned once already to a fairly unambiguous adoption of interest-rate steering in the 1970s, another peak in the ascending RPD occurred in 1979–82. In October 1979, Paul Volcker became chairman of the Board of Governors and felt that inflation needed to be stopped. The Fed concluded that the time was also ripe for taking a serious monetarist approach in day-to-day monetary policy implementation, by substituting interest-rate targeting by an RPD target, which this time was defined as *non-borrowed reserves*, i.e. reserves held by banks minus borrowed reserves, the recourse to the discount window. However, the Fed still managed to steer short-term interest rates to some extent, albeit within a wide range, the level of which was also dependent on, and implicitly communicated via, the implied target for borrowed reserves. It seems difficult today to reconstruct what was exactly done. According to Strongin (1995: 475):

> *Non-borrowed reserves targeting was the most complicated of the reserves operating procedures that the Federal Reserve has ever used and it lasted the shortest length of time…. Considerable debate within the Federal Reserve system about how these procedures actually worked is still going on.*
>
> Strongin (1995: 475)

In 1980, the Monetary Control Act with its changes to the reserve requirement system and subsequent deregulatory measures triggered further changes in the evolution of M1 and M2, and possibly contributed to a weakening of the relationship between these monetary aggregates and economic activity/prices in 1982–3. This was taken as a good excuse for changing the operating procedures again in 1983.

These days views on the Volcker episode are split. Some, for instance Goodhart (2001) and Mishkin (2004a), argue that the whole approach was just about avoiding

the Fed having to take responsibility for the necessary strong hiking of interest rates to bring inflation down, and for the associated economic effects such as a strong rise in unemployment (in a repeat of the 1920 episode). In the words of Goodhart (2001), the episode, 'if properly analyzed, reveals that the Fed continued to use interest rates as its fundamental modus operandi, even if it dressed up its activities under the mask of monetary base control… there was a degree of play-acting, even deception…'. The 'smokescreen' (Mishkin 2004a) created by Volcker would thus have been simply a necessary condition for bringing inflation to an end under conditions of imperfect central bank independence. On one hand this 'political economy' explanation is plausible to some extent, and in line with the interpretation given for the sudden rise of the RPD in the Fed's discourse at the beginning of the 1920s and with the fact that the Fed never did let short term-rates fluctuate freely. On the other hand, one should probably also admit that Volcker and his FOMC colleagues were at least partially convinced by the RPD.

As the early 1920s saw the birth of RPD, the early 1980s could be regarded as its swansong – and also as the beginning of its decline. In 1980, the BIS had edited a volume dedicated entirely to the 'monetary base approach' to monetary policy implementation. Almost all central bank practitioners writing in that volume expressed reservations (BIS 1980). The US Monetary Control Act, prescribing RPD-based features such as contemporaneous reserve accounting,[1] ironically came into force in 1983, just after non-borrowed reserve targeting had been given up due to its impracticality. Since 1983, RPD has been in steady decline, i.e. both the rhetoric of central banks and monetary policy implementation technique have, piece by piece, eliminated elements motivated by the RPD. Academic work also started to turn away from the RPD, although the related process does not seem to be over.

Today, monetary economics textbooks still contain many references to RPD concepts. For example substantial space is devoted to the money multiplier [2] or to the Poole (1970) model, which claims that the optimal choice between interest rates and monetary quantities as the operational target is an empirical question. Note that today's dismissal of monetary quantities as operational target does not imply that they are unimportant for central banks. Quite the contrary, monetary aggregates continue to be fundamental elements of central banks' monetary policy strategy in the macroeconomic models they use for setting the appropriate level of the operational target: short-term interest rates.

Open market operations based versus standing facilities based implementation of monetary policy

This subsection first defines the two types of monetary policy operation and monetary policy implementation approach.

Standing facilities are available at any time to be used at the discretion of individual commercial banks: that is, the central bank defines and announces

the conditions (maturity, interest rate and collateral requirements) in advance but its monetary policy counterparts decide on the actual use. They can be liquidity-providing (as the traditional rediscounting or the ECB's marginal lending facility) or liquidity-absorbing (as the ECB's deposit facility).

In contrast to standing facilities, open market operations are conducted only at the initiative of the central bank. Open market operations were originally understood as outright purchases or sales of securities, normally government paper, in the 'open market', that is, the inter-bank market. In contrast, today they mainly consist in repurchase operations or collateralized credit operations with limited maturity (for example, two weeks) conducted in the form of specific auctions, that is, not really in the 'open market'.

While it seems at a first perspective straightforward to distinguish the two types of operation, there is in fact a continuum between the most extreme cases, and what is today called open market operations may in fact be regarded as being close to standing facilities. Consider the following spectrum, moving from the purest form of open market operations to the purest form of standing facilities.

- **Outright operations.** Outright operations inject or withdraw funds to/from the market without necessarily giving prominence to any (short-term) interest rate. Specifically, this is the case for outright operations in stocks, metal or foreign exchange, where indeed there is no money interest rate at all associated with the deal.

  - *Discretionary, non-published outright operation*. The purest form of an open market operation is an outright operation conducted ad hoc by the central bank without appearing in the market as the central bank (i.e. acting through an agent or broker) and also without publishing the operation through any other means.
  - *Regular outright operations.* Regularity is in principle a feature of standing facilities and any element of regularity blurs the nature of open market operations as being conducted under absolute central bank discretion.

- **Non-regular reverse operation.** Reverse operations unavoidably put emphasis on the interest rate, which is a first element of standing facilities.

  - *Without pre-announced volume* (and still a variable-rate tender). If the volume is not pre-announced, it will be unclear to the market whether the central bank, when deciding on the allotment amount, cares about the resulting interest-rate. Specifically, it is difficult in this case for market participants to place their bids in the tender, since they do not know which liquidity conditions and interest-rate conditions the central is in fact aiming at.
  - *With pre-announced volume* (and variable-rate tender). If the volume of an operation is pre-set, it is unambiguously clarified that this parameter is set by the central bank, but that the interest rate is an endogenous outcome of the bidding process.

- **Regular reverse operations.** As mentioned, regularity is a feature of standing facilities.

  - *Variable-rate tenders*. Variable-rate tenders are less similar to standing facilities than fixed-rate tenders as they do not prejudge the interest rate.
  - *Fixed-rate tenders, discretionary allotment ratio*. In both fixed-rate tenders and standing facilities the interest rate is pre-set. If the allotment amount is at the discretion of the central bank (i.e. the central bank can fix any allotment ratio), this represents – relative to a pre-set 100% allotment – an open market operations feature.
  - *Fixed-rate tender, 100% allotment*. Here, no discretion remains on the side of the central bank. The only difference relative to a standing facility is that the operation is not necessarily offered daily.
  - *Daily fixed-rate tender, 100% allotment*. This is a standing facility. A remaining issue is when access is possible.
  - *Fixed-rate tender, 100% allotment, accessible at any time until the closure of the payment system*. This corresponds to today's understanding of standing facilities.

Central banks can implement monetary policy exclusively through standing facilities, through a mixture of standing facilities and open market operations, and, at least according to some monetarists like Milton Friedman (1982), also purely through open market operations. In the following, we review a few alternative approaches, moving from the purest standing facility approach to the purest open market operations approach. Before discussing these approaches one by one, a small model is presented to provide a systematic classification.

A stylized model on the overnight interest rate

The model uses the following notation (see for instance Bindseil (2004b) for a more detailed explanation of this model, which goes back to Poole (1968): M is the outstanding volume of open market operations, netted as a central bank balance sheet *asset. A* is the autonomous liquidity factors, netted as a central bank balance sheet *liability. B, D* are the recourse to borrowing and deposit facility, respectively, while R denotes the reserves of banks with the central bank. The central bank's balance sheet identity ('Assets = Liabilities') can be expressed accordingly as $M+B = A+D+R$. All balance-sheet quantities with an upper bar denote averages over the reserve maintenance period. Assuming that the required reserves are zero, it follows from the balance sheet identity that the aggregate liquidity imbalance, the difference between the average supply of liquidity and the average autonomous factors, $\overline{M} - \overline{A}$, necessarily lead to recourse to standing facilities. The liquidity imbalance is assumed to have a probability density denoted by $f_{(\overline{M}-\overline{A})}$.

Finally, let i_t be the overnight interbank interest rate on day t of the reserve maintenance period, with $t = 1 \ldots T$ and let i_B and i_D be the rates of the borrowing facility and the deposit facility, respectively.

Under some simplifying assumptions about the money market microstructure,[3] the interbank overnight rate, i.e. the target variable of the central bank, is given by the following equation:

$$\forall t = 1 \ldots T : i_t = i_B P\left(\overline{M} - \overline{A} < 0\right) + i_D P\left(\overline{M} - \overline{A} > 0\right)$$

$$= i_B \int_{-\infty}^{0} f_{(\overline{M} - \overline{A})}(x)\mathrm{d}x + i_D \left(1 - \int_{0}^{\infty} f_{(\overline{M} - \overline{A})}(x)\mathrm{d}x\right). \tag{1}$$

In words: the overnight rate on any day will correspond to the weighted expected rate of the two standing facilities, the weights being the respective probabilities that the market will be 'short' or 'long' of reserves at the end of the maintenance period before having recourse to standing facilities. Otherwise banks could do so-called intertemporal arbitrage, making an expected profit by substituting reserve holdings on day t with reserve holdings on day T. The equation reveals that there are some degrees of freedom for the central bank in steering its target variable, the short-term interest rate. Indeed, it has three policy variables (two standing facility rates and the volume of open market operations), but only one target variable. The following alternative implementation approaches may be viewed as reflecting the central bank choices on how to make use of these two degrees of freedom.

(I) Pure SF approach: the Reichsbank in 1900

It is easiest to understand this approach by looking at the German Reichsbank's balance sheet of 1900 (Table 4.1).

Besides metal, the asset side of the Reichsbank mainly contained credit granted to banks through borrowing facilities, whereby discounting of bills dominates lombard lending (advances). Outright holdings of securities and open market operations play a negligible role. Monetary policy implementation by the Reichsbank hence consisted mainly in setting the discount rate. Since the banks were always structurally short in liquidity, they took massive recourse to the discount facility and hence the discount rate was guiding the short-term interbank rate very closely. In the simple model presented above, the Reichsbank approach is obtained by

Table 4.1 Simplified Reichsbank financial statement, averages for weekly statements in 1900, in million of Goldmark

Gold and silver	817	Notes in circulation	1,139
		Deposits (of banks and others)	513
Discounted trade bills	800		
Lombard lending to banks	80	Capital, reserves, other	45
Sum	1,697	Sum	1,697

Source: Bindseil (2004b, Table 2.1)

setting $M = 0$ and having A always positive. Equation (1) becomes:

$$i_t = i_B P(\overline{M} - \overline{A} < 0) + i_D P(\overline{M} - \overline{A} > 0) = i_B \cdot 1 + i_D \cdot 0 = i_B. \qquad (2)$$

The Reichsbank approach to monetary policy implementation has a series of advantages: (i) complexity of implementation technique is at a very minimum and there is no need at all to conduct any open market operations; (ii) control of short-term interest rates is most effective; (iii) there is no need to forecast autonomous liquidity factors (such as banknote circulation), since changes in autonomous factors are simply translated into changes in the recourse to the discount facility; (iv) when the targeted short-term interest rate changes, the central bank needs only to adjust the discount rate – nothing more.

(II) Limited SF approach

This approach is similar to the Reichsbank approach in so far as the control of short-term interest rates is ensured by the structural recourse to one standing facility. The difference is, however, that through open market operations, the volume of the recourse is reduced somewhat. In terms of our simple model and equation (1): Now, $M > 0$ (for $A > 0$), but still $P(M - A > 0) = 0$ such that one again obtains equation (2).

Relative to the Reichsbank approach, this could have the advantage of (i) increasing interbank money market activity (see below); and (ii) giving the central bank more leeway in terms of the modified duration of its financial position. The central bank may for instance prefer to hold some of its assets (liabilities) in longer-term debt instruments, due to risk/return considerations. It may also be in the interest of banks that the central bank chooses a higher duration, since the banks may have an aversion to large amounts of short-term debt (possibly in relation to liquidity regulations).

A drawback relative to the Reichsbank approach is that it is more complex for the central bank to operate: there is a need for the central bank to conduct open market operations, and accordingly to decide how to specify these operations (see below). In this regard, the central bank has to establish a forecast of the structural evolution of autonomous factors, and to decide how it wants to take account of this forecast in its actual allotment decisions. That is, to decide how to distribute the supply of liquidity via open market operations in the course of the reserve maintenance period. This decision, which is relevant for any approach different from that of the Reichsbank, is not straightforward to make in practice. The simple setting of our stylized model does not give any guidance in this regard (showing also, however, that this decision is not so crucial). If one uses more sophisticated models of the overnight rate, taking account of institutional specificities and various kinds of market imperfection, for example, there is a risk that the central bank may slightly miss the overnight interest-rate target, if the supply of liquidity in the course of the reserve maintenance period is inadequate.[4] Moreover, it is less clear how far this approach works well with reserve averaging in place.[5]

The implementation techniques currently used by the Bank of Japan, the Central Bank of Norway, and the People's Bank of China may also be viewed as falling under this category. In Japan, the zero bound is implemented by systematically having some excess reserves with banks (which are in a certain sense deposited in an implicit 0% deposit facility). The People's Bank of China simply remunerates excess reserves of banks (which are always positive) at a certain rate. Again, this may be viewed as an implicit deposit facility at the target rate.

(III) The symmetric corridor approach

This approach is regarded as probably today's state of the art. It is used by a large and growing number of central banks (the Eurosystem, the Bank of England, Canada, New Zealand, Australia, and many others). It is based on the idea that the expected liquidity needs of banks (as determined by autonomous factors and reserve requirements) are exactly covered by open market operations, so as to keep the probability of recourse to any of the standing facilities identical, and thus market rates would stay in the middle of the corridor set by standing facilities. In terms of equation (1):

$$i_t = i_B P(\overline{M} - \overline{A} < 0) + i_D P(\overline{M} - \overline{A} > 0) = i_B \frac{1}{2} + i_D \frac{1}{2}. \tag{3}$$

If autonomous factors are symmetrically distributed, then it is enough to always set $M = E(A)$.

Some central bankers seem to consider it a key advantage of approach III, as compared to II and I, that it allows for a more 'vivid' and liquid interbank money market, leaving more room for the market 'to function'. It is argued that fixing the overnight rate at one of the standing facilities (approach I and II) paralyses the interbank market, turning it into an administrated market place. However, as is discussed further later, it is not crystal clear that this approach leads to a better functioning of the money market than does II. In fact it has several drawbacks, resulting mainly from its complexity. First, steering of interest rates in a stochastic context will always be more difficult than in the deterministic setting of approaches (I) and (II). Related to that, the specification of open market operations becomes trickier. Second, it requires very precise liquidity forecasts by the central bank. Third, this approach may lead to higher interest-rate volatility towards the end of the reserve maintenance period: when news on autonomous factor development emerges after the last open market operation of the reserve maintenance period has been conducted, short-term rates will diverge from the target rate. Yet, it should be remarked that it is relatively easy to overcome this problem of end of period volatility. For instance, the ECB has recently conducted an open market operation on the last day of the maintenance period. Additionally, the Bank of England has lately announced that it will introduce a so-called 'reserve band'[6] as well as a narrowing of the standing facility corridor on the last day of the maintenance period.

(IV) Asymmetric fixed difference approach: e.g. Fed 2004

In this approach, the corridor set by standing facilities is not symmetric, and often there is no deposit facility at all (or, in other words, only an implicit one offering a remuneration rate of zero). For instance the Fed since 2003 has offered a borrowing facility at a rate one percentage point above the target rate, while it offers no deposit facility with a positive remuneration. Under this Fed approach, M has to be set such that the probability of the banking system to be short, $P(\overline{M} - \overline{A} < 0)$, is, in our model, equal to $(i_B - 1)/i_B$, and the probability of being long $1/i_B$, so that indeed the overnight rate settles at $i_B - 1$:

$$i_t = i_B P(\overline{M} - \overline{A} < 0) + i_D P(\overline{M} - \overline{A} > 0) = i_B \frac{(i_B - 1)}{i_B} + 0\frac{1}{i_B} = i_B - 1.$$

$$(4)$$

For example if the target rate is 3% and the borrowing facility rate is 4%, then, to have market rates at 3%, the market needs to perceive the probability of being short as being ¾.

The advantage of this approach relative to (III) could be that there is no need of a deposit facility, i.e. from this perspective the system appears to be somewhat simpler. However, there are additional severe drawbacks and complexities which should outweigh this: (i) the asymmetry itself may be regarded as a complexity; (ii) since there is no floor for the overnight rate other than its zero lower bound, volatility of interest rates will *ceteris paribus* be higher than under the symmetric approach; (iii) the calibration of open market operations has to take into account higher order moments of the probability distribution of autonomous factors. In the example above where the target rate is 3%, for instance, if the variance of autonomous factors increases, then $P(M - A > 0)$ increases, and M has to be reduced to bring it back to $1/i_B$. Still, in spite of this complexity in calibrating M, it should be mentioned that the Fed has a relatively positive experience using this approach. The market expects that the Fed will, on average, manage to steer the overnight rate to the explicitly announced target, which is accordingly used as a kind of benchmark for overnight trading.

(V) Asymmetric variable difference approach (Fed 1974)

In contrast to all previous approaches, this approach allows changing the short-term interest-rate target without changing the standing facility rate. Again, assume that there is only a borrowing facility.

In this approach's purest form, the rate of the borrowing facility is set rather high such that it is unlikely that the stance of monetary policy will ever require a higher target rate. Then the market rate is steered in the wide corridor only through open market operations, i.e. through the control of the probabilities of the market being long or short at the end of the reserve maintenance period. It seems that there are no examples of central banks that have practised this approach
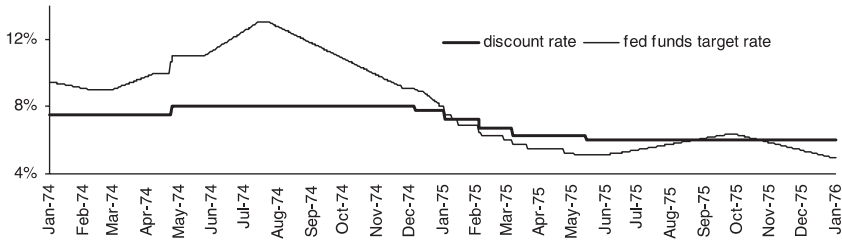
Figure 4.1 Open market operations approach (partial) – discount facility and targeted market rate in the US during 1974–75. *Source*: web site of the Federal Reserve Board.[7]

in its pure form so far, but elements of the approach have often been present. It was for instance applied to some extent by the Fed during the 1970s for example, when changes in the federal funds target were much more frequent than changes of the discount rate. This is illustrated by Figure 4.1 for the years 1974 and 1975.

This approach shares the drawbacks of asymmetry with (IV). In addition, the approach does not seem to be parsimonious in the sense that it remains unclear, under this approach, which of the instruments will be used in the event of a change of the target rate. Often, central banks used this to send more complex signals through their different instruments. One might wonder whether verbal transmission of such signals would be more easily understood.

Today, when target rates are published, and central banks aim at a high degree of transparency of their policy intentions through verbal communication, the idea of communicating more complex messages on policy intentions through the use of monetary policy instruments is unanimously rejected.

(VI) A standing facility free implementation (an impossible approach)

This approach is more a vision of some monetarists than a realistic monetary policy implementation mode. Monetarists who wanted to see a strict quantitative approach also in monetary policy implementation generally considered standing facilities, meaning interest-rate control, but no control of reserves, as a sin. In contrast, open market operations for them reflected the right idea of quantitative control. For instance Friedman (1960: 50–1) argues that open market operations alone are a sufficient tool for monetary policy implementation, and that standing facilities (e.g. the US discount facility) and reserve requirements could thus be abolished:

> *The elimination of discounting and of variable reserve requirements would leave open market operations as the instrument of monetary policy proper.*

> *This is by all odds the most efficient instrument and has few of the defects of the others… The amount of purchases and sales can be at the option of the Federal Reserve System and hence the amount of high-powered money to be created thereby determined precisely. Of course, the ultimate effect of the purchases or sales on the final stock of money involves several additional links… But the difficulty of predicting these links would be much less… The suggested reforms would therefore render the connection between Federal Reserve action and the changes in the money supply more direct and more predictable and eliminate extraneous influences on Reserve policy.*
>
> <div align="right">Friedman (1960: 50–1)</div>

Friedman (1982), along the same lines, argues that interest rates as operational targets are neither possible nor desirable. In terms of operational target, he seems to suggest an 'open market operations volume target':

> *Set a target path for several years ahead for a single aggregate – for example M2 or the base. …Estimate the change over an extended period, say three or six months, in the Fed's holdings of securities that would be necessary to approximate the target path over that period. Divide that estimate by 13 or 26. Let the Fed purchase precisely that amount every week in addition to the amount needed to replace maturing securities. Eliminate all repurchase agreements and similar short-term transactions.*
>
> <div align="right">Friedman (1982)</div>

For today's central bankers, implementing such an approach would mean creating an interest-rate volatility far beyond anything that has been seen in the US since the setting up of the Federal Reserve in 1914, and thus a state of general financial destabilization which would certainly also make the control of money, prices and economic activity impossible.

Do we really still need open market operations?

In the previous section, six monetary policy implementation approaches were presented, spanning the entire range from a pure standing facilities approach to a pure open market operations approach. It was argued that today's perceived state of the art seemed to be the symmetric corridor approach (III). While disadvantages of the more open market operations oriented approaches (IV) and (V) were mentioned and it was explained that (VI) is undesirable, only relatively weak arguments were brought forward against the standing facility approaches (I) and (II). In this section, it will be argued further that, indeed, little can be found to speak against (I) and, in particular, (II), and also that industrialized countries' central banks could seriously reconsider whether moving to (I) or (II) would not be the logically final step in overcoming the quantity-focused detour in monetary policy implementation.

Impact of implementation approach on overnight money market activity

As already mentioned, it can be argued that the choice between the first three approaches, the *pure* SF Approach (I), the limited SF approach (II) and the symmetric corridor approach (III), relates mainly to the desired functioning, notably the liquidity, of the interbank money market. The following discusses in somewhat greater detail how each of these approaches affects the liquidity of the interbank overnight deposit market (in short: the overnight market) as measured by the volumes transacted.

There is abundant anecdotal evidence that trading in the overnight market is driven by idiosyncratic liquidity imbalances of individual banks. That is, only if a bank is either 'short' or 'long' of liquidity, in the sense that it has a surplus or a deficit of liquidity compared to its desired end-of-day position, will it access the overnight market. While in principle one could also imagine that interest-rate volatility could facilitate trading in the overnight market, because it encourages hedging and position-taking, banks report that this is not the case, owing to the disproportional balance-sheet expansion and capital consumption compared to the very modest profits resulting from such trading. In today's euro area or US money markets, there is hardly any volatility of rates except for the very end of the maintenance period. Nevertheless, trading volumes on other days remain at the observed levels (and do not tend to be significantly lower than at end of maintenance periods, when interest-rate volatility is higher). This shows that the larger volatility that, *ceteris paribus*, results from this symmetric corridor approach, as compared to the SF approaches, does not in itself add liquidity to the market. Furthermore, one could in any case argue that speculative position taking in the overnight money market has no social value, i.e. it would be hard to defend the central bank deliberately engineering conditions under which speculative activity is rewarding for some (the sophisticated players) at the expense of others (naïve traders, noise traders). Moreover, one may also expect that a decrease of the role of private information in a market also triggers an *increase* of trading volumes, since non-informed traders no longer have the transaction costs associated with the existence of informed traders, (as in Glosten and Milgrom 1985). This argument suggests that market liquidity should increase when volatility and uncertainty about the overnight rate decrease, and hence that the liquidity of the overnight market could even increase, when moving from a symmetric corridor to an SF approach.

The following discusses the link between transaction volumes in the overnight market and the target recourse to the borrowing facility under the assumption that overnight trading indeed only derives from idiosyncratic liquidity imbalances of individual banks. Assume that the market would always remain at least marginally short in central bank deposits at the end of the maintenance period, such that end of period recourse to the borrowing facility would always occur. A target volume of zero for the borrowing facility corresponds to the symmetric corridor approach (III), while positive volumes correspond to the pure or the limited SF approach, (I) and (II).

The larger the targeted recourse to the borrowing facility, i.e. the closer the central bank is to the pure SF approach, the smaller are the volumes transacted in the overnight market. If the overall daily need for refinancing is so large that all banks are in a deficit at the end of the day, no matter which (conceivable) idiosyncratic liquidity shock they receive, it is clear that there will not be any transactions in the overnight market. In this case all liquidity shocks will simply lead to an adjustment of the amount by which individual banks take recourse to the borrowing facility. If banks receive an incoming payment they take less recourse to this facility, while an outgoing payment results in a larger recourse. This is not the case in the limited SF approach where the central bank only targets a small (but sufficient) recourse to the borrowing facility at the end of the maintenance period. In this case, there will, in practice, be as many 'short' and 'long' banks as is the case for the symmetric corridor approach. For instance, the ECB's experience from the so-called 'underbidding' episodes shows that small but well-anticipated deficits can indeed move rates close to that of the borrowing facility while there is no effect on interbank activity.

Yet, the above does not explain why volumes should necessarily be smaller under the pure SF approach than they are under the symmetric corridor approach. Had the central bank provided the same amount of missing liquidity via an open market operation and targeted a zero net recourse to standing facilities, banks would have been in the same situation. Instead of adjusting their recourse to the standing lending facility when facing liquidity shocks they would adjust their participation to the open market operation, bidding less when they receive an incoming liquidity shock and bidding more when there is an outgoing liquidity shock. In fact, there is not much difference between the pure SF approach and the symmetric corridor approach if, in the latter, the central bank is supplying huge amounts of liquidity through frequent, say daily, open market operations. Hence, the more frequent the open market operations are and the larger the volumes are in each of these operations, the greater is the similarity between the symmetric corridor approach and the pure SF approach in terms of market functioning. The only, relatively minor, difference is that under the symmetric corridor approach banks will still have to go to the overnight market in order to offset liquidity shocks resulting from surprising allotment amounts in the open market operations and/or late payments.

Another aspect that is important for the transaction volumes in the overnight market is the number of banks that in fact have access to the relevant central bank operations. The banks which do not have such access still have to transact in the interbank market, ultimately transferring their liquidity imbalances to the counterparties of the central bank. Thus, if only a limited number of banks are eligible for the central bank operations, there will always be significant trading volumes in the overnight market, at least between the counterparties of the central bank and those who have no access to the open market operations. Finally, the extent of reserve averaging is of course also key in the determination of the interbank transaction volumes. The larger the reserve averaging, the easier it is for banks to buffer out their idiosyncratic liquidity shocks via their end-of-day liquidity position with the central bank instead of via the interbank market.

In summary, transaction volumes in the overnight market decline, being to an increasing extent substituted by the operations of the central bank, when (i) the volumes in these operations increase; (ii) the frequency of these operations increase; (iii) the number of banks that can actually participate in these operations increases; (iv) when the potential for averaging reserves over a reserve maintenance period increases. Hence, only if the symmetric corridor approach is implemented through open market operations with a less than daily frequency (the ECB case) and/or the volumes in these operations are limited (the FED case) is this approach expected to lead to significantly larger transaction volumes in the overnight market than the pure SF approach. There is no reason to expect that the symmetric corridor approach should be associated with volumes that are importantly larger than those resulting from the limited SF approach.

Is overnight money market activity desirable per se?

But why do central banks really need to care about volumes in the overnight market? Could not the liquidity-distributing role of the overnight market simply be performed by the central bank through its operations? As long as the central bank manages to fix the marginal value of central bank liquidity precisely, why is then a market needed? Three aspects could be relevant in this regard.

First, there may be an issue from the perspectives of financial stability and equal treatment. In practice, there will always be some banks needing access to an interbank market. Indeed, even in the pure SF approach, it is unreasonable to assume that all banks will be short. Inevitably there will always be at least a few long banks, for instance because they have a different customer base and business model. Likewise, some banks will not have access to the operations of the central bank (normally foreign and/or small banks) and they will therefore still have to transact via the interbank market. If the overnight market is very thin, a risk exists that these few banks which are actually dependent on this market will face significant search costs and related liquidity risks because the counterparties of the central bank, which do not need the money market, may even have abolished their trading desks responsible for short-term domestic money markets. However, it is questionable whether such extreme conditions would materialize even under the pure SF approach. Owing to the transparency and stability of this approach, one should expect that a transparent and competitive market should emerge for providing liquidity to the banks which do not have direct access to the central bank facilities.

Second, it may be argued that the need of banks to transact in the interbank market, instead of just having the central bank as counterpart, imposes more 'discipline' on their liquidity management, which again could boost financial stability. However, one can in fact reverse this argument, claiming that the regular availability and use of a standing facility actually increases financial stability, because it safeguards the liquidity of the banking system, as long as sufficient collateral is available. The full collateralization implies that banks in financial distress are not subsidized. Moreover, when one takes into account that most central banks are now offering their counterparties the possibility of going into unlimited

overdraft in the course of the day (again only against collateral) one wonders why it should be so important to discipline – or constrain – banks' management of their end-of-day liquidity position.

Third, nowadays the financial markets of the developed economies rely heavily on a credible and reliable overnight reference rate, such as EONIA in the euro area, the effective federal funds rate in the US, SONIA in the UK etc. The importance of these reference rates has increased remarkably over the recent years, as they are being used for the pricing and revaluation of all kinds of financial assets and instruments, notably interest rate swaps. However, it is not clear whether this argument can alone justify the maintenance of huge volumes in the overnight interbank market. If the central bank manages to steer the marginal costs of liquidity very precisely, for instance via the pure SF approach, one could in principle imagine that the policy rate of the central bank would take over the role as a reference rate. Nevertheless, from a practical point of view it is not obvious how to manage the transition from market-based reference rates to policy-based reference rates, since the market would only adopt the latter, once it has been convinced through sufficient experience that the marginal costs of liquidity are perfectly mirrored in the policy rate.

Leaving aside this more practical problem, one could argue that the volume of market transactions cannot be a welfare indicator per se anyway. Low transactions volumes may be a sign of high transaction cost, and thus of low welfare. But they may also be a sign that the pre-trade allocation is appropriate, i.e. that trading needs or perceived trading opportunities are limited. Moreover, it is costly to carry out physical transactions (e.g. settlement costs, search costs etc.) and a priori it seems counterintuitive for the central bank to force unnecessary trading. The burden of the proof that a higher transaction volume in the market is beneficial should be on the side of those bringing forward the argument. Of course, there might be circumstances under which a higher transaction volume that occurs independently of a lowering of transaction costs brings more welfare through some positive externalities, as exemplified above. There may also be cases where an increased volume of transaction with the public sector (here: the central bank) is welfare-reducing per se. However, these cases need to be demonstrated before concluding that they are applicable. In the case discussed here, arguments have always remained vague.

Overall we conclude that the shrinking of the transaction volumes in the interbank market that may follow from a move to approach (II) would, first, be insignificant, and, second, would not imply/reveal a loss of welfare. One may thus want to conclude that there are no strong arguments against moving to this approach, which scores better than (III) in terms of both simplicity and transparency.

Pure versus limited recourse to standing facilities (approach I vs. approach II)

Should central banks, however, move to the pure standing facility approach (I)? This approach seems to have two draw-backs relative to (II); money market

activities are reduced to a larger extent and the duration of the central bank assets is more restricted to the short-term. Following the above reasoning, the relevance of the first argument is, however, less clear and can mainly be justified on the grounds of central banks' lack of recent experience and associated uncertainty with the practical implications for the money market.

Consider more closely the second argument, which says that providing all liquidity through recourse to the borrowing facility means providing everything at one maturity, say overnight, and that this is a restriction which is likely to be undesirable. On the one hand, this argument does not seem to be fully correct, as one can of course also offer standing facilities at different maturities in parallel. The original maturity of the discount facility was indeed flexible: normally all eligible paper (e.g. trade bills) with a maximum residual maturity of three months could be discounted. Nothing would prevent central banks from offering standing facilities at different maturities. For instance, the Eurosystem could substitute its main refinancing operations with a one-week-maturity borrowing facility. It could offer this either only weekly (this would be equivalent to a fixed rate tender with pre-announced 100% allotment), or even daily.

However, a problem arises when the maturity of the standing facility could stretch into a period of potential policy rate changes. This issue is well known from fixed rate tenders, where it created under or overbidding; see e.g. Bindseil (2005) and the literature quoted there. In the case of standing facilities the situations is even more detrimental, since in fact the central bank could be endlessly arbitraged. For reverse open market operations, this problem can be solved by conducting them as variable-rate tenders with pre-announced allotment volume. This is what the ECB has been doing smoothly since 1999 with its 'longer-term operations' which have three months maturity. By pre-announcing the allotment volume, the ECB makes clear that the marginal interest rate is driven purely by the bidding behaviour. There is no way to substitute such three-month operations by standing facilities at a fixed interest rate, as participation would be extremely unstable and would depend mainly on rate-change expectations. Also, the central bank would be viewed as targeting the three-month rate. One may conclude that the maturity of standing facilities is limited to a period in which no rate-change expectations occur. In the case of the ECB the entire main refinancing operations, which make up 75% of the allotment volume, could be substituted in this way by a weekly standing facility or, more precisely, by a weekly fixed rate tender with pre-announced 100% allotment. This is discussed in the next section. In any case approach (I) constrains the maturity structure of central bank assets, which is at least potentially undesirable. The challenging issue of the most appropriate maturity structure of (domestic) central bank assets will be addressed very briefly in the following section.

Specification of open market operations

Assume now that the implementation approach is among the three (II), (III) and (IV). What can we then say about the most appropriate specification of open market operations? This section will try to overview the main considerations

that are relevant for designing in the most appropriate method for open market operations.

Outright versus reverse operations

The Fed and the Eurosystem handle this issue in largely opposite ways: while the Fed has an outright portfolio of US treasury bonds of more than USD 500 billion, and provides liquidity through reverse operations only to a limited extent, the ECB rolls over the entire liquidity needs of the euro-area banking system of more than EUR 300 billion in its reverse operations. Which of these two approaches is preferable? Or would each be preferable due to different environmental parameters in the two areas?

Normally, the following advantages are attributed to reverse operations: first, they avoid any undesirable effects on securities markets. Second, they spare the central bank the need to think about which (fixed income) securities to purchase, and probably how to ensure market neutrality of purchases. Third, where outright holdings are mainly in the form of Government securities, e.g. to avoid credit risk, they could be viewed as Government financing and as creating an undesirable additional link between the Government and the Central Bank. Finally, reverse operations conducted through a tender with a wide range of counterparties allows the liquidity to be channelled directly to the counterparties in need of it. In outright operations, the liquidity needs to be redistributed fully by the system.

The main disadvantage of reverse operations relative to outright operations seems to be that they somehow limit the duration of central bank assets, and thus also imply a high turnover of central bank operations, and hence maybe transaction costs.[8] On the other hand, following the previous section, reverse operations will also lead to smaller interbank volumes, relative to outright operations, and hence could in fact also reduce transaction costs. In theory, it is of course possible to conduct very long-term reverse operations (e.g. in the style of the Eurosystem's longer-term refinancing operations, but even with longer maturity). However, it is not usual to make repurchase operations with a duration exceeding a year. The reason is that a repurchase operation is a bilateral relationship and is thus not tradable, i.e. the claims or liabilities resulting from it cannot be realized before maturity. Both counterparties and the central bank have no interest in being locked in for very long periods in a bilateral transaction, as the desired liquidity position changes over time. This is why longer-term financing operations are normally conducted through some tradable instrument. Therefore, a central bank coming to the conclusion that it wants to have a duration of five years for its assets will not aim to implement this through very long-term reverse operations.

This leads to the question of what the desired duration of central bank assets is. One might argue that if the economy as a whole tends to have longer-term refinancing needs, then the central bank should also aim at providing longer-term financing, to avoid the need for a costly duration transformation. On the other hand one could argue that banks want to be flexible in their financing behaviour, and thus like to have short-term liabilities with the central bank, at least if they

know that they can always refinance again at the central bank when the current refinancing matures.

From the point of the central bank, one could also view the duration decision as being a mere investment problem: how much interest-rate risk does the central bank want to take into its balance sheet, and what expected return does it want? Not being threatened by liquidity problems, and having a long-term horizon as an investor, it would seem that the central bank should not be overly risk-averse in the short run, and should probably not hold less interest-rate risk in its balance sheet than the average investor. This would suggest that it should not have a much shorter asset duration than the one of the fixed income market portfolio, which is around five years in the US and euro area. Of course there may be other considerations that lead to a high risk aversion of central banks and the possible desire to have a short asset duration.

It is not obvious how to reach a clear-cut conclusion on this point. If a central bank is sure that it wants to have a modified duration of its assets clearly above one year, be it for investment or economic considerations, it will be forced to hold a part of its assets in outright form. If the central bank has no view on the modified duration of its assets and counterparties are also content with a high turnover of central bank refinancing, then all liquidity can be provided through reverse operations, and its advantages such as market neutrality can prevail. It should be noted that the ECB has substantial room for increasing the duration of its monetary policy assets without building up outright portfolios, namely by, for example, shifting a larger part of liquidity provision to the longer-term refinancing operations.

Finally, one may find at least one argument why the Fed relies so much on outright operations but the ECB does not: for the latter, the choice of what assets to hold outright would be more complicated, reflecting that it currently consists of 12 jurisdictions (i.e. how to subdivide the portfolio across countries?). Also, the issue of potential Government financing through outright portfolios may be taken more seriously in the case of the euro area, taking into account the construction of monetary union and the inflationary histories of some of the member countries (e.g. German hyperinflation in the 1920s).

Maturity and frequency of reverse operations

Leaving aside considerations of the duration of central bank assets from a central bank investment or macroeconomic point of view as well as of transactions volumes in the interbank market, the most appropriate maturity and frequency of reverse open market operations seem to depend on a series of factors:

- *Parsimony*: for the sake of simplicity, the number of reverse operations outstanding at any moment in time should not be larger than needed;
- *Avoid the need for operations of both a liquidity-providing and a liquidity-absorbing nature on a regular basis for substantial amounts*. Again this simplifies the liquidity management of both the central bank and its counterparties.

In many cases the central bank is applying different tender procedures for absorbing and injecting liquidity, and in addition counterparties seem to behave differently in liquidity-providing and liquidity-absorbing tenders. The longer the maturity of operations, the higher is the likelihood of needing to do opposite operations for significant amounts.

- *Interest-rate control*. The frequency should be sufficient to ensure a sufficiently precise achievement of the operational target. In the case of approach (II), this should also be achieved without an excessive expected final recourse to the borrowing facility.

- *Limited turnover*: providing the entire liquidity through, say, overnight operations would seem undesirable as it would maximize turnover volumes and thus maybe increase transaction costs unnecessarily. Note, however, that there is a trade-off between transaction costs resulting from central bank borrowing and transaction costs associated with overnight trading. As argued in the previous section, turnover and hence transaction costs in the interbank market decline when the turnover in central bank operations increases.

- *Inherent mechanism stabilizing the size of operations*. The interaction between allotment policies in open market operations, reserve maintenance periods and autonomous factor shocks may lead to a destabilization of the size of operations. This was for instance the case for the Eurosystem until March 2004: two overlapping 2-week-maturity operations tended to diverge more and more in size over time and needed to be corrected through additional *ad hoc* operations. This problem was repaired by eliminating the overlap between the operations.

It is difficult to construct a single 'optimal' combination of maturity structure and frequency of open market operations from these principles, since much depends also on the length of the reserve maintenance period and the extent of autonomous factor shocks.

Fixed- versus variable-rate tenders

Fixed-rate tender

In fixed-rate tenders, the central bank pre-announces the interest rate (or price) applicable for the transaction, and the counterparts submit the amounts they wish to obtain at that rate/price. Two sub-variants have been used:

(i) *Discretionary allotment variant*: If the total bid amount is above the amount the central bank wishes to provide, it allots 'pro rata', i.e. each bid is satisfied at a certain percentage. This method has been applied extensively by most central banks.

(ii) *100% allotment variant*: the central bank pre-commits to allot the full amount of bids. The disadvantage of 100% allotment relative to pro rata allotment is that the central bank gives away its power to adjust the total allotment to make it correspond to its forecast of needs. This is relevant since the sum of

the bids of many banks is unlikely to be close to the aggregate needs, even if the banks have as accurate forecasts of autonomous factors as the central bank. This 'co-ordination' problem can lead to strong swings in the aggregate liquidity conditions, which in turn affect the overnight rate if they are too large to be absorbed through the averaging provision of reserve requirements. However, the 100% allotment variant has also several advantages. First, ex ante, it fixes short-term interest rates very firmly at the policy rate (the fixed tender rate) due to its similarity to a standing facility: counterparties know that later in the maintenance period they can raise – or deposit – any amount of liquidity at the fixed tender rate. Second, it makes bidding very easy, since banks can perfectly anticipate their actual allotment amount. Third, it is a bullet-proof way to avoid the problems of over- and underbidding that are always associated with the discretionary allotment variant of a fixed-rate tender. Hence, it could make sense to apply this allotment variant early in the maintenance period, when co-ordination failures can relatively easily be absorbed through reserve averaging and only apply a discretionary allotment at the end of the maintenance period. However, under approach (II), in which the fixed tender rate would be set at the borrowing rate, it may not even be necessary to apply discretion in the last operation, as banks should have no incentive to bid for an amount of liquidity which would reverse the aggregate position into a surplus. Hence, there seems to be no 'danger' that the tight liquidity target for the end of the maintenance period would be missed.

Variable-rate tender

In variable-rate tenders, bidders submit rate/quantity pairs such that, after aggregating all bids, the central bank faces a standard downward-sloping demand curve. The central bank's allotment decision then consists in choosing one point on this curve. All bids above the selected rate, called the marginal rate, are fully allotted. Bids below the marginal rate are disregarded. Bids exactly at the marginal rate are allotted pro rata, the central bank choosing the allotment ratio. The following sub-variants may be distinguished:

(i) Pure variable-rate tender with discretionary allotment amount. This is the usual tender procedure in the US.

(ii) Variable-rate tender *with pre-announced allotment amount*. Under this variant, the allotment decision by the central bank is automatic, since the intersection of the demand curve with the vertical pre-announced supply curve determines the marginal rate. Its advantage is that it avoids the market assigning any signalling content to the allotment decision and the resulting marginal rate. The ECB applies such a procedure strictly in its monthly 'longer-term refinancing operations' and in a somewhat muted way to its main refinancing operations, as well as by pre-announcing its so-called benchmark allotment amount from which the actual allotment rarely deviates.

(iii) Variable-rate tender with one-sided restriction to bid rates, e.g. a minimum bid rate. In this variant, the central bank announces beforehand that it will disregard

bids below a certain minimum level. This has been applied by the ECB in its main refinancing operation since 2000.

Finally, all variable-rate tenders can generally be specified either as an *American* auction ('multiple price auction'; i.e. each successful bidder pays the price he bid for) or as a *Dutch* auction ('uniform price auction'; i.e. each successful bidder pays the marginal rate). Today, American auctions are generally preferred, since they are said to provide more incentives for bidding realistically.

Pros and cons of the two tender procedures

To the extent that fluctuations in aggregate liquidity resulting from 'co-ordination failures' in the 100% allotment variant of the fixed-rate tender procedure can indeed be absorbed through the averaging provision of reserve requirements, this tendering procedure seems to dominate all others, because of its simplicity and effectiveness in anchoring short-term interest rates. However, this conclusion is less clear when discretion is needed by the central bank to ensure sufficient stability of the aggregate liquidity conditions. The main advantages of applying fixed-rate tenders and variable-rate tenders when the central bank actually wants to influence the quantity allotted are:

Advantages of fixed-rate tenders (with discretionary allotment):

(1) Their ability to send a strong signal on the central bank's monetary policy stance. Indeed, they constitute an implicit pre-commitment of the central bank to steer the corresponding short-term market rates to levels around the tender rate (otherwise, over- or underbidding would occur). Of course, the central bank could alternatively announce explicitly a target market interest rate, as does the Fed.

(2) Central bankers often argue that with a variable-rate tender, the public would attach signalling content to the marginal rates, i.e. would try to extract monetary policy signals out of them, and that this sometimes unavoidably leads to misunderstanding. However, the policy content of marginal rates in variable-rate tenders should depend on the central bank's allotment policy. A technique for avoiding giving policy content to marginal rates in variable-rate tenders is to pre-announce the allotment volume, as discussed above. Therefore, this is probably not a legitimate argument against variable-rate tenders.

(3) Logical consistency with interest-rate steering. Today, central banks again explicitly steer short-term interest rates. It therefore appears natural to offer reserves at the target rate. In contrast, it may appear counterintuitive to let the rates of central bank operations fluctuate, although they are in a clear arbitrage relationship to the market rates at which the central bank aims.

(4) Fixed-rate tenders have the advantage of not putting less-sophisticated bidders (e.g. smaller banks) at a disadvantage. Indeed, bidding in fixed-rate tenders appears simpler than in variable-rate tenders, since, in the latter case, the bank also has to make up its mind on the rates at which to bid.

Advantages of variable-rate tenders:

(1) Banks can express their relative preferences for central bank funds through the bid price; more generally, they contain all the efficiency advantages of genuine auctions as an allocation mechanism.
(2) The phenomena of over- and underbidding, which always potentially endanger the efficiency of fixed rate tenders, are avoided.

As mentioned, the relative merits of the two may depend on other aspects of the framework, such as the announcement of a target rate, or the role of standing facilities.

Conclusions

The times when open market operations were undisputedly considered to be the superior instrument of monetary policy implementation are over; see Friedman (1982) for a description of the old view. Justifying the need for open market operations under an explicit short-term interest rate as operational target appears to be less obvious than one may expect, since all liquidity needs can also be satisfied through a borrowing facility, as was the practice of central banks before 1914. Yet, our analysis came to the conclusion that open market operations still have some distinct advantages. In particular, they allow for a lengthening of the duration of central bank assets, and they may contribute to an active interbank money market.

In contrast, the relatively simple analytical framework we applied, which can be further developed, did not point out arguments justifying the use of open market operations to steer liquidity conditions at the margin (and thus control short-term rates), Actually, it suggests that the steering of short-term interest rates through a systematic end-of-maintenance period recourse to one standing facility (here an overnight borrowing facility) could appear to be the most natural and simple way to control short-term interest rates.

The size of the recourse to the borrowing facility should, at least as a starting point, remain small, but be such that, despite uncertainties regarding autonomous factors, the recourse takes place with virtual certainty, although the bulk of the liquidity deficit should be supplied through open market operations. We label this approach the 'limited' standing facility approach as opposed to the 'pure' standing facility approach, in which all liquidity is supplied through the borrowing facility. The 'limited' approach would imply the smallest change compared to the present functioning of the interbank money market and it would give the central bank more leeway to steer the duration of its assets. Still, the most appropriate duration of the central banks' assets, and its relevance for the determination of the central banks' operating procedures, has not yet been clarified. Moreover, it is unclear whether in fact the changes to the functioning of the money market that would follow from the 'pure' standing facility approach, including a decline of transaction volumes, could not lead overall to greater social welfare. Hence, further analysis and especially more practical experience with the 'limited' standing facility approach could even

point towards a return to the pure standing facility approach that was applied 100 years ago. In this context, it may also be interesting to study the approach of a zero-width interest rate corridor, i.e. with the rates of the two standing facilities at exactly the same level. We have not studied the consequences of this most extreme standing facility approach.

We prefer open market operations in which the allotment decision is automatic, as this prevents central bankers from inventing complex, non-transparent and maybe fallacious allotment strategies, and bidders from trying to read messages in the allotment decisions. Two options for automatic allotment procedures exist, namely variable-rate tenders with pre-announced volumes, and fixed-rate tenders with pre-announced 100% allotments. The choice among the two approaches depends mainly on the benefits associated with the central bank having discretion to decide on the allotment amount. If these benefits are large, which is typically the case either in the last operation of the maintenance period or in all operations if reserve averaging is insufficient, the variable tender with pre-announced allotment volume is preferable. Otherwise the fixed-rate tender with pre-announced 100% allotments is the most preferable, due to its simplicity and superiority in anchoring the level of short-term interest rates in almost all circumstances.

Finally, outright operations should come into play if the central bank deems it appropriate to lengthen the duration of its assets beyond what can reasonably be achieved through repo operations (say beyond one year) or if it considers that such operations are more efficient, e.g. are saving transactions costs. If this is the case, the outright portfolio should probably be as market-neutral as possible, and the desired modified duration could be reached through an appropriate split up of the total liquidity deficit between the outright portfolio and the portfolio of short-term reverse operations.

Notes

1 As argued in Friedman (1982) for instance, contemporaneous reserve accounting, i.e. an overlap between the calculation of the reserve base and the reserve maintenance period, would be key to the RPD approach to monetary policy implementation.

2 Earlier explicit scepticism on the usefulness of the money multiplier approach had been expressed even in the US, see for instance Garfinkel and Thornton (1991).

3 Specifically the following assumptions are made:

- There are no 'no-overdraft' constraints for the banks' accounts with the central bank, except from on the last day of the maintenance period.
- Banks are risk-neutral. Together with the above assumption, this implies that reserves on different days within the same maintenance period are perfect substitutes, which is known as a situation with 'perfect reserve averaging'.
- All banks have the same information set, perceiving the same density function $f_{(\overline{M}-\overline{A})}$ for the end-of-period liquidity imbalance.

- In the last moment of the reserve maintenance period, all banks know their individual liquidity positions for sure and a trivial trading session takes place: if there is an aggregate shortage of liquidity, i.e. if $\overline{M} - \overline{A} < 0$, then all liquidity imbalances (short and long) are squared at the rate of the borrowing facility. Conversely, if there is an aggregate surplus, then all imbalances are squared at the rate of the deposit facility.

4 Using a model which is more complicated than the one presented above, Gaspar *et al.* (2004) show how the overnight rate may deviate from the target rate if the central bank supplies reserves inadequately in the course of a maintenance period. See Würtz (2003) for a comprehensive model of the euro overnight rate capturing various other effects not incorporated in the simple model used here.

5 When rates are steered to one standing facility, say the lending facility, some banks may make use of this facility before the last day of the maintenance period. This in turn may change the liquidity position for the remaining days of the maintenance period, and the central bank will have to absorb liquidity through open market operations in order to re-establish the liquidity deficit. As an alternative, the central bank could steer the overnight rate so that it is sufficiently below the lending rate in order to reduce incentives to actually use the lending facility before the last day of the period. This, however, may become relatively complicated. A simpler alternative could be to abolish the averaging provision of reserve requirements, which would avoid the recourse to standing facilities on one day affecting the liquidity conditions on subsequent days. See Kran (2001) for an illustration of this discussion in the case of Norway.

6 A reserve band consists in somewhat relaxing the binding constraint of reserve requirements when these are remunerated at the policy rate. Banks only have to fulfil their reserve requirements within a band say of plus/minus 1%. Reserve holdings that exceed 100% of the requirements are fully remunerated as long as they do not exceed 101%, while a deficit of 1% does not imply any kind of penalty. This allows for an automatic absorption of unexpected developments in the autonomous factors without any notable fluctuations in the overnight rate, as long as the size of the former remains within the width of the reserve band. A different variant of the reserve band consists in the so-called carry over facility, which is offered by the Fed. According to this scheme, part of the excess reserves in one maintenance period can be used as reserve holdings in the subsequent maintenance period.

7 Even though the discount rate was for most of the time far below the market rates, the real cost of accessing the borrowing facility was much higher, well above the Fed funds target rate, because of the so-called 'stigma' (moral suasion) that was, as mentioned early, associated with the use of this facility.

8 In the previous section, we saw that standing facilities limit the duration of central bank assets relative to reverse open market operations. Moving gradually from outright operations to reverse operations and standing facilities in terms of structural liquidity provision also constrains the duration of central bank assets gradually.

Comment on Bindseil and Würtz

William T. Gavin[1]

Bindseil and Würtz provide a useful classification and description of the alternative procedures that central banks use to implement monetary policy decisions. The authors take as given the decision about the monetary policy stance made at regular policy meetings and discuss how that decision is implemented between meetings. They go on to describe of continuum of strategies for open market operations, ranging from an extreme interest-rate peg to a rule based on Friedman (1982) that increases the monetary base at a rather constant and smooth rate.

The discussion is framed in two broader macroeconomic issues. The first is a discussion of the reserve position doctrine (RPD) that was more fully developed in Bindseil (2004a). The second is the proposition that operating targets for reserve quantities are a bad idea and that monetary policy should be implemented using interest-rate guides. This comment offers an alternative interpretation of the RPD in US monetary history and describes institutional reforms that were aimed at making the reserve supply function nearly horizontal at high frequencies but nearly vertical in the long run. It was devised to make the open market operations procedures like the one recommended by Friedman (1982) operational. The final section provides further support for interest-rate smoothing at high frequencies.

Monetarism and the reserve position doctrine

The authors in this chapter and Bindseil (2004a) unfairly lump the free reserve and borrowed reserve operating procedures together with operating rules based on unborrowed reserves or the monetary base. Meigs (1962) coined the term the 'reserve position doctrine' (RPD) to describe the Federal Reserves practice of using borrowed reserves and free reserves to implement policy decisions. The Fed argued that they could not control total reserves, but that some components that they could not control in the short run (such as borrowed reserves and free reserves) displayed regular behaviour vis-à-vis market interest-rates. Therefore, they argued that they could operate using these procedures without maintaining tight control over interest rates. Meigs used this logic to argue that the central bank could control unborrowed reserves, thereby retaining control over the path of total reserves in the long run.

The key to the monetarist advocacy of a reserve quantity was not a desire to cause interest-rate volatility in the short run, but to provide a nominal anchor in the long run. Karl Brunner (1973) extended Poole (1970) to include more detailed analysis of credit markets and more types of shock. He agreed that the volatility of money demand shocks was relatively high at monthly and higher frequencies, and, by Poole (1970), one should probably operate with an interest-rate target. The problem was that other unobservable shocks emanating from credit markets called for the central bank to maintain control over the money supply. He advocated control over quantities in the short run as a way of instituting a nominal anchor for the monetary system.

The ideal policy would allow the central bank to have a target for total reserves, but would make the reserve supply curve nearly horizontal at high frequencies. There were several proposals aimed at achieving this result. Two alternatives from the early 1980s were based on staggered reserve accounting and extended carryover provisions.

Staggered Reserve Accounting. Under this regime, as originally proposed by Cox and Leach (1964), the banks are separated into four groups, each with monthly reserve maintenance periods, but with different settlement days. Under their plan, a quarter of the banks would settle on each of the first four Wednesdays of the month. The banks that were settling could borrow or lend reserves with each other or with the non-settling banks. The idea was to make the reserve supply curve highly elastic in the near term when money demand volatility was known to be dominant, but to keep the reserve supply function more inelastic over longer horizons. This proposal would simplify open market operations and allow the Fed to maintain total reserves on a path consistent with a long-run price objective. In 1981 when interest rates were highly volatile, the staff at the Board of Governors used their money market model to do a dynamic analysis of staggered reserve accounting. They found that when using a total reserve operating target with staggered reserve accounting, interest-rate volatility was no greater than would be expected under a successful interest-rate targeting regime.[2]

Extended Carryover. Poole (1975) recommended a simple reform that would also eliminate excess volatility in the market for bank reserves while allowing the central bank to target total reserves. Under his scheme, the central bank would never need to lend adjustment credit through the discount window. All lending could be limited to whatever emergency loans are appropriate to a lender of last resort operation. Poole proposed that the carryover provision be modified so that any excess or deficiency in a required reserve balance that does not exceed 50 per cent of an institution's required reserves may be carried forward to the next maintenance period. In each maintenance period, required reserves would be increased by 110 per cent of any reserve deficiency, or decreased by a credit for 90 per cent of any reserve excess, in the previous maintenance period. The limit on the percentage of carryover and the penalties could be modified to accommodate the central bank's desire to contain the trading range for the interest rate on bank reserves.

Both of these institutional features for reserve requirements would permit a central bank to follow Friedman's advice and use a path for total reserves as the guide for open market operations.

There is also plenty of evidence that monetarists did not group operating targets for borrowed reserves and free reserves into the same category as rules based on unborrowed or total reserves. There is a very large literature criticizing borrowed-reserve and free-reserve procedures as being disguised methods for targeting the interest rate. Some examples from Fed economists and Fed critics include

- Wheelock (1990), who argues that the borrowed-reserve targeting procedure adopted after the First World War was actually an interest rate operating procedure;
- Brunner and Meltzer (1964), who argue that targeting free reserves was a form of interest rate targeting;
- Poole (1968), who uses a model of a bank minimizing costs over the reserve maintenance period to show that a free-reserve target was approximately equivalent to an interest rate-target;
- Gavin and Karamouzis (1982), who show that the Volcker Fed's borrowed-reserves target was effectively an operating target for the federal funds rate, and
- Thornton (1988a), who provides further evidence that, as implemented, the borrowed-reserves target often looked more like a target for the interest rate than a target for borrowed reserves.

But this is only a quibble about their interpretation of Federal Reserve and monetarist history. I think that their main point, that central banks should find a way to smooth interest rates in the short run, is correct.

The Fed's experiment with nonborrowed reserves

Until the adoption of the nonborrowed reserve procedure in October 1979, the Fed had never operated using a procedure in which daily open market operations were guided by a path for a monetary aggregate. As the author notes, this period was not a pure experiment. But there was a weekly path for nonborrowed reserves that guided daily open market operations. The open market desk adjusted these paths mechanically with the arrival of information about transaction deposits and the multiplier.[3]

Cogley and Sargent (2005) estimate that the standard deviation of the innovations to inflation and the 3-month Treasury bill rate rose sharply during this 3-year period. The volatility of both the interest rate and the inflation moved sharply up in October 1979 and fell back to lower level levels after October 1982. It is well recognized that interest rate volatility rose with change in operating procedures. It is less well understood that this procedure also produced an increase in the variability of inflation.

The Fed abandoned the nonborrowed reserves procedure in October 1982 and began using a borrowing target, which was intended to achieve a smooth path for the interest rate on federal funds around a desired trading rate. Throughout the rest of the 1980s, actual policy decisions were meant to achieve a desired trading level for the federal funds rate, but the FOMC did not have an explicit target.

Why an interest-rate operating target?

Interest-rate smoothing is a form of inflation smoothing. Intuition for this can be seen in the money demand analysis of Friedman (1969). The demand for real money balances is a function of a scale variable, such as income, and an opportunity cost variable, such as the nominal interest rate, such that $M_t^D/P_t = H(\overset{+}{Y_t}, \overset{-}{R_t})$. Panel (a) in Figure 4.2 is based on Figure 3 from Friedman (1969), an illustration of the response of money demand and the price level following a surprise decision to permanently raise the money growth trend (inflation) from zero to a positive number: 2 per cent in panel (a). The nominal rate rises by the size of the increase in the inflation rate and the demand for money drops immediately. Since the central bank has exogenously fixed the money growth rate, the price level must rise to accommodate the fall in real balances. In an economy where the long-run expected inflation trend is subject to shocks, the inflation rate is highly variable relative to the money growth rate.

Panel (b) illustrates what happens if the central bank uses the interest rate as the monetary policy instrument. In that case, the credible announcement of 2% inflation requires raising the nominal interest rate target by 2%. The increase also leads to an immediate drop in the demand for real money balances. With a nominal interest rate rule, however, the money supply is endogenous and inflation is fixed by the policy rule. It is the money stock, rather than the price level, that responds by shifting downward to clear the money market. Hence, in an economy with stochastic inflation and an interest-rate rule for monetary policy, the money growth rate is much more variable than the inflation rate. That result is consistent with our observations from modern economies where central bank, generally use the nominal interest rate to implement policy.

Poole (1970) concluded that the choice between an interest rate and a money supply operating target depended on model parameters and the relative variances of different types of economic shock in a static IS/LM macro model. Woodford (2003) synthesizes 35 years of advances in macroeconomic theory and applies it to understanding optimal monetary policy. Using this framework, Gavin *et al.* (2005) revisit the issue of whether the central bank should use the interest rate or a monetary aggregate as the instrument or operating target for monetary policy. Our analysis generally supports the Bindseil and Würtz assertion that central banks should use interest-rate targets.

But the lessons from this new framework go beyond this simple question about which instrument to use. In these models the money demand relationship is stationary, but it will not appear so to the econometrician. If the central bank is using an

Panel (a) Money Growth Rule*
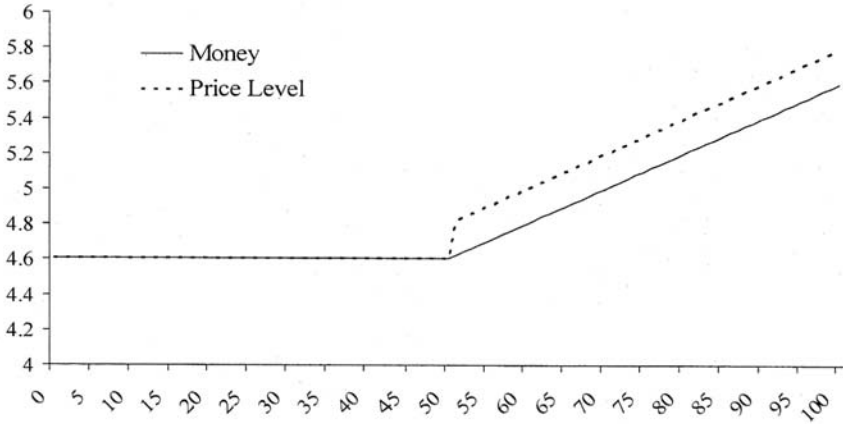
Panel (b) Interest Rate Rule*
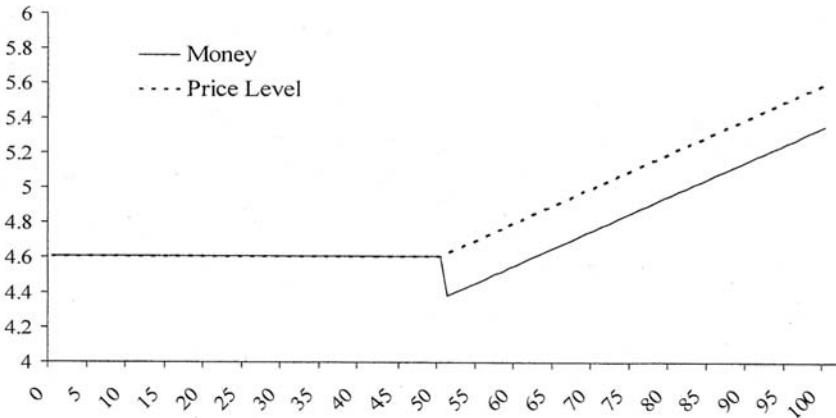
Figure 4.2 Monetary Policy Rules and a Change in the Inflation Trend.
        *There is a shift from 0 to 2 percent in the inflation objective in period 50.

interest-rate operating target, the money supply will 'jump' in response to shocks to interest rates or income. The result is that the money supply will appear to be relatively unconnected to other economic variables.

Another thing that we have learned from Woodford's framework is that using the interest rate to target inflation can be treacherous for a central bank that is not committed to price stability. In these models a passive reaction to inflation surprises can cause real indeterminacies which are associated with problems such as asset pricing bubbles and self-fulfilling prophesies of deflation. In general, the fragility of equilibrium solutions goes away as the central bank lengthens its

inflation-targeting horizon. Committing to a multiyear target for inflation actually increases the central bank's ability to conduct stabilization policy.

Do open market operations matter?

Bindseil and Würtz did not address issues involving payment system risk and mechanisms for imposing market discipline on bank managers. A standing facility should not be freely available to banks that have taken on excessive risk. Forcing banks to use the interbank lending market may lower supervision and regulatory enforcement costs.

The details of the operating procedures and reserve requirement regulations will be different in every country and the choice about where to operate on the continuum between a pure standing facility and a modified quantity target will depend on such details. The problem will be easier for a central bank that is committed to price stability. In general, the combination of operating procedures and reserve regulations should result in a reserve supply function that is highly elastic between policy meetings.

Notes

1 The opinions expressed in this comment are those of the author and not necessarily official positions of the Federal Reserve Bank of St. Louis or the Federal Reserve System.
2 See Tinsley *et al*. (1981). This paper is an internal Fed memorandum.
3 Stevens (1981) describes the details of this operating procedure. Avery and Quast (1993) use daily data to measure the dynamic response of interest rates and transaction deposits to shocks to nonborrowed reserves (deviations from target path).

5 Monetary policy in a changing financial environment

A case for the signalling function of central banks' operating framework

*Laurent Clerc and Maud Thuaudet**

Recent decades have been marked by far-reaching changes in financial markets. The combined effects of financial deregulation and innovation against the backdrop of globalisation and the development of new information and communication technologies have already raised some concerns about the effectiveness of monetary policy and the relevance of the operating frameworks of central banks. However, since their inception, central banks have been confronted with a changing environment. Central banks have continuously adapted their monetary policy operating procedures in the face of structural changes, which may have accelerated over the last two or three decades, in particular owing to technological advances,. The main trends, identified by Borio (1997) – namely the strengthening of the market-orientation of monetary policy implementation; the widening of eligible assets and available instruments; the focus on interest rates as operating targets and the transparency of policy signals – have continued if not increased.

Most central banks implement their monetary policy decisions using a two-step procedure (Taylor 2001; Woodford 2003): first, based on a wide set of macroeconomic, financial and monetary indicators, a key policy rate or an interest rate target is set by a monetary policy committee (e.g. the Federal Open Market Committee in the US, the Governing Council at the ECB, the Monetary Policy Committee at the Bank of England) consistent with its objectives, primarily price stability. This decision is generally taken on a monthly basis or even at a lower frequency (eight meetings per year for example), irrespective of the size of the open market operations involved. Then, possibly on a daily basis, the central bank operations trading desk carries out the appropriate operations to maintain the money market rate close to the target rate or to steer it closer. The conventional view is that central banks affect short-term interest rates through open market operations in the market for bank reserves. The effect of these operations is initially reflected in the overnight rate and subsequently in other short-term interest rates. The ability of the central bank to steer the overnight rate stems from its position as a monopoly supplier of bank reserves. However, the declining role of reserves, the improvement of payment and settlement systems, and the more liquid securities markets raise questions about the effectiveness of open market operations as an instrument of monetary policy and hence about the ability of central banks to influence the economy. The point we set out to make in this chapter is that the operating frameworks of

central banks are flexible enough to adapt to these ongoing structural changes and for monetary policy to remain effective. However, the relative weight given to a particular monetary policy instrument, as well as its main purpose, may change over time or in particular circumstances. In particular, the trend towards market-oriented monetary policies, in the context of the information economy, stresses the importance of communication and transparency both in the monetary policy decision-making process and in its daily implementation and therefore constitutes a case for the signalling function of the operating framework of central banks. In effect, for most central banks, the management of expectations has become of paramount importance.

In the first section, we briefly review the main structural changes observed over the last three decades and their possible impact on the transmission mechanism of monetary policy. We then go on to present the operating frameworks of the main central banks and the modifications implemented in the light of these structural changes. In the remaining section, we assess the extent to which current operating frameworks and available instruments are still relevant and effective, focusing on the signalling of monetary policy.

Structural changes

Increased deregulation and significant improvements in information technologies have profoundly transformed the financial landscape in the most advanced economies. Although the majority of these developments have clearly improved the efficiency of the financial sector in allocating risk and capital and thereby have contributed to higher economic growth, a large body of the literature has focused more on the challenges they might raise for central banks, in particular concerning their ability to influence market rates and, by extension, the economy. In this section, we briefly review the main trends affecting the financial environment, focusing first on some changes that directly affect the banks' demand for reserves and thereby possibly alter the transmission mechanism of monetary policy, second on the changes that affect the implementation of monetary policy for technical reasons, such as the developments related to eligible assets or securities markets, before moving to those stemming from some institutional changes concerning central banks. Appendix 1 at the end of the chapter summarises our main findings and provides some indications on the possible impact of these changes on the transmission mechanism of monetary policy put forward in the literature.

Changes that directly affect the demand for reserves

The disintermediation process

The combination of financial deregulation and financial innovation has resulted in the decline of the traditional role of banks in the financing of the economy.[1] This trend has numerous implications for both the transmission mechanism and

the implementation of monetary policy. In this context, the main issue stems from the assumption that monetary policy acts chiefly by rationing credit flows to the economy. In this case, the dismantling of various forms of direct control over the volume of bank lending in most industrialised countries during the course of the 1980s and the removal of deposit interest-rate ceilings, with a view to a free adjustment of banks' retail interest rates (Sellon 2002), meant that it was more difficult for central banks to influence the economy directly and consequently to achieve their primary objective of price stability. Another consequence of this trend is the decline in the demand for reserves through which central banks theoretically influence money market rates. The declining role of banks in the financing of the economy implies in reality that the liabilities underlying the loans are not banks' deposits anymore, which are usually subject to reserve requirements. Moreover, financial and technological innovations have exacerbated this decline in the demand for reserve balances by raising the ability of financial institutions to sweep funds from reservable to non-reservable accounts (Sellon and Weiner 1996, 1997; Taylor 2001). This is particularly the case for saving and sweep accounts, money market funds and certificates of deposit, which are subjected to lower, if any, reserve requirements. As Romer and Romer (1990) pointed out, in countries where reserve requirements are binding banks can mitigate any impact of tight monetary policy on their lending by issuing CDs.

However, it is not clear whether these changes have really impaired the ability of central banks to steer interest rates and to influence the economy. First, the idea that the effectiveness of monetary policy depends on the importance or on the special role of banks in the financing of the economy is to some extent challenged by the fact that, in the past, there were already situations in which this role was limited. For example, most private credit creation in the US in the 1950s was through the non-bank sector. Similarly, building societies, which lie outside the banking sector, played a major role in the financing of the housing sector in the UK in the 1960s. In both cases, the scope for monetary policy to influence aggregate demand or unregulated interest rates on private loans remained unaffected. Second, these changes do not seem, at a first glance, to impact on the ability of open market operations to affect interest rates on loans and on liabilities of banks or non-banks. This is evidenced for instance by recent research which tends to show that despite many ongoing structural changes, the transmission of monetary policy impulses to retail bank rates has not only been amplified but has also become faster over recent years; see for instance Coffinet (2005) or De Bondt *et al*. (2005) for recent evidence on the euro area.

Electronic money, payment systems and securitisation

The development of private electronic money is another threat to the monopoly of central banks and their ability to influence interest rates as it might also lead to a sharp decline – if not the disappearance – of banks' demand for reserves, the elimination of the demand for settlement balances (King 1999) and bring about the risk of a 'decoupling at the margins', i.e. the decoupling of central bank operations

from the markets in which financial claims materially affect agents' economic decisions (Friedman 2000). However, several authors, such as Freedman (2000), Goodhart (2000) or Woodford (2000), doubt that the role of central banks in providing final settlements will disappear in the foreseeable future. Besides, central banks could issue electronic money, require reserves from electronic issuers.

Technological advances have led to a significant improvement in the functioning of payment and settlement systems, resulting in particular in a dramatic increase in the speed of settlement facilitated by the development of real-time gross settlement systems (RTGS). In addition to RTGS, private clearing schemes now offer banks more flexibility on collateral requirements than usual central bank payment systems. As a result, banks have increased their ability to predict their liquidity position in the course of the day and therefore are more likely to adjust their liquidity position before the inter-bank market closes. In this context, the demand for central bank reserves may not only decline but may also mainly arise from payment needs rather than from reserves requirement which may be behaviourally different. In addition, the central bank's monopoly of the supply of bank reserves is challenged by the emergence of private clearing mechanisms.

Securitisation is a process whereby assets are pooled and security interests in the pool are sold – typically to institutional investors. Securities created this way include mortgage-backed securities and asset-backed securities, which are backed by various types of asset such as small and medium enterprise loans, credit card receivables or consumer instalment loans. This technical change raises a challenge in terms of the transmission channels of monetary policy as the effectiveness of monetary policy may depend less on its ability to steer interest rates on loans than market rates of both different nature and maturity.

On the other hand, most of these structural changes, which help to improve the overall economic efficiency, may also contribute to a better transmission of monetary impulses. For instance, securitisation, like other developments in credit derivatives, asset management and investment banking activities, is likely to strengthen the position of banks on securities markets. Moreover, as the dependency of banks' retail rates on market interest rates has increased, these stronger links between banking and securities activities should therefore lead to a more diffuse transmission of monetary policy decisions to the market rates.

Technical changes affecting the implementation of monetary policy: developments related to eligible assets

In order to implement monetary policy effectively, central banks have, in principle, a wide set of instruments at their disposal for their market operations. However, central banks rely mostly on government bonds to carry out their open market operations and generally face statutory restrictions on the types of financial instrument they can use in these operations or accept as collateral in their transactions. Over recent years, several episodes have raised questions about the choice of securities for such interventions. For example, in around the year 2000, the reduction in government debt and the attendant expected decline in the supply of government

securities, both in the US and the UK, raised the issue of a possible lack of depth in the Treasury market and its possible adverse impact on its functioning (Hoenig 2000). More recently, the Eurosystem has also been criticised for not discriminating between the twelve government issuers with different creditworthiness, thereby taking financial risk and weakening incentives towards financial discipline in Europe (Buiter and Sibert 2005). In addition, in particular due to securitisation, banks tend to shift collateral from government bonds to loans and asset backed securities. As a consequence, central banks may rely on the set of available collaterals to carry out their open market operations. The efficiency of these open market operations will then depend on the degree of homogeneity of the underlying assets.

The main issue regarding the set of collateral is the extent to which, under normal circumstances, a central bank can take credit risks on its balance sheet. Despite the above mentioned statutory limitations, central banks are already flexible enough to adapt to different circumstances. For instance, the Eurosystem and Bank of England have already chosen to implement large-scale repo operations, rather than outright operations, which have the advantage of not requiring a highly liquid underlying market for securities[2] and of accepting a wider range of collateral assets. Other central banks rely on collateralised lending facilities to provide the market with liquidity. In addition, a broad range of private securities are already accepted as collateral by the Eurosystem, the Bank of Japan and the Bank of England. Finally, in a comprehensive analysis of the Federal Reserve Act, Clouse and Small (2004) also show that whatever the circumstances ('unusual and exigent', or usual), the tools of monetary policy of the Fed could be easily expanded. It should, however, be borne in mind that central bank asset acquisition policies can affect the conduct of monetary policy, in particular as regards the level of independence vis-à-vis the government (Broaddus and Goodfriend 2000).

Institutional changes: communication and transparency of central banks

Finally, given their market-orientation, the development of information technologies and the increasing role played by expectations in the transmission mechanism of monetary policy, central banks initiated a crucial change in the implementation of their monetary policy in the 1990s. Given their independence and their need to be clearly understood and fully credible, central banks have enhanced their communication and increased the transparency of their decision-making process. In most central banks, decisions are now usually taken collegially by a committee or a board. Monetary policy decisions are communicated in a timely manner and, in some cases, the minutes of the meeting or the votes are published. Most central banks announce their operating targets. Table 5.1 presents the main features of the decision-making process of some central banks.

As far as the operating framework of central banks is concerned, greater transparency and improved communication have also been achieved through the provision of the central bank forecasts of the autonomous factors, as illustrated by the recent changes implemented by the ECB since March 2004, or the regular

Table 5.1 Decision-making and communication among some central banks

	FOMC (US)	ECB (EU)	BoC (Canada)	BoE (United Kingdom)
Number of voting members of policy board/committee	12	18	6	9
Announcement	Immediately	Immediately	Immediately	Immediately
Vote published	Immediately	No	No	With minutes
Minutes released	Three weeks after meeting	No	No	Two weeks after meeting

release of data or information on liquidity factors, reserve maintenance, excess reserves… This greater focus on the smooth functioning of money and financial markets has also led central banks to place increasing importance on the signals they convey – or should not convey – through their market operations. We will return to this issue later on.

The operating frameworks of central banks

The growing role of financial markets in the financing of the most advanced economies has resulted in a steady decline of central bank base money relative to other means of payments. As a consequence, the magnitude of central banks' monetary policy operations has shrunk relative to the size of the markets central banks are assumed to influence (see Table 5.2).[3]

Table 5.2 Financial magnitudes

	Monetary base (percentage of GDP)		Broad monetary aggregate (percentage of GDP)		Stock of domestic debt securities (percentage of GDP)	
	1985	2004	1985	2004	1990	2004
Australia	5.4	4.9	41.1	74.1	34.1	60.9
Canada	4.2	3.8	53.4	70.1	73.3	76.7
Euro area	*n.a.*	8.0	*n.a.*	85.2	*n.a.*	109
Japan	9.1	22.9	96.7	140.2	90.4	192.0
New Zealand	3.1	2.6	69.9	101.1	27.2	25.8
Sweden	5.8	4.3	47.7	46.1	82.5	91.8
UK	3.6	3.3	63.3	98.0	38.1	47.8
US	5.4	6.6	76.0	80.5	125.7	161.6

Source: IMF, BIS, Datastream.

Note:
Broad money is represented by M3 in all countries except Japan (M2+CD) and the UK (M4). Data for the domestic debt securities (outstanding amounts) are available on the BIS database only from 1990 onwards.

In such a context, some have raised the issue of whether monetary policy operations have any effects on interest rates; see for instance McCloskey (2000) for a rough calculation or Thornton (1995). Moreover, the failure of long-term interest rates to respond appropriately and materially to monetary policy easing and subsequently tightening in the US has been considered an indication that monetary policy has less influence on markets than it used to have in the past; see for instance *The Economist* (2005). Indeed, as already pointed out in the case of exchange rate interventions, the ability of monetary policy to influence such large markets appears paradoxical. The fact that the central bank is a monopolist supplier or withdrawer of reserves is one of the main reasons put forward to explain such a power (see for instance Friedman 1999). Operating frameworks are then the key to understanding how monetary policy is transmitted to the economy.

Main changes in the operating framework of central banks since 1990

In the wake of the structural changes observed in particular on financial markets, the basic framework for implementing monetary policy has been slightly modified on several occasions over the last decade. Table 5.3 provides a broad overview of the main modifications observed in the operating frameworks of central banks.

Operating frameworks have changed in four main ways:

1. First, most central banks have set up standing facilities, either deposit (Bank of England) or lending (Reserve Bank of Australia) facilities, or adopted a channel system (Bank of Canada, Reserve Bank of New Zealand or the ECB) by which they increase their ability to steer interest rates by providing caps and floors to money market rates and thereby bounding the volatility of these rates. However, the adoption of such a mechanism does not imply per se the absence of any source of volatility as experienced recently by the Eurosystem, which changed its operating framework in March 2004 to address the volatility created by underbidding in its main refinancing operations (MRO) at a time when markets anticipated a change in the monetary stance within the maintenance period.

2. Technological advances have led to significant changes in payment and settlement systems; central banks have benefited from these improvements, playing also a central role in the development of real-time settlement systems which contribute to their financial stability objective.

3. The set of eligible assets used for open market operations has expanded dramatically. Some central banks have also developed longer-term maturities for their refinancing operations, with long-term balances, from 3 to 6 months.[4] One rationale for providing long-term maturities is to reduce interest-rate volatility on money markets. However, the general trend is towards a reduction in the average maturity of market operations, as central banks are more active than they used to be.

4. Finally, central banks have improved their communication and transparency as far as their operating framework is concerned, trying to reduce the unnecessary

Table 5.3 Major changes in central banks' operating frameworks

Country	Major change in operating framework(*)	Change in the eligible assets or counterparties	Change in the type of operation	Technical change (settlement system, operation schedules)	Change in the communication policy
Australia	*June 1998:* introduction of the cash rate	*12 June 1996:* the Reserve Bank broadens the range of counterparties, from authorized short-term money market dealers to all members of the Reserve Bank Information and Transfer System (RITS). The RBA pays interest on balances remaining overnight in Exchange Settlement Accounts of banks and special service providers. *July 1997:* enlargement of the range of eligible assets to securities issued in Australia by the central borrowing authorities of State and Territory governments *October 2000:* enlargement of eligible assets to Australian dollar securities issued by some supranational organisations. *June 2001:* enlargement of the range of collateral *July 2002:* announcement of preferred maturity for repo operations	*June 1997:* lending facility set up	*April 1998:* RTGS	

Table 5.3 cont'd

Country	Major change in operating framework(*)	Change in the eligible assets or counterparties	Change in the type of operations	Technical change (settlement system, operations schedules)	Change in the communication policy
Canada	*4 February 1999:* introduction of the LVTS (Large value transfer system) and implementation of the channel system[1]		*September 1998:* abandon of the symmetric intervention on foreign exchange markets *September 1999:* introduction of a second round of Special Purchase and Resale Agreements or Sale and Repurchase Agreements *April 2001:* discontinuation of the second round		*Mid 90's:* development of the MCI (monetary conditions index) *February 1991:* announcement of inflation control targets

New Zealand	17 March 1999: implementation of the Cash rate system (channel system)		8 February 1999: announcement of the Cash rate system

August 2001: changes promoted in Svenson's report accepted by the government and the RBNZ |
| UK | 1999: large expansion of eligible collateral, changes in the Gilt market trading conventions

22 July 2004: announcement of the introduction of a system of Voluntary reserves by March 2006 | 1997: introduction of the repo rate as the main policy rate; new procedures adopted for daily market operations

June 2001: introduction of a deposit facility with a +/− 100bp corridor system | April 2000: the function of managing the Government's cash flow is transferred from the BoE to the Treasury's Debt Management Office (DMO) |

Table 5.3 cont'd

Country	Major change in operating framework(*)	Change in the eligible assets or counterparties	Change in the type of operations	Technical change (settlement system, operations schedules)	Change in the communication policy
US	1995: statement of short-term market operations objectives	1991: review of the market for Treasury securities (including primary dealers) following irregularities disclosures: no more market share criterion	1994: automation of the bidding process	Spring 1992: The Fed's portfolio is liquid enough (no further reduction in the maturity required)	January 1997: the Desk reports the par value of each of its open market operations with primary dealers at the conclusion of the operation
	August 1998: reserve requirement lagged.	November 1995: the Desk changes its approach to outright coupon purchases.	December 1996: the desk announces that it will not conduct customer-related repurchase agreement	September 1996: confirmation by the FOMC that the primary objective in managing the composition of its domestic securities portfolio is to ensure a high degree of liquidity January 1997: the desk moves its intervention to later in the morning (10.30 am)	
	January 2003: New discount window: sound financial institution may borrow directly at the primary credit facility.				

| Euro area | 1 January 1999: stage three of EMU, introduction of the euro | Acceptance of G10 assets + Single list of collateral | 28 June 2000: the MROs are conducted as variable-rate tenders (minimum bid rate fixed) instead of fixed rate | July 1990: stage one of EMU, free movement of capital within the European Union | 1 January 1994: stage two of EMU, separation between central banks and public sector | March 2004: change in the schedule of the maintenance period, reduction of the maturity of the MRO from two weeks to one | March 2004: Release of forecast of average autonomous factor and of the calculation of the benchmark amount |

volatility of interest rates around monetary policy decisions and thereby reinforcing the signalling function of their open market operations.

An overview of the current operating frameworks of central banks

Tables 5.4 and 5.5, which elaborate on Borio (1997), Borio *et al.* (2001), Banque de France (2001), Allen (2002) and Bindseil (2004b), provide an overview of the current operating frameworks used by the central banks of some of the most advanced economies. These operating frameworks are characterised by the following features:

1. Most central banks implement monetary policy by setting a target for some short-term interest rates that is consistent with their primary objective of price stability. The targeted rate is generally the overnight rate, as in the case of Australia, Canada, New Zealand and the United States, consistent with the fact that central banks usually conduct monetary policy operations by intervening in the inter-bank market in order to affect the level of bank reserves. Some countries or areas directly use the tender rate applicable to their main refinancing operations. This is for instance the case of the Eurosystem, which fixes the minimum bid rate of its main refinancing operations, and of the Bank of England and the Riksbank through their repo rate. Due to its particular circumstances, the Bank of Japan is the only central bank in this panel that has maintained a quantity-oriented operating procedure in the context of the implementation of its quantitative easing policy from March 2001 to March 2006. But this remains an option in the context of deflationary pressures, as illustrated recently by Bernanke (2002), who advocated the outright purchase of longer-maturity government bonds to exhaust any remaining leeway to lower interest rates fully in a situation where nominal interest rates are already near the zero lower bound.

2. Most central banks seem to rely on standing facilities or on a 'channel mechanism' (see Figure 5.1). The main objective of this kind of operating framework is to limit money market interest-rate volatility. As stressed by Blinder (1999), the current level of the overnight rate is of negligible importance in terms of its effects on economic agents' behaviour. Rather, central banks affect economic decisions through their ability to influence market expectations regarding the path of future overnight rates. In this context, the volatility in the money market may blur the monetary policy signal, but also affect the central bank's credibility and raise some concerns about its ability to stabilise market expectations. Standing facilities play two major roles: they contribute to the smooth functioning of the money market and they signal the monetary stance. The relative importance of these roles depends on the way monetary policy is implemented in practice. When combined with an averaging provision for reserve requirements, standing facilities provide a powerful tool for stabilising the overnight rate (Perez Quirós and Rodriguez-Mendizábal, 2003). In other cases, they are key instruments for steering money market interest rates but they seem to be

Table 5.4 An overview of operating frameworks

	Australia	Canada	Eurosystem	Japan	New Zealand	Sweden	UK	US
Key policy rate	O/N target	O/N target	Minimum bid rate	Outstanding balance of the current accounts at the Bank of Japan[a]	O/N target	Repo rate	Repo rate	O/N target
Maturity (days)	1	1	1		1	7	1	1
Operating target	O/N	O/N	O/N	O/N[b]	O/N, S-T	O/N	S-T (Repo rate)	O/N (Fed funds rate)
	1 day	1 day	1 day	1 day	30–90 days	1 day	1–33 days	1 day (discount rate window)
Corridor (bp)	50	50	200	[c]	50	150	200	*
Reserve requirements			*	*				*
Maintenance period			1 month	1 month				2 weeks
Main operation	RT	RT	RT	RT	RT	RT	RT	RT/OT
• Maturity (days)	1–30 and 90–180	1	7–90	1 to 365	variable	7	14	1–15
• Regular interval	*	*	*	*	*	*	*	
• Frequency	1*[d]	1 per day	1*w and 1*m[d]	<4 per day	1 per day	1 per week	≤3 per day	≈1 per day
Overall frequency	1 per day	1 per day	≈1 per week	>1 per day	≈1 per week	>1 per week	>1 per day	≈1 per day

Continued

Table 5.4 cont'd

	Australia	Canada	Eurosystem	Japan	New Zealand	Sweden	UK	US
Key signals								
• Announcement target	*	*	*	*	*			* (funds rate target)
• Tender	*		*	*	*	*	*	*
• Standing facility	*	*	*	lending facility	*	*	*	lending facility[e]
							deposit facility when liquidity surplus	

Notations: O/N: overnight; S-T: short term; RT: reverse transaction; OT: outright transaction; *: yes.

Notes:
a Determined in the market at a certain level below the ceiling set by the Lombard-type lending facility.
b Formerly the overnight call rate. The change was decided on March 19, 2001 to implement monetary easing. The new procedures for money market operations continue to be in place until the consumer price index (excluding perishables, on a nationwide statistics) registers stably a zero percent or an increase year-on-year.
c Since February 2004, the BOJ has been considering introducing a securities' lending facility that would provide the market with JGSs held by the bank.
d Main refinancing operations are implemented on a weekly basis, whereas longer-term refinancing operations are implemented on a monthly basis.
e Discount window.

Table 5.5 Discretionary operations

Type		Underlying instruments	Impact on liquidity	Maturity	Frequency	Settlement	Allotment/ Pricing	Basic refinancing	Gross-tuning	Day-to-day calibration	Creation shortage	Signal
AU	RT	Government securities	+/–	≤1m	1 per d	T	V[a]	*		*		
		State and territory gov.	+/–	≤1m	1 per d (n)	T	Bilateral	*		*		
	FXS	US$	+/–	≤3m	occasional	T to T + 2	Bilateral	*		*		
	OT	Government securities	+/–	≤1m or 3/6m	infrequent (2 in 2004)	T	V[a]	*		*		
		State and territory gov.	+/–	≤1m or 3/6m	≤1 per w	T	V[a]	*	*			
CA	RT	Gov. securities[b]	+/–	1d	as needed	T	F	*	*	*		
EZ	RT	Gov. and private sec.[c]	+	1w	1 per w	T + 1	V*[d]	(*)				
		Gov. and private sec.[e]	+	3m	1 per m	T + 1	V	*	*			
	OT	Gov. and private sec.	+/–	not standardized	as needed	T	Bilateral			*	*	*
	FXS	Widely traded currency	+/–	not standardized	as needed	T, T + 1, T + 2	Bilateral			*	*	
	DC	ECB debt certificate	–	≤1y	as needed	T + 1	V				*	
	CFD	Fixed-term deposits	–	not standardized	as needed	T	F				*	

Table 5.5 cont'd

Type		Underlying instruments	Impact on liquidity	Maturity	Frequency	Settlement	Allotment/ Pricing	Basic refinancing	Gross-tuning	Day-to-day calibration	Creation shortage	Signal
JP[f]	RT	Treasury bills	+/−	≤1y	≤2 per d	T to T+2	V	*	*	*		
		Financing bills	+/−	≤1y	≤2 per d	T to T+2	V	*	*	*		
	RP	Japanese Gov. bond	+	≤1y	≤1 per d	T+2	V		*			
		Commercial Paper	+	≤3m	as needed (usually 1 per w)	T+2	V		*			
	OT	Bill purchases[g]	+	≤3m	as needed	T to T+4	V		*			
		Sales of TB/FB	−	≤6m	as needed	T+3	V		*			
NZ	RT	Gov. securities	+/−	Variable	1 per d	T	V	*	*	*		
		Treasury bond (sale)	+/−	Variable	1 per w	T+1	V		*	*	*	
		Government bond	+/−	Variable	periodically	T+3	V			*	*	
	FXS	US$, €, AU$	+/−		as needed	T+2	Bilateral		*			
SE	RT	Riksbank or foreign debt certif.	+/−	≤1y	1 per w	T+2	F/V	(*)	*			
	CL/I	Debt certificate	+/−	1d	as needed		Bilateral		*			
	OT	Debt certificate	+/−	≤1y			F/V		*	*		*

FXS				variable		F/V					
UK	RT	Good liquidity currency	+/–	variable							*
		Gilts	+	≈2w^h	≤2 per d	T	F		*	*	*
		Euro-denominated sec	+	≈2w	≤2 per d	T	V*		*		*
		Eligible bills	+	≈2w	≤2 per d	T	V*	(*)			
	OT	Treasury bills	+/–	≤2w^i	≈1 per w (more when needed)	T	V	*		*	*
		Eligible bank bills	+/–	≤2w		T	V			*	*
		Eligible local auth. Bill	+/–	≤2w		T	V		*	*	*
	S	Eligible sec	–	3m		T	V	*		*	*

Table 5.5 cont'd

	Type	Underlying instruments	Impact on liquidity	Maturity	Frequency	Settlement	Allotment/ Pricing	Basic refinancing	Gross-tuning	Day-to-day calibration	Creation shortage	Signal
US	RP	Gov. securities[j]	+/−	1-15d	Several per 2w	T	V	*	*	*		
	RT	Gov. securities[k]	+	1d	Several per 2w	T	V	*	*	*		*
	OT	Treasury bills[m]	+/−	Variable	5-10 per y	T + 1	V		*			

Symbols: RT = reverse transaction; FXS: foreign exchange rate swap; OT: outright transaction; *: yes; d: day; w: week; m: month; y: year; V = variable rate (interest rate) tender; V* = pre-announced volume and/or minimum rate; (*) = keynote operation (main refinancing operation conveying information on monetary policy); F = fixed rate (volume) tender.

Notes:
a Once a week, longer-term operations are announced. Their maturities are typically from 90 to 180 days. Maturities are at the discretion of counterparties (their offer consist of proposing a rate, a maturity and an amount), but the RBA announces two or three preferred terms and divides into smaller allotments the total allotment announced.
b 'Special Purchase and Resale Agreement and Sale and Repurchase Agreement': used to manage liquidity and as a signal to enforce the operating band in the morning.
c They are called 'Main refinancing operations'.
d With minimum bid rate.
e Long-term refinancing operation.
f In 1996, the Bank of Japan decided not to use loans in monetary control any more.
g Two kinds of bill purchase: outright purchases of bills and outright purchases of bills collateralized by corporate debt obligations.
h Repos are normally invited to one or two dates.
i The maximum residual maturity for the bills is inferior to the longest-dated repo for which bids have been invited that day (usually around two weeks).
j 'System-repurchase agreement' (adds reserves balances temporarily against Treasury and federal agency securities) or 'Matched sale-purchase transactions' (drain reserve balances temporarily against treasury bills).
k 'Customer-related repurchase agreement' (adds reserves balances temporarily against Treasury bills).
m Mainly purchases of Treasury bills (sales are very infrequent).

used infrequently: their signalling function is therefore predominant. In the Eurosystem, the daily recourse to standing facilities appears fairly small and confirms the exceptional nature of the standing facilities in providing or absorbing overnight reserves. The central banks of Canada, Australia, New Zealand, the UK and the Eurosystem have operated a 'channel or a corridor system' (see Figure 5.1), i.e. a mechanism by which the overnight rate is kept near the central bank's target rate through the provision of a lending and a deposit facility, unlike the Fed which only maintains a primary credit facility (the new discount window), since January 2003. The standing facilities thus draw a corridor around the overnight rate. This corridor might be fairly tight: for example, the rates offered by the central banks in Canada, Australia and New Zealand are 25 basis points over and below the target rate. The Eurosystem, which combines this system with reserve requirements, and the Bank of England offer a wider range of 100bp over and above the minimum bid rate and the repo rate respectively, thereby seemingly tolerating higher volatility in money market rates;

3. Few central banks have maintained reserve requirements. Due to financial innovations and pressures from the banking industry, which considers that these requirements put depository institutions at a competitive disadvantage relative to other unregulated financial institutions, reserve requirements have been reduced to a historically low level or even simply removed. The ECB, which uses this system to create a liquidity shortage, remunerates the required reserves at a rate corresponding to the average of the 'marginal rate of allotment' of the main refinancing operations over the maintenance period (ECB 2004). Reserve requirements perform two main functions: they reduce interest-rate volatility by allowing banks to buffer out temporary liquidity shocks (the buffering function); they increase the *ex ante* liquidity shortage of the banking system in order to improve the ability of the central bank to operate efficiently as the marginal supplier of liquidity and therefore to enhance its ability to effectively steer the overnight rate (the enlargement function). Specific reserve requirements, called the cash ratio, can also be implemented. These are used only as a seigniorage income that funds the central bank's services and are generally limited to fairly small percentages of transaction and term deposits;

4. While moving towards a greater homogeneity with a dominance of reverse transactions, operating frameworks still display significant differences with respect to the maturity and the frequency of their operations. However, as mentioned earlier, the trend is towards the reduction in the average maturity. Part of these differences may also be endogenous to the underlying operating framework. For example, countries operating a channel system can in principle maintain the overnight rate within a tight range regardless of what the level of supply balances might be. Therefore, frequent quantity adjustments become less important. However, the improper design of standing facilities may also, in itself, lead to a more or less frequent use of standing facilities than expected (Furfine 2003). The frequency of central banks' operations seems to be the result of a subtle trade-off between different and potentially
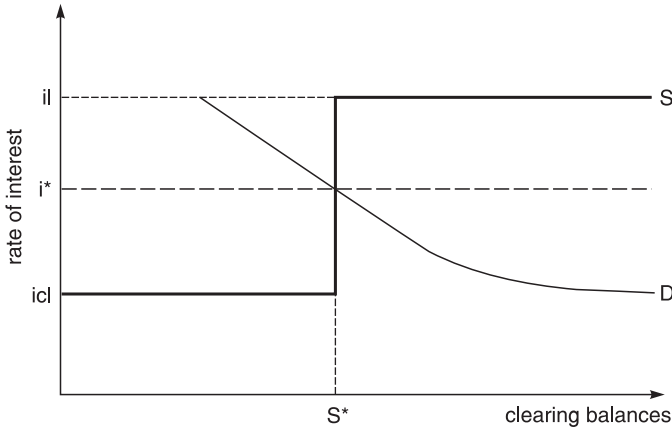
The 'channel' system implemented in Australia, Canada, the euro area, the UK and New Zealand relies on standing facilities to control the overnight interest rate. Because standing facilities are available without restrictions, the *supply curve* for clearing balances looks like a stair. The vertical segment S* is located at the net supply of clearing balances apart from any obtained through the lending facility: it is the level of clearing balances that offset the changes in autonomous factors and that are used for market operations. The target supply of clearing balances is adjusted for technical reasons from day to day, but does not convey any policy signals. The horizontal segment to the left at the deposit rate shows that the deposit facility sets a oor for the overnight rate, independently of the demand for clearing balances. The horizontal segment to the right indicates the perfectly elastic supply of overnight balances at the lending rate form the lending facility. The equilibrium is determined at the intersection between demand and supply. It is worth comparing the supply curve under a 'channel' system and the one implemented by the Fed in the US. Under the US arrangements, there is no deposit facility. The discount window is rationed, which implies that the right part of the supply curve is steeply sloped. However, as noted by Woodford (2003), the static analysis of the Fed's supply function is problematic because the Fed's supply of clearing balances is determined via a reaction function that responds to the previous day's discrepancy between the fund rate and the Fed's target.

Figure 5.1 The 'channel' system.

conflicting objectives: allowing market forces to work on the money market, steering short-term interest rates or smoothing interest-rate volatility due to market misinterpretation of monetary policy messages, operational mistakes or improper design of the operating framework.

5. The range of underlying securities and eligible assets also varies considerably across countries, mainly reflecting the availability of underlying assets as well as idiosyncratic market structures and historical factors. As regards this latter aspect, the Japanese experience is an illustration of the flexibility of the operating framework facing unusual circumstances: in a situation of deflation where the nominal interest rate has already hit the zero lower bound,

the Bank of Japan has enlarged the scope of its market operations dramatically. In fact, from 2003 to 2006, the Bank of Japan has been able to purchase risky assets and more long-term government bonds. It also has expanded the range of eligible collateral and introduced asset-backed securities purchases. All these measures were intended to spur aggregate demand through increases in the monetary base by increasing liquidity for financial intermediaries and households and trying to affect expectations of the future path of interest-rate as well as inflation expectations.

Finally, the design of central banks' operational frameworks also factors in financial stability considerations, as the same operations, procedures and collaterals that are needed to implement monetary policy decisions would also be used to carry out lender-of-last-resort operations or emergency liquidity assistance. To this extent, the widening of eligible assets, the desire to rely on a large set of counterparties for open market operations, the growing importance of standing facilities, which are operations conducted by central banks at the initiative of financial institutions, and the buffering function of reserves directly contribute to the financial stability objective of central banks not only by optimising the functioning of the lender of last resort but also by avoiding the propagation of systemic risk. The same rationale has led central banks to promote and develop the efficiency of financial markets, in particular for derivative and swap markets.

The effectiveness of monetary policy in a changing environment

In recent years, New Keynesian models have become increasingly popular and have founded the basis of the 'Science of monetary policy', according to Clarida *et al.* (1999). In this literature, the level of the relevant variables for the monetary policy-maker is generally treated as independent of the choice of operating procedures. Canzeroni and Dellas (1998) show, however, in a general equilibrium model with nominal wage rigidity, that the choice of a procedure can have a sizeable impact on the average level of the real interest rate by affecting the variability of aggregate consumption. In particular, they find that the real rate is higher under a nominal interest-rate targeting procedure. Though in this chapter the concept of 'operating procedure' would better be named 'monetary policy strategy', we can draw from this analysis *the conclusion*, that monetary policy strategies and operating frameworks (in the usual meaning) are in fact intricately interrelated and therefore should not be treated independently as they are, so far, in the literature.

Do structural changes affect the effectiveness of central bank operating procedures? Indeed, some of the recent developments question the relevance of instruments such as reserve requirements, the role of open market operations, the mechanisms through which the central bank affects the interest rate in the information economy. The greater focus on the communication and the signalling

function of monetary policy instruments may have also changed their purposes, with greater focus on interest-rate volatility. In this section, we will focus on two main aspects, reserve requirements and open market operations, before raising some questions regarding the design of appropriate operating frameworks aiming to enhance the signalling of monetary policy.

Reserve requirements

The sharp decline in required balances observed in the 1990s has triggered a debate over the role of reserve requirements in the implementation of monetary policy. At the current juncture, only a limited number of central banks still rely effectively on such an instrument, the ECB being amongst the exceptions.[5] One peculiarity of this instrument is that its function has evolved substantially over the years, its use being associated with very different objectives such as helping banks to smooth out temporary liquidity shocks, creating or enlarging the liquidity deficit, generating central bank income or providing an averaging facility without the need for open market operations. The two main functions put forward by the ECB, i.e. the 'enlargement' and the 'buffering' functions, are, however, contingent on the environment. First, reserve requirements may not be an important or essential contributor to the liquidity deficit of the banking sector; other elements, such as the strong growth of liquidity-absorbing factors, banknotes in circulation for instance, may well be sufficient to create or enlarge such a deficit. As an illustration, Figure 5.2 below shows that a zero reserve ratio will not directly affect the optimal liquidity deficit, that the liquidity deficit is mainly driven by banknotes and is probably already sufficient, without reserve requirements, to place the Eurosystem
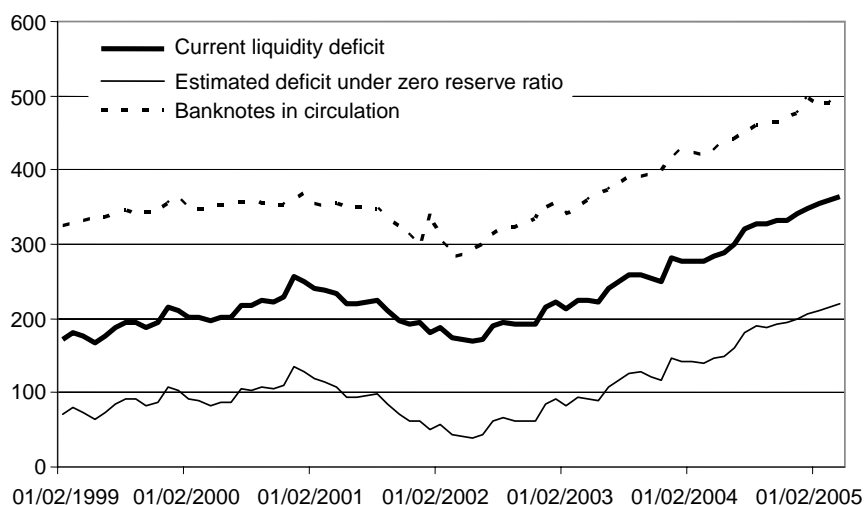

Figure 5.2 Liquidity deficits (EUR bn) and banknotes in circulation. *Source*: ECB's Monthly Bulletin – authors' calculation.

as the marginal supplier of liquidity, provided that the trend for banknote circulation does not reverse, as already observed prior to the cash changeover, which is also questionable if electronic money develops significantly in the near future. Another drawback of too large reserve requirements is that counterparties then need to mobilise huge amounts of collateral. However, in the particular context of the Eurosystem, many features of the current framework directly stem from its decentralised nature.

Second, it is not clear whether reserve requirements are a prerequisite for reducing the volatility of the overnight rate. The effectiveness of such a system may well depend on its own specific features: for example, whether or not reserve requirements are averaged or the various ways of averaging (i.e. whether the calculation period is lagged, semi-lagged or contemporaneous with the maintenance period) may well explain why some central banks, such as the Eurosystem, may achieve a remarkable stability in the overnight rate despite operating only on a weekly basis thanks to an averaging mechanism whereas other central banks, which operate reserve requirements as well, have to resort to fine tuning operations to stabilise market rates. Moreover, as illustrated by Demiralp and Farley (2005) in the case of the US, the significant decline in reserve balances has not resulted in a permanent increase in the volatility of short-term interest rates. Instead, the Domestic Trading Desk at the Federal Reserve Bank of New York has adapted to structural changes in the demand for reserves and, after an initial rise of the volatility of short-term rates in the early 1990s, volatility then declined. However, the buffering function might still be justified in a context where signalling is considered a key element in the transmission mechanism of monetary policy and where 'excessive' volatility in the overnight rate may blur the monetary policy stance. This may explain why some central banks still consider reserves as vital in their operating system.

Open market operations

Among the main trends affecting the operating frameworks of central banks, we highlighted, in the previous section, the use of the short-term interest rate as the key instrument of monetary policy, and the growing reliance upon standing facilities or channel-type systems, all of which could challenge the justification for open market operations. As shown for instance by Woodford (2001; 2003) in the case of a channel system, the central bank can maintain overnight rates within a fairly tight range. In this context, it might not be necessary to resort to a quantity adjustment through open market operations in response to deviations of the market rate from the target rate. Instead, changes in the level of overnight rates are simply brought about through changes in both the deposit and the lending rates in parallel with the target rate. Moreover, recent contributions have suggested that open market operations may not be essential for driving interest rates. Instead, some central banks seem to steer interest rates through an announcement effect of open-mouth operations (Guthrie and Wright 2000; Taylor 2001). However, Thornton (2004) finds no evidence that either open market or open-mouth operations can explain the Fed's ability to steer the overnight rate but

instead proposes the interest-rate-smoothing hypothesis as an alternative explanation. Under this hypothesis, changes in short-term nominal interest rates are mainly due to shocks to the real economy or to inflation expectations.

Whether the adoption of a channel system should then automatically be accompanied by a sharp reduction in the frequency of open market operations – if not their disappearance – is another issue. As can be seen from Table 5.5, despite apparently similar operating systems, the frequency of discretionary operations differs significantly across countries: for example, the Bank of England intervenes several times per day whereas the ECB usually intervenes only once a week. The frequency of open market operations depends on the other features of the operating framework, in particular the existence of reserve requirements. Moreover, a channel system might be prone to manipulations by large players in the money market, making strategic use of the central bank standing facilities as shown in a recent paper by Ewerhart *et al.* (2004b). According to the authors' findings, everything else being equal, the availability of fine-tuning is a necessary condition for avoiding such behaviour. This could provide further justification for discretionary open market operations given that one of the main motives for the central bank's intervention is also to eliminate or reduce the noise generated by strategic market behaviour so as to maintain the signalling of monetary policy.

Signalling issues and the appropriate design of operating frameworks

The 'New Consensus' around central bank communication and the use of a target rate as the main indicator of the monetary policy stance means that the specifications of the operating system must be designed to facilitate the signalling of monetary policy. Indeed, the uses of reserve requirements, standing facilities, or the combination of the two in some cases, and open market operations have been motivated by this objective recently. The main issue here is to ensure that markets do not misinterpret central banks' operations. This implies in parallel that central banks do not send policy signals through their open market operations or possibly through changes in their reserve requirements or in the width of their standing facilities. There is obviously a governance issue here: should the monetary policy signal be sent by the monetary policy committee or should it be delegated to the operating desk?

Market-oriented monetary policies also require that the design of the operating procedures avoid a structural recourse to standing facilities, which could eventually dry up market liquidity. This may call into question the width of the corridor or the channel system, given that too narrow a corridor would probably reduce the incentive of monetary and financial institutions to engage in market transactions. Moreover, when standing facilities are coupled with reserve requirements with averaging, the width of the corridor should probably be larger than the usual monetary policy step (i.e. the average of the absolute size of key policy rate changes) in order to avoid extreme recourse to standing facilities in the event of changes in interest-rate expectations during the maintenance period. Another argument made by Ewerhart *et al.* (2004b) is that the likelihood of a manipulation decreases with the width of the interest-rate corridor. Therefore, the optimal width

of the corridor seems to directly depend on the main features and specifications of the operating system.

Finally, the clarity of the central bank's communication could be improved by a clearer separation between the two stages of the conduct of monetary policy, i.e. the interest rate decision per se (stage one), which relies on a comprehensive analysis of macroeconomic, monetary and financial developments on the one hand, and the daily operations which aim at steering market interest rates on the other hand (stage two). To some extent, appropriate communication and reasons behind the interest rate decisions should be sufficient to ensure a proper anchoring of market rates, along the path desired by the central bank, with the task of the operating framework being to ensure a smooth functioning of the markets. In the design of the operating framework, the width of the corridor should therefore correspond to the volatility tolerated by the central bank, i.e. considered as not impairing the signalling of monetary policy.

In this context, it is quite surprising that despite having set operating procedures relying on standing facilities, reserve requirements or a combination of both instruments, central banks sometimes seem to intervene 'automatically' in the market when the spread between the overnight and the target rates exceed some particular threshold within the corridor or appears to persist over a few days. Indeed, the widening or the persistence of the spread may interfere with the signalling of the policy rate but if this is considered as a cause for concern from a monetary policy perspective, this issue should probably better be dealt with by appropriate communication by decisional bodies rather than through the conduct of fine-tuning operations.

Conclusion

Central banks have adapted their operating procedures over recent decades in the context of a rapidly changing environment. New technologies and financial innovations have brought about structural changes at an unprecedented pace. Alongside the widening of instruments, eligible assets and securities, central banks have also become more active: they have increased their focus on short-term interest rates; the maturity of their market operations has declined significantly; the frequency of discretionary operations has increased in parallel, maybe as a consequence of the sharp reduction in reserve requirements (the Eurosystem being an exception). All these developments have benefited both the monetary-stability and the financial-stability objectives.

The focus on the short-term interest rate has been accompanied by further attempts to make the central bank communication clearer, more transparent and operating procedures more oriented towards the improvement of the signalling of monetary policy.

The evolutionary process is more akin to a Darwinian process than a Schumpeterian one; old species, such as central banks, which are fortunately not dinosaurs, are adapting gradually to their rapidly changing environment rather than being the passive victims of the 'creative destruction' process.

Appendix 5.1 Main structural changes and their possible impact on the transmission mechanism of monetary policy as put forward by the literature

Type of change	Instrument affected	Description	Consequence on MP	Country/date	Reference
Financial regulation/ deregulation	Deposit interest-rate ceilings	Removal of the ceilings so that banks can freely adjust their interest rates and do not face outflow of funds when there is a policy tightening	Better transmission through the credit channel	US, 1980–82	Sellon (2002)
	Geographic and product-line barriers	Removal to increase competition among foreign or domestic financial institutions Openness to international capital flows*	Competition among countries	World, 1980s	Sellon (2002)
	Regulatory bank capital, risk management (Basel II)	Basel II has created a forward-looking regulatory scheme for managing bank risk and capital. It requires banks to assess their risk exposures	Basel II ensures higher financial stability and better transmission of monetary policy impulses since it broadens its visibility by increasing market transparency	World, 2004	Caruana (2005)
Financial innovation	Capital markets	Demand side: development of capital market as an alternative to bank financing	*Development of new sources of credit that do not rely primarily on central banks as liquidity providers†*	World, 1980s	Sellon (2002)
		Supply side: development of voluntary long-term saving (mutual funds, pension funds, life insurance) to face lower costs when entering into securities markets	*Changes in bank loan rates affect smaller businesses and households†*	Mainly Europe (catching up with the US) 1990s	Padoa-Schioppa (2002) Friedman (1999)

Securities markets	Securitisation: shift away from the dominance of non-marketable instruments (bank loans) to marketable securities (credit securities)	Interest-rates on loans are mainly tied to those on securities. The effectiveness of MP depends less on its ability to steer loans interest rates than market rates	World 1990–2000	Sellon (2002)
	Banks are not compelled to hold reserves against some forms of deposits like saving accounts and certificates of deposit	*The demand for bank money erodes[†]. CDs are available as an alternative source of funds.* But they had a greater impact on MP when CB implemented MP tightening by reducing the amount of reserves (not raising interest rates)	World 1970	Romer and Romer (1990) Padoa-Schioppa (2002)
	Development of credit derivatives, asset management and investment banking activities by banks	*A stronger bridge between banking and securities activities ensures a better transmission of MP to all the markets[‡]*	Romer and Romer (1990) Friedman (1999)	
	Growth of the size of securities markets compared to the magnitude of central banks' market operations	The signalling function of MP is reinforced		

Appendix 5.1 cont'd

Type of change	Instrument affected	Description	Consequence on MP	Country/date	Reference
	Settlement systems	Better management of intra-day liquidity thanks to: – A better forecast of banks liquidity position. (increasing speed of settlement / real-time gross settlement system set up in most countries and more information available to counterparties); – Intra-day settlement facility (private or public)	*Banks do not need to resort to central bank's settlement balances during the day*[†]	World, 1990–2000	Friedman (1999)
	e-money	Non-bank firms can develop their own payment cards and settlement system	*The demand for central banks money erodes: they are not monopoly suppliers of money any more*[†]	US, 1999	Friedman (1999)
	Variable-rate loans	Loan rates adjust to market rates thanks to index rate changes. Banks transfer to their client a part of the credit and interest rate risks. Risk-adjusted pricing is encouraged by Basel II	*MP is transmitted more quickly to consumers and business through the wealth effect but in a procyclical way*[‡]	More developed in the US 1990s	Sellon (2002)
Institutional changes of Central banks	Operating target	Central banks usually announce their operating target	*Greater transparency of central banks leads to faster and less volatile response to MP decisions*[‡]	US 1994 euro area 1999 UK 1997	Sellon (2002)
	Communication	Central banks make a greater use of markets expectations to influence quotations	*The signalling function of the central bank is reinforced*[‡]	US 2002	Bernanke (2002)

Supply of government or Treasury securities	Due to the reduction of public debt in several countries, the shrinking supply of government securities alters the information content of debt market indicators (yield curve, spreads of private securities over government securities)	Central banks have to consider resorting to new assets (private securities) or new instruments (large-scale repo operations, lending facilities, swaps)	US 2000 Europe (Maastricht treaty) 1995–9	Hoenig (2000)
Long-term securities	The Bank of Japan has increased the amount of outright purchase of long-term government bonds	Longer-term securities are a way for Japan to implement monetary easing when nominal short-term interest rate is zero	Japan 2001	
	Some central banks, such as the ECB, now offer long-term balances (3 to 6 months)	Long-term balances increase the average maturity of the Reserve Bank's outstanding repurchase agreements which reduces volatility	Australia, New Zealand, US 2002	
Required reserves	Central banks adapt their reserve requirements to higher competition among financial intermediaries: decrease in the required amounts, payment of interests on required reserves close to the market rates	The reserves requirement system does not penalise banks compared to non-credit financial institutions anymore ('level playing field')	US 1991	Meyer (1998)

No measurement is possible for institutional changes.

*There could be a change in such a policy resulting from the Asian crisis in 1997.
Italics: variable the author does not suggest looking at.
World: all countries studied: Australia, Canada, euro area, Japan, New Zealand, Sweden, UK, US.
†Changes that jeopardise the effectiveness of monetary policy.
‡Changes that emphasise the signalling function of the central bank.

Notes

1 For an international analysis and an interpretation of the decline of traditional banking, see Allen and Santomero (2001).
2 This is because the pool of eligible collateral is large.
3 In some cases, the base-to-GDP ratio can, however, understate the holding of central bank money in the economy, as is the case in the UK, where the base definition only includes the voluntary operational balances the Banks hold with the Bank of England.
4 In the case of the Eurosystem, the decentralised nature of its operational framework also explains such a choice as it aims at providing stable liquidity provisions for small and very specific institutions.
5 The People's Bank of China (PBOC), not reviewed in this chapter, is another exception, the reserve ratio being an important policy instrument whereby the PBOC seeks to control the money multiplier.

Comments on Clerc and Thuaudet

Ingmar van Herpt

The chapter by Laurent Clerc and Maud Thuaudet gives a comprehensive overview of the current literature on monetary policy operations and their effectiveness in the wake of changes in the financial environment. I agree with the general conclusion, namely that operational frameworks of central banks remain flexible enough to remain effective in the face of changing circumstances. Particularly, the conclusion that central bankers are no dinosaurs I found very reassuring. Because the chapter is largely descriptive rather than analytical, it is difficult to comment, but I make some remarks on various topics that were raised.

I first address some of the trends mentioned that may pose a possible future challenge to the effectiveness of monetary policy implementation. First, the concern that arose in the late 1990s about the decline in government debt, and as a consequence the possible drying up of collateral, has subsided over the past few years due to increasing public deficits and public debt in many industrialized countries. Also, as the authors rightly argue, most central banks these days accept a wide variety of assets in their money market operations in addition to government debt. Secondly, we have seen a shift from 'high opportunity cost' collateral such as liquid government securities, to 'low opportunity cost' collateral such as securitized assets and even bank loans. As the current practice in the Eurosystem illustrates, this trend does not have to affect the effectiveness of monetary policy operations. However, as the authors suggest, the increasing heterogeneity of eligible assets may raise efficiency issues, as the collateral management of the central bank, including the framework of credit risk management, becomes more resource-intensive. Thirdly, the authors argue that as a result of the growing role of financial markets in the economy, the size of central bank reserves has shrunk relative to the size of the markets central banks are assumed to influence. However, one could argue that this does not necessarily pose problems to monetary policy *implementation*. In the end it is the marginal supply and demand of bank reserves that influence the target interest rate, i.e. it is the absolute level of central bank reserves that matters rather than the relative size of reserves. Of course, the issue of implementation should be viewed separately from the impact of disintermediation on the *transmission* of the monetary policy stance.

As a separate point, in the paragraph on eligible assets, the authors refer to the criticism by Buiter and Sibert (2005) that the Eurosystem would not

discriminate between the twelve government issuers with different creditworthiness, thereby taking financial risk and weakening incentives towards financial discipline. However, their criticism is flawed because they got the facts wrong. First, the argument by Buiter and Sibert was based on the wrong assumption that the Eurosystem does not value the collateral it receives from counterparties at market prices. However, the collateral framework of the Eurosystem, including its valuation principles, has been in place now for six years, and mark to market valuation has always been a crucial element in it. Furthermore, the Eurosystem has been fully transparent on its valuation principles, as, obviously, the hundreds of counterparties that submit collateral every day for monetary policy operations or intra-day credit from the Eurosystem need to know exactly how collateral is valued. Second, the Eurosystem, in its public document 'The implementation of monetary policy in the euro area', specifies that tier one assets must meet high credit standards, and that in the assessment of the credit standard the ECB takes into account, inter alia, available ratings by market agencies (recently, this requirement has been further publicly specified to mean a rating of at least A- from at least one of the three main rating agencies). This means that it is factually wrong to argue that the Eurosystem does not make any differentiation between paper of different credit risk, be it government paper or private paper.

On the issue of reserve requirements, I have a somewhat more optimistic view on the future of this instrument than the authors. First, I wonder whether reserve requirements are really such an endangered species as the authors suggest. Apart from the Eurosystem, reserve requirements are still used in a number of industrial countries, albeit admittedly in various degrees of importance. The Bank of England has recently announced that is planning to introduce a remunerated voluntary reserve requirement with averaging facility. Furthermore, reserve requirements are also often in the tool box of IMF technical assistance missions to central banks. Second, reserve requirements may turn out to be a very useful instrument to meet a number of the possible future challenges mentioned in the chapter, such as a possible adverse development in the demand for bank reserves. That is because reserve requirements are an effective tool for guaranteeing a certain minimum in the demand for bank reserves. Third, some authors argue that due to financial innovation the basis for reserve requirements may be eroded because banks switch more easily from reservable to nonreservable liabilities. However, the incentive to do this may not be very large. Indeed, from contacts with liquidity managers of commercial banks, it turns out that banks often like reserve requirements, as long as they are remunerated against the market rate and have an averaging facility. The reason is that an average reserve requirement facilitates the daily liquidity management because banks, except for the last day of the maintenance period, do not have to steer their balances within a narrow range or even to zero.

On the issue of signalling, it is crucial to make a clear distinction between the monetary policy strategy and monetary policy implementation. I fully agree with the authors that the central bank should be very careful not to leave the impression that it uses monetary policy implementation for signalling the monetary policy stance. According to the current consensus view, the monetary policy stance is

signalled to the market by setting the interest rates at which the central bank is willing to engage in transactions with the banking system, i.e. the open market operations and the standing facilities. Liquidity management, like allotment decisions in open market operations or changing the reserve ratio, should not be used for signalling the monetary policy stance. First of all, it would not be consistent with having a short interest rate as an operational target. Second, it is bound to create confusion, because it becomes very difficult for the market to distinguish between actions that are purely of a technical nature and actions that have a monetary policy meaning.

6 The interplay between money market development and changes in monetary policy operations in small European countries, 1980–2000

Jens Forssbæck and Lars Oxelheim

The implementation, as well as the underlying 'philosophy', of monetary policy has undergone radical changes in most industrial countries during the last few decades. These changes have been paralleled by a similarly radical development of financial markets – including money markets (short-term debt markets), which are the main 'forum' for the implementation of monetary policy. The instruments available to a central bank usually fall into one of three categories: direct regulations (e.g. interest-rate regulations and credit ceilings), standing facilities (deposits and loans at the central bank available to banks at their own initiative), or discretionary operations (e.g. repurchase transactions, foreign-exchange swaps, issuance of central-bank securities or outright transactions in short-term markets). In the post-war period, up to the early or mid-1980s, central banks used to rely primarily on the former two categories. The financial deregulation wave of the 1980s and 1990s largely coincided with, or was conditional on, a general reorientation of monetary-policy operating procedures toward the third category. Both the tools used by central banks and the variables on which the tools were designed to operate shifted – essentially from a Keynesian demand-side-oriented monetary policy operating on monetary aggregates, to an inflation-oriented monetary policy operating on interest rates and playing on market terms.

In this chapter, we study the parallel processes of financial market deregulation and development on the one hand, and reform of the operative frameworks of monetary policy on the other, and the extent and nature of the association between the two processes, in 11 small, European countries from the beginning of the 1980s and up to the launch of EMU. We focus on the development of domestic money markets, and address aspects of this development such as the size and structure of various market segments, and institutional and regulatory changes, besides empirically examining the extent of reorientation of monetary policy instruments. We hypothesise that the parallel processes are intertwined and that developments in any one particular country are best described as a continuous interplay of market outcomes and policy choices.[1] We also provide tentative empirical evidence to that effect.

The 11 countries in our study are basically just a complete list of the developed European countries that *unambiguously* fitted the 'small, open economy' criterion

(and had their own currencies) during the 1980s and 1990s. The countries are: Austria, Belgium, Denmark, Finland, Greece, Ireland, the Netherlands, Norway, Portugal, Sweden and Switzerland. The diversity of these countries in terms of monetary policy regimes pursued (from hard-currency countries such as Austria, to countries with near-emerging-market status, such as Greece) and level of institutional integration (from core EMU countries such as the Netherlands to *sonderweg*, non-EU countries such as Norway) also make them an excellent laboratory as regards the link between money market development and the conduct of monetary policy. The choice of study period is based on previous research on the financial-market 'transformation' process (Oxelheim 1996).

The chapter is structured in the following way. We begin by reviewing the main developments in domestic money markets. These largely comprise two interlinked processes: deregulation and liberalisation on the part of authorities, and innovation and growth on the part of 'markets'. These two processes are treated in separate sub-sections. The next section mirrors the first in that it analyses the changing operative procedures of central banks along two lines: the decreasing role of direct controls (closely related to the general deregulation of financial markets), and the increasing role of market operations. In the following section, we identify the main drivers of the changes in central-bank operations. Thereafter, we empirically examine the sources and effects of fluctuations in money-market liquidity in the case countries and give tentative evidence of a determinant of the intensity of open market operations. A final section concludes.

General developments in domestic money markets

The countries covered in this chapter all followed the general trend among industrial countries of broad-based financial-sector deregulation in the 1980s and 1990s. Below, we make a brief summary of that process. We go on to recount the main developments in money market innovation, differentiation and growth, in each of the countries.

Financial deregulation

The regulations in force in a majority of European countries until the 1970s or, in most cases, the 1980s were of four major types: interest-rate controls, quantitative credit and investment regulations, restrictions on the issuance of financial instruments and market-entry/branching or ownership restrictions. These 'repressive' regulations typically served multiple purposes but the major ones were to achieve monetary control and to achieve broader social/economic policy objectives.

As can be seen from Table 6.1, which summarises the situation around 1980 in terms of regulation in the sample countries, several countries applied all major types of regulation. For instance, Portugal in 1980 was very much still marked by the effects of the nationalisation of financial sector in 1974 and a system whereby the Banco de Portugal was equipped with almost limitless authority to intervene

Table 6.1 Financial repression in 1980

	Interest-rate restrictions	Specific credit controls[a]	Overall credit growth limit	Investment obligations	Issuing restrictions	Branching restrictions
Austria	√	√	√	√	√	√
Belgium	√	√	–[b]	√	√	√
Finland	√	√	–	–	√	√
Greece	√	√	√	√	√	√
Ireland	√	√	√	n.a.	n.a.	n.a.
Netherlands	–	√	√	–	√	√[d]
Portugal	√	√	√	√	√	√
Denmark	√	√[e]	√[c]	–	√	–
Sweden	√	√	–	√	√	√
Norway	√	√	√		√	√
Switzerland	√	–	–	–	√	√

n.a.: Information not available.

Notes:
a Quotas or ceilings imposed on individual banks or groups of banks/financial institutions, and similar detailed credit controls.
b Abolished in 1978.
c Formally guidelines.
d No real restrictions, but a separation in a legal sense of different types of credit institution was made, and the rules on prudential supervision varied accordingly.
e Abolished in 1980.

Sources: Edey and Hviding (1995); OECD *Financial Market Trends* (various); Oxelheim (1990, 1996); Vihriälä (1997); Wyplosz (2001); various national sources.

in all aspects of financial intermediation. All or most regulation types were also used, in Austria, Greece, Norway and Sweden for instance.

(*a*) *Interest-rate regulations* were in force in all countries in the sample except the Netherlands at the start of the study period (see Table 6.1). Administrative control over interest rates – in particular, keeping interest rates at low levels – was used as a general monetary-policy instrument, as a way to boost demand and as a means of providing cheap financing for the government.

Interest-rate controls began to be dismantled in the late 1970s in Austria, Denmark, Ireland, Norway and Sweden. By the mid-1980s, interest rates in Denmark, Ireland, Norway and Sweden (as well as the Netherlands) had been essentially liberalised. In most of the continental-European countries, the main steps were taken in the second half of the 1980s.

By 1990, Austria, Finland and Switzerland had also completely liberalised interest rates; Belgium had, in principle, also deregulated interest rates, but retained some minor controls on specific categories or types of credit. The last among the survey countries to abolish interest-rate regulations, Greece and Portugal, completed the process a few years into the 1990s, in accordance with their gradual implementation of European Community directives (see Rautava 1994; Edey and Hviding 1995).

The typical sequencing pattern was that the liberalisation of wholesale interest rates occurred first, followed by lending rates and deposit rates.[2] The process was mostly gradual, and sometimes hesitant on the part of the authorities. An illustration of this is that formal rules and restrictions (a ceiling, a quota etc.) were often initially followed by *implicit* regulations in the form of recommendations or various types of agreement before being *de facto* liberalised. Such was the case in Austria, Belgium, Denmark, Greece, Ireland, Norway, Portugal and Sweden. These implicit regulations were enforced through the understanding that the central bank could, and would, enforce its goals by means of the reinstatement of formal regulations if deemed necessary; see, e.g., Grønvik (1994).[3]

(*b*) *Quantitative credit and investment restrictions*, in one form or another, were employed in a majority of the countries (again, see Table 6.1). The low-interest-rate policies pursued by several of the countries, in combination with high inflation rates, led to very low (or even negative) real interest-rate levels. This, in turn, led to high credit demand, indicating that credit had to be rationed and the market as a whole had to be regulated in detail, as regards both prices and quantities.

As an effect of the co-dependence of various types of regulation, credit controls to some extent became obsolete or irrelevant as interest rates were being liberalised.[4] Hence, most of these regulations were abolished in Austria, Denmark, Finland, Ireland, Netherlands and Sweden in the first half of the 1980s. Belgium had initiated the deregulation of credit in 1979 but the process took more or less the entire 1980s to be completed. Of the other countries, Switzerland had not applied quantitative controls since the 1970s. Norway abolished credit regulations in 1988, Portugal around 1990, and Greece a few years into the 1990s.

(*c*) *Issuing restrictions* on securities were used to control the extension of credit through direct channels (i.e. through issues in the open market). Usually, rules and regulations on minimum maturities etc. were combined with various authorisation requirements.

The initial emergence of short-term securities markets in several countries was directly conditional on the abolition of one or several restrictions on the issuance of debt securities. Conversely, where such deregulations did not occur, or occurred late, an important condition for the emergence and growth of markets was lacking. Controls on (debt) securities issuance were mostly in place for slightly longer than interest rate and credit controls. Exceptions are Denmark (which had a relatively free and internationally oriented bond market based on private debt already in the 1970s), and the Netherlands, where regulation was comparatively limited. Switzerland was low on formal regulation but the growth of the domestic market was hampered by business practice, as well as by tax policy and other factors. Finland, Ireland, Sweden and Switzerland lifted issuing controls in the first half of the 1980s. In some countries important liberalisation measures were implemented in the mid-1980s (for instance in Norway – see Norges Bank, *Penger & Kreditt*, 26:1, 1995). The Netherlands, although comparatively liberal in several respects, applied rules on minimum maturities that constrained the development of short-term markets and were fully abolished only in 1990.

In other countries, important steps toward the opening-up of securities markets occurred in the context of a reform of government-financing systems. Such is the case, for example, in Austria and Belgium - around 1990 – (De Broeck *et al*. 1998) and Greece - early/mid-1990s – (Soumelis 1995). Generally, however, the liberalisation of markets for private debt was slower than other categories. For instance, the Portuguese fixed-income market was not formally opened to all domestic issuers until 1994 and to foreign issuers 1995 (de Pinho 2000). Also, as previously mentioned, market development was in some cases stifled by the existence of various types of more or less informal authorisation requirement. For instance, Switzerland abolished numerous cartel-like conventions and permanent securities-issuance syndicates of banks in 1990.

(*d*) *Market-entry rules* or *line-of-business regulations* – the separation of banking and securities businesses, the separation of commercial banking from investment or savings banking, and other branching restrictions – limited the segmental integration within the financial system. A similar effect is implied by regulations limiting *ownership* linkages between different types of financial institution, between financial institutions and other industry sectors, and between domestic and foreign institutions. In addition, one sort of 'ownership restriction' was the indirect control by the government of the financial sector through the dominance of state-owned banks in combination with market-entry restrictions. This applies primarily to the countries with previously entirely nationalised financial sectors (Greece and Portugal) but also, to some extent and during some periods, in other countries. In Norway, for instance, government ownership of major banks was one consequence of the banking crisis around 1990.

Regulations within this category were partly or wholly lifted in the 1980s and early 1990s in some countries, including Austria, Belgium, Denmark (where de-compartmentalisation of the banking sector had occurred already in 1975), Finland, Norway and Sweden. Moreover, a 'spontaneous' functional market integration (taking place, for instance, through banks establishing subsidiaries within the securities-trading business, or purchasing finance companies) is often considered a major feature of the financial-market transformation process undergone by the industrial countries in the 1980s; see e.g. the survey in OECD (1989). To some extent, this implies a diminishing practical importance of remaining regulations.

Restrictions on foreign-bank entry should also be included in this category. In the sample, Finland, Norway, Portugal and Sweden were among those countries that opened their domestic markets for foreign banks during the 1980s. In some other countries, including the Netherlands and Switzerland, rules on foreign-bank access to the domestic market were already relatively liberal at the start of the 1980s, whereas in much of the rest of the continental European countries significant steps were taken only with the implementation of the EU's Second Banking Directive (effective in 1993).

In the area of ownership control, the deregulation wave made a comparatively modest impression in the 1980s and 1990s, and several such regulations remained in the mid-1990s (Herring and Litan 1995). State-ownership of a large proportion of domestic financial institutions also outlived financial deregulation in some countries. The Greek banking sector, for instance, was still completely

dominated by state-owned banks when ownership regulations were abolished. In terms of assets, the government's ownership share was about 75% (see Hope 1993). In other countries, state-ownership of banks became an effect of banking crises in the early 1990s: after the crises, the governments of Norway and Finland ended up with ownership shares of 52% and 35%, respectively; see the *Banker* (1993); also see the *Economist* (1992) and Warner (1993) for short background articles on the deregulation and privatisation of Portuguese banks.

The deregulation process in the 11 focus countries is summarised in Table 6.2.

Table 6.2 Summary of the financial deregulation process

	Deregulation initiated in... (item(s) first liberalised):	*Financial sector lastly liberalised by... (item(s) last deregulated):*
Austria	1979 (some interest rates liberalised)	1990s (authorisation requirement for securities issues lifted)
Belgium	1978 (credit ceiling abolished)	1992 (decompartmentalisation / decartelisation of banks)
Finland	1983 (some interest rates liberalised)	1991 (authorisation requirement for securities issues lifted etc.)
Greece	1987 (some interest rates liberalised)	Mid-1990s (deregulation of banking)
Ireland	1984 (some interest rates liberalised; credit guidelines lifted)	Late 1980s[a]
Netherlands	1981 (credit controls lifted)[b]	*c* 1990 (minimum-maturity requirement for securities abolished)
Portugal	1984 (some interest rates liberalised; market-entry rules eased)	1994 (securities markets fully opened for private issuers)
Denmark	1980 (bank lending ceilings lifted)[c]	1989 (issuing controls on securities completely abolished)
Sweden	1978 (some interest rates liberalised)	1985 (ceilings on bank lending lifted)
Norway	*c* 1980 (some interest rates deregulated)	1990 (all quantitative controls and most issuing controls abolished by this time)
Switzerland	Early 1980s (interest rates on bonds liberalised)[d]	*c* 1990 (issuing restrictions abolished; permanent securities-issuance syndicates dissolved)

Notes:
a Minor interest-rate 'rigidities' (in the shape of informal agreements) remained until the mid-1990s.
b Less regulated overall at the start of the 1980s than most other markets here included; interest rates were essentially already free in the 1970s.
c Less regulated overall at the start of the 1980s than most other markets here included: a decompartmentalisation of banking had already been carried out in 1975; some interest rates were free during the 1970s (but partly reregulated in 1979), etc.
d Most other interest rates already free.

Sources: See Table 6.1.

Money market growth and development

The money market is usually defined as a market for short-term debt, generally with original maturities of up to one year (Stigum 1983). One main segment of money markets is the interbank market. The other segments are primary and secondary markets for various short-term securities, and a derivatives market. The foreign-exchange (FX) markets and domestic money markets are also closely interlinked through the existence of markets for forward-exchange contracts and swaps, which make certain types of FX transaction equivalent to single-currency transactions.

Because the interbank segment is defined *in terms of participants* and the 'open-market' segments usually *in terms of instrument* there is a considerable overlap between these segments. The interbank market is sometimes taken to mean the market for very short-term, that is, overnight up to a few weeks, deposits and loans. Central-bank facilities for such deposits and loans are included. Virtually all types of instrument – including derivatives – are traded interbank. The segmental structure is therefore not wholly clear, and tends to vary from country to country.

Table 6.3 summarises the starting years for the main segments in all 11 countries. It indicates a progressive convergence during the 1980s and 1990s of the *presence* of different types of money-market instrument.

The most traditional money-market segment is the interbank deposit market. It includes the central bank's deposit and loan facilities and its structure and function are, as a consequence, to a high degree determined by the incentives regarding banks' liquidity management implied by the central bank's choice of operative framework. Deposit markets turned up in most countries as monetary policy instruments changed during the 1980s and 1990s. The segment largely retained its importance throughout the 1990s in spite of the emergence of alternative instruments (such as repurchase agreements in particular). For instance, transactions in the uncollateralised segment were estimated at about twice the size of collateralised transactions in the euro area in 1999 (Santillán *et al.* 2000).

In the short-term securities markets, considerable dissimilarities can be seen between the focus countries, both in terms of the relative total size of the market and in terms of the relative importance of specific segments of the market, as evidenced in Figure 6.1 and Table 6.4.

In the short-term securities segment, Treasury bills or equivalent short-term government securities are typically the most important sub-market. In several countries (Austria, Belgium, Ireland and Sweden, for example), short-term government securities have existed for a long time, but were traditionally non-marketable, and sold directly to final holders at regulated rates until a decade or two ago. True markets for T-bills mostly emerged in connection with relaxations or complete abolition of issuing restrictions (years are shown in Table 6.3).

Two other main cash-instrument types — commercial paper (generally issued by non-bank entities) and certificates of deposit (a securitised bank liability) — were introduced in several countries in the mid-1980s but, as revealed by Table 6.4, their importance varies greatly. In some cases (for example Finland and Sweden), the introduction of CDs preceded the introduction of tradable

Table 6.3 Money-market innovations, domestic market (year of introduction or year of deregulation of various money market segments)

	Interbank deposit market/ '-IBOR' reference rate	Treasury bills or treasury notes	CDs/ central-bank CDs	Commercial paper	Single-currency interest-rate futures	Single-currency interest-rate swaps and/or options	Foreign-exchange or currency swaps[a]	Repo market/ repos adopted by central bank
Austria	n.a./1989	1987[b]	../1995	..	1993	1994	c 1990	../1995[c]
Belgium	1988/1988	1990[d]	1992/..	1990	1988	1991	1980s	n.a./n.a.[e]
Finland	1986/1987	1991	1982/1987	1986	1992	1988	1980s	../1991
Greece	n.a./1994	1985	../..	..	g	g	g	c 1995/1997
Ireland	1978/1993	1960s[h]	n.a./..	1989	1989	1989	c 1990	1997/1997
Netherlands	n.a./1986	1970s	1986/1994	1986	1987	1994[i]	1976	n.a./n.a.
Portugal	1989[l]/1992	1985[m]	1993/1994	1994	1996	1993	1987	n.a./c. 1992
Denmark	1970s[f]/1988	1975	../1992	..	1988	1988	1970s	1993/1992
Sweden	1985/1987	1982	1980/1992	1983	1984	1985	n.a.	1980s/1984
Norway	1993/1993[j]	1985	1985/..	1985	1993	n.a.	1970s	1996/..[k]
Switzerland	n.a./n.a.	1981	../..	..	1990	1994[i]	1970s[n]	1998/1998

.. Not applicable / a viable market in the instrument does not exist.

n.a.: Data not available.

Notes:

a Refers to 'interbank swaps'; central banks have been using swaplike instruments for considerably longer – the German Bundesbank, e.g., since 1958 (Hooyman, 1994).

b Refers to the year from which government debt is issued by competitive bidding.

c The OeNB started to make advances against securities in 1985, but began to make systematic use of repos only in 1995.

d Refers to the year from which treasury certificates are issued by competitive bidding.

e The BNB has been conducting advances against collateral for a long time.

f The market remained inactive until the reform of the monetary-policy operating framework in 1992.

g A limited derivatives market has existed since 1994.

h Exchequer bills.

i Options.

j Refers to the domestic reference rate NIDR; an 'international' reference rate (NIBOR) also exists.

k Norges Bank conducted 'temporary bond purchases' between 1984 and 1986.

l Refers to the year of liberalisation of the interbank market.

m Treasury bills; so-called 'negotiable cash bonds' were introduced in 1983.

n The SNB has been using swaps for monetary-policy-making purposes for a longer time.

Sources: Alworth and Borio (1993); BIS (1999); Batten *et al.* (1990); De Broeck *et al.* (1998); *Euromoney* country surveys (various); Holbik (1991); Khoury (1990); Kullberg (1991); Lahdenperä (1995); Norges Bank (1995); OECD *Financial Market Trends* (various); Oxelheim (1996); Pinto (1996); and sources to Table 6.4.

(a) EMU countries

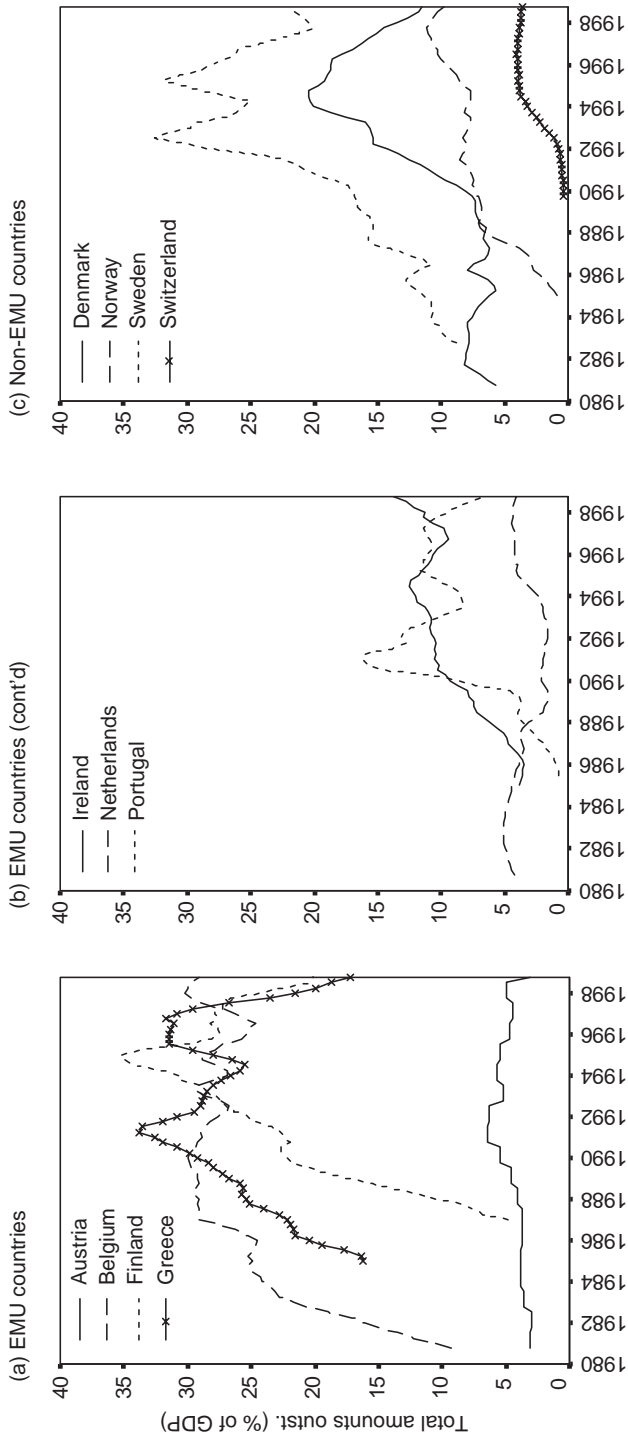(b) EMU countries (cont'd)

(c) Non-EMU countries

Figure 6.1 Total outstanding amounts of short-term securities (% of GDP); one-year moving averages of quarterly, end-of-period data (except Austria: annual data). *Notes* and *Sources*, see Table 6.4.

Table 6.4 Short-term securities markets, outstanding amounts (% of GDP at year-end)

	1985					1992					1998				
	T-bills/ notes	CDs	CB CDs	CP/ other	Total	T-bills/ notes	CDs	CB CDs	CP/ other	Total	T-bills/ notes	CDs	CB CDs	CP/ other	Total
AT	3.7				3.7	5.2				5.2	3.2				3.2
BE	24.0				24.0	24.0	1.8	1.0	3.1	28.8	16.9	5.9		4.0	26.8
FI[a]					0	3.1	16.9		3.8	24.8	2.3	16.0	0.8	1.7	20.7
GR	24.3				24.3	29.8				29.8	15.0				15.0
IE	1.5	2.1[b]			3.6	0.4	4.5[b]		4.8	9.7	2.2	4.2[b]		9.5	16.0
NL[c]	4.0				4.0	0.0	1.3		0.7	4.0	2.1	0.8	0.0	0.5	3.4
PT[d]	0.8				0.8	8.4				8.4	2.1	0.2		2.3	4.5
DK	4.7	3.9			8.6	14.3		0.6		14.9	9.2		3.0		12.3
SE[e]	11.5	1.2			12.7	20.5	0.8		8.2	29.4	12.9	1.1		6.6	20.7
NO[f]	1.6	0.1		1.1	2.8	4.7	0.0		1.9	6.6	2.4	3.9		2.8	9.1
CH					0	2.0				2.0	3.7				3.7
Mean					7.7					14.9					12.3
(sd)					(9.0)					(11.1)					(8.2)

Notes:
a 'CP/other' includes industrial paper and local authority paper.
b Saving certificates.
c Incomplete data on CDs before 1990; CP: annual data until 1990.
d T-bills: amounts for 1985 include only T-bills held by banks and other monetary institutions; CDs: includes only certificates held by non-financial corporations.
e 'CP/other' includes certificates issued by mortgage credit institutions, industrial paper, finance-company promissory notes, and local-government paper.
f 'CP/other' includes notes of mortgage credit institutions and financial institutions, and other short-term paper.

Sources: Austrian Federal Ministry of Finance (BMF) and Austrian Federal Financing Agency (BFA); Ministère des Finances Belge, Administration de la Trésorerie; Danmarks Nationalbank; Suomen Pankki; Bank of Greece; Central Bank of Ireland; De Nederlandsche Bank; Norges Bank; Banco de Portugal; Sveriges Riksbank; Banque Nationale Suisse; BIS, *Quarterly Review: International Banking and Financial Market Developments* (various); GDP figures from IMF *International Financial Statistics*.

government securities. In other cases, diversification of the market to other than government issues occurred several years after a T-bill market had been established (Ireland, the Netherlands, Portugal).

Commercial-paper markets gained importance in some (but far from all) countries toward the late 1980s (Norway, Sweden) or further into the 1990s (Belgium, Ireland). There seems to be some indication that where commercial-paper markets could be benchmarked against a liquid government-bill market (or other instrument with a market-supporting role), their development came earlier and was more extensive (Alworth and Borio 1993).

In addition to these cash instruments, various derivative instruments play an important role, as do repurchase agreements (repos), which – according to BIS estimates – was the fastest growing instrument/transaction type internationally during the 1990s. However, data are scarce. Reporting in different countries is also such that available historical data are not readily comparable (BIS 1999). Existing data indicate considerable variations in derivatives as well as repo markets. For example, in Belgium, repos became the main financing tool for domestic banks in the 1990s and largely replaced more traditional interbank transaction types (Commission of the European Communities 1999). Similar trends were visible in other countries (particularly those with ample stocks of collateral). Others were partly stifled by thin debt markets (the Netherlands, Norway), ambiguities with regard to regulatory policies, legal status and tax treatment (Ireland, Portugal, Switzerland), or excessive concentration of market participants.

Changes in central-bank operations 1980–2000[5]

Until the mid-1980s central banks relied largely on traditional deposit and loan facilities (standing facilities), supported by various direct controls, for the conduct of monetary policy. The ordinary credit facilities were mostly supplemented by some sort of tranche-division system (Denmark, Finland), penalty-rate system (Austria, Sweden), or a combination of both (Belgium, the Netherlands) to allow central-bank control of the marginal cost of banks' borrowing under the facilities, and thereby of the supply of liquidity to the banking system.

All our focus countries reformed their operative frameworks for monetary policy substantially during the 20 years we study. In some countries, the revision of the monetary-policy operating framework took the form of comprehensive reforms (Denmark 1992, Switzerland 2000); in others, developments proceeded more piecemeal (see Table 6.5). In several countries (Belgium, Finland, the Netherlands) the trend toward a gradually increasing diversification of liquidity-supply instruments became visible toward the mid-to-late 1980s. Others followed suit during the 1990s (Denmark, Portugal, Austria).

The diminishing role of quantitative controls

The diversification of instruments used by central banks as well as by other money-market participants during the 1980s and 1990s in parallel with the lifting

Table 6.5 Some major changes in central-bank operating procedures between repression and EMU[a]

Country	Year	Change of monetary policy (instruments)/main components of change
AT[b]	1995	Reform of liquidity-management arrangements: introduction of repurchase transactions for liquidity provision and of central-bank CDs for liquidity absorption; reduction of reserve ratios.
BE[b]	Mid-1970s	Abolition of reserve requirements.
	1985	Introduction of a more flexible discount-setting system, and revision of the central bank's credit and deposit facilities (resulting ultimately in the emergence of an efficient day-to-day interbank market).
	1991	Tender procedures introduced for the issuance of government paper, leading to more market-oriented procedures for monetary policy, including the gradual adoption of repurchase transactions as the main liquidity-management instrument.
FI[b]	1983	Quotas for central-bank credit abolished; banks asked to manage liquidity through call-money market.
	1987	Open-market operations in CDs initiated.
	1991	Repurchase transactions introduced by the central bank.
	1992–95	Several adjustments in the technical design of the central bank's credit and deposit facilities, as well as that of the minimum-reserve system.
GR[b]	c 1990	The central bank switches its operational regime from direct regulation to indirect instruments.
	1997	Repurchase transactions initiated by the central bank.
IE[b]	Mid-1980s	The exchequer-account overdraft facility is abolished; collateralised operations introduced.
	Mid-1990s	The central bank stops discounting exchequer bills, and adopts repurchase transactions as its keynote operation; minimum reserve ratios substantially reduced.
NL[b]	1994	Reform of liquidity-policy framework; central-bank CDs introduced.
	1998	Reform of liquidity-policy framework.
PT[b]	1985	The central bank starts to issue treasury bills on behalf of the government.
	1986	The central bank is formally authorised to issue short-term securities and to pay interest on the government's and the credit institutions' deposits.

Continued

Table 6.5 cont'd

Country	Year	Change of monetary policy (instruments)/ main components of change
	1992	Repurchase transactions initiated by the central bank.
	1994	Revision of liquidity-policy framework: central-bank CDs introduced; the central bank's credit facilities still relatively complex, with some facilities subject to quotas, some available at penalty rates.
DK	1992	Comprehensive reform of monetary-policy instruments: revision of the central bank's credit and deposit facilities (so as to stimulate money-market activity); introduction of central-bank CDs for liquidity absorption and of repurchase transactions for liquidity provision; no reserve requirements.
	1999	Extension of collateral basis for the central bank's repos and some other minor changes of technical nature.
SE	1985	Reform of the central-bank's credit and deposit facilities: the fixed-quota-and-penalty-rate system was abolished, and an 'interest-rate ladder' was introduced.
	1988	Changes in operating procedures: liquidity may be supplied to banks by lending on market terms.
	1990	Reserve requirements lifted (formally set to zero).
	1993–97	The central bank issues its own CDs to soak up liquidity.
	1994	New interest-rate-management system introduced (motivated largely on the new monetary-policy regime – the inflation target), based on *Bundesbank*-type repos, with the fixed repo rate serving as target for the overnight interbank rate.
NO	1984–1987	The central bank conducts 'temporary bond purchases' – effectively a form of repurchase transactions.
	1985	The certificates market was launched, expressly for the purpose of involving the public more directly in the money market, increasing the control of the central bank over the supply of liquidity and enhancing the efficiency of monetary-policy transmission.
	1987	Reserve requirements abolished.
	Mid-1990s	Simplification of the central bank's credit and deposit facilities; (re)introduction of repurchase transactions for liquidity provision.

Table 6.5 cont'd

Country	Year	Change of monetary policy (instruments)/main components of change
CH	1998	Repurchase transactions initiated by the central bank.
	2000	Reform of monetary-policy framework: interest-rate targeting strategy replaces the traditional monetary-targeting strategy; repurchase transactions become the central bank's keynote operation.

Notes:

a All EMU countries' central banks together with the ECB make up the Eurosystem and have shared a common policy framework since 1999 (Greece since 2001); the main refinancing operations of the ESCB are executed by the national central banks.

Selected sources: BIS (1997b); Schweizerische Nationalbank, Bulletin Trimestriel 4 (1999); Borio (1997); Danmarks Nationalbank (1992, 1999); Hasko (1996); Hasko and Kuisma (1995); Hörngren (1994); Kasman (1992); Kneeshaw and van den Bergh (1989); Kuosmanen (1996); Mehlbye and Topp (1996); Norges Bank (1995); Oxelheim (1996); Pinto (1996); Sveriges Riksbank (1994).

of most direct regulations. This sub-section therefore focuses on one direct control that remained in use by many central banks – the minimum reserve requirement.

During the 1990s, practically all our case countries followed an international trend among industrial countries toward lowering or completely abolishing reserve requirements (see Table 6.6). The major arguments behind these reforms were to reduce the tax effect of reserve requirements and to neutralise the competitive disadvantage of subjected depository institutions vis-à-vis other financial institutions – domestic or foreign (Bank of Japan 1995).

The original objectives of the reserve-requirement instrument were to maintain banks' liquidity even in the case of large deposit withdrawals, and to influence liquidity for monetary-policy purposes. The function of reserve requirements as a mechanism to control monetary-aggregate quantities on an ongoing basis was largely abandoned during the late 1980s or early 1990s. Nowadays, reserve requirements serve three main purposes. One is as a means of providing for banks' ongoing liquidity needs (having banks in a position of reliance on the central bank facilitates the conduct of monetary policy). A second purpose is to improve the flexibility of banks' liquidity management (reserves can be used to settle interbank payments). Finally, reserve requirements (particularly if unremunerated) can provide seigniorage income for the central bank, thereby contributing to its profitability and (economic) independence (Grønvik 1994; Bank of Finland Bulletin 12 1996; BIS 2003).

Countries that abandoned the use of reserve requirements more or less entirely relatively early on include Belgium (mid-1970s), Norway (1987) and Sweden (1990). In Norway, for example, both primary reserves (that is, cash-reserve requirements) and secondary reserves (compulsory bond holdings by banks and

Table 6.6 Reserve requirements

	1970s		Late 1980s[a]			Late 1990s[b]		
	RRIF	Max.	RRIF	Max.	Diff.	RRIF	Max.	Diff.
Austria	√	10.5[c]	√	9.0[d]	√	√	5.0	√
Belgium	√	6.2[e]	×	×	×	×	×	×
Finland	√	3.2[f]	√	7.8	×	√	2.0	√
Greece	√	n.a.	√	n.a.	n.a.	√	12.0	×
Ireland	√	13.0[f]	√	10.0[g]	–	√	3.0	×
Netherlands	√	7.0[h]	√	var.	√	√	var.	√
Portugal	√	15.0[e]	√	17.0[i]	×	√	2.0	×
Denmark	√[j]	3.0	×	×	×	×	×	×
Sweden	√	5.0[e]	√	4.0	×	×[k]	×	×
Norway	√	5.5[l]	×	×	×	×	×	×
Switzerland	√	n.a.	√	2.5	√	√	2.5	×
Memo:								
Eurosystem[m]	..	..	..	..	..	√	2.0	×

RRIF: Reserve requirements in force
√ Yes
× No
Max.: Maximum reserve ratio applied.
Diff.: Different ratios for different types of liabilities/deposit (this information was unavailable for a majority of countries for the 1970s; therefore the column has been left out for that decade).
.. Not applicable
n.a. Not available

Notes:
a 1988 unless otherwise indicated;
b Individual country ratios of EMU countries refer to ratios applied before the launch of the Eurosystem;
c 1972;
d 1990;
e 1974;
f 1979;
g 1986;
h 1973;
i 1989;
j Temporarily in force 1975–76;
k The required reserve ratio was set to zero in April 1994, and has not been used as a policy instrument since;
l 1976;
m since 1999.

Sources: BIS (1997b); Bank of Japan (1995); Borio (1997); Central-bank bulletins (various); ECB (1998); Holbik (1973); Kneeshaw and Van den Bergh (1989); OECD Financial Market Trends (various); Pinto (1996).

insurance companies) had been used since the 1960s. From 1971 only the primary reserve requirements were used in Norway, but they were altered often and by a lot.

Minimum reserve requirements were in use as a liquidity-management instrument until the late 1990s in the Netherlands, Austria, Finland, and Ireland;

but the only country where they played a significant role for active liquidity management until the late 1990s was Greece (until its entry into the EMU), where the instrument was deemed necessary to retain control over the liquidity supply in the face of large capital inflows (this parallels earlier experiences in, for instance, Portugal).

The increasing role of market instruments in central-bank operations

Three main types of discretionary instrument predominate: short-term (cash) securities, repurchase operations, and swaps. Effective open-market operations to some extent presuppose an existing market to operate in. Thus, central banks have typically, at some point or other, come to favour the creation of markets, and have often stimulated and supported their development. This holds for interbank deposit markets as well as for short-term securities markets.

The absence of an efficient interbank market is bad news for the central bank because banks may then rely on central-bank facilities to gain access to liquidity even when other banks are very liquid, creating a situation of excess liquidity in the banking system and poorer monetary transmission.[6] For monetary policy to bite, banks' *marginal* liquidity needs must be settled with the central bank. Hence, when – as a consequence of financial deregulation – direct controls (such as specific credit quotas to individual banks) can no longer be used to deal with excess-liquidity problems, there appears an incentive for central banks to create adequate instruments to drain liquidity and to stimulate the formation of markets for alternative short-term assets. Examples are the establishment of efficient day-to-day interbank markets in Belgium and Sweden (1985–88), both of which were anticipated effects of changes in the layout of monetary-policy operating procedures (BNB 1985; Kneeshaw and Van den Bergh 1989). More generally, the initial emergence of a markka money market was stimulated by the Bank of Finland's decision to withdraw its presence from the forward exchange market (around 1980). Parallels exist in, for example, Denmark and Portugal (Danmarks Nationalbank *Monetary Review*, August 1996; Pinto 1996).

The emergence of short-term securities markets adds a dimension to liquidity management for central banks. In practice, cash operations in short-term securities by central banks are relatively rare, even where the size of these markets is sufficiently large to make such operations feasible (Borio 1997). One reason is that other types of operation are more flexible. Other reasons which have carried some weight in several countries are the wish to avoid potential conflict with other public-policy objectives – notably public-debt management (for example in Denmark and Portugal) and tax policy, and the wish to avoid circumvention of limits on central-bank lending to the government. These problems are particularly relevant in emerging stages of money-market development (Mehran *et al*. 1996; Kneeshaw and Van den Bergh 1989).

To avoid conflicts of interest and to increase the effectiveness of monetary policy, it has been relatively common for central banks in small countries to issue their own securities (central-bank CDs) in the primary market in order to

absorb liquidity from the banking system. In some cases, this was one of the main strategies of the central bank. Countries where the issue of central-bank paper played an important role during shorter or longer periods include Finland (from 1987 onward, but particularly during the 1990s), the Netherlands (1994–9), and to some extent Ireland and Portugal among the EMU countries; and Denmark (1992 onward) and Sweden (1992–6) among the non-EMU countries.

Even in the absence of outright transactions in securities, the existence of a liquid securities segment in the money market is often argued to facilitate the central bank's operations by providing collateral for repurchase agreements and similar collateralised transactions. To the extent that it does so, the varying degrees to which short-term securities markets have emerged in the focus countries imply correspondingly varying possibilities for the respective central banks to exploit the flexibility and other advantages of repurchase agreements and similar instruments.[7] During the course of the 1990s this type of instrument was adopted as a main liquidity-management instrument in Austria (1995), Finland (mid-1990s), Denmark (1992), the Netherlands (refers to 'special loans'), Sweden (1994), Switzerland (1998), and then, from the time of its inception in 1999, in the whole Eurosystem (see Table 6.7).

In principle, of course, any type of security — not just short-term securities — may be used to underpin collateralised transactions. The common argument that efficient short-term securities markets are needed for the conduct of open-market operations by central banks is therefore not necessarily particularly strong (see, however, below). Recent developments, in which the ECB has gradually expanded its palette of security types eligible for collateral in repurchase operations, are also an illustration of this. In the US (BIS 2001) and the UK (Bank of England 2002), where that palette is somewhat narrower, the debate in recent years has been more concerned with the 'quality' (rather than the original maturity) of the collateral: more specifically, the concern has been with the feasibility of open market operations and the eligibility of private securities for central bank operations in an environment of declining government issues (McCauley 2001, and Wojnilower 2000).

Nonetheless, the introduction of the common monetary-policy framework in the euro area in 1999 altered the use of *short-term* paper as collateral for central-bank operations quite substantially. In most EMU countries, the use of short-term paper (particularly T-bills) as collateral for the ECB's refinancing operations increased as compared to the pre-EMU collateralised transactions of the respective national central banks. In Belgium, Ireland and the Netherlands, the proportion remained largely unchanged, whereas in Portugal and Finland, it decreased.[8]

Some countries without liquid short-term markets relied on foreign-exchange operations (particularly swaps) for liquidity management. The pre-eminence of swaps over spot or regular forward-exchange operations simply reflects the greater importance of swaps in the interbank market. Swaps are the major instrument by which banks cover their forward foreign-exchange commitments to customers (Hooyman, 1994). Countries where FX swaps played a significant role for liquidity management by the central bank and/or by the banking system as a whole include

Table 6.7 Targets and main open-market operations before the launch of EMU

Country	Orientation/ main target	Main operating variable	Key instrument	Collateral for repurchase transactions	Other open-market operations
Austria	Exchange rate	Overnight rate	Repurchase agreements	Government and private securities	Foreign-exchange swaps
Belgium	Exchange rate	1–3-month rate	Repurchase agreements	Trade bills; government securities	Interbank operations; foreign-exchange swaps; etc.
Finland	Inflation (formally)/ exchange rate	1–3-month rate	Repurchase agreements	T-bills; government bonds; central-bank and bank CDs; AMCA notes[a]	Outright money-market operations; sales of central-bank CDs; foreign-exchange operations
Greece	Inflation/ exchange rate	M3/M4N growth rate and total credit expansion are 'tentative' targets	Deposit tender operations	Government securities	Reverse repos; foreign-exchange swaps
Ireland	Inflation/ exchange rate	1-month rate	Repurchase agreements	Government securities	Foreign-exchange swaps
Netherlands	Exchange rate	1-month rate	'Special loans' (repo-equiv.)	Government and private securities	Sales of short-term paper; foreign-exchange swaps; etc.
Portugal	Inflation/ exchange rate	Overnight rate	Repurchase agreements	Government securities[b]	Central-bank CDs; TIM[c]

Table 6.7 cont'd

Country	Orientation/main target	Main operating variable	Key instrument	Collateral for repurchase transactions	Other open-market operations
Denmark	Exchange rate	1–14-day rate	Secured loans (repo-equiv.); central-bank CDs	Government securities; mortgage bonds	Foreign-exchange operations
Sweden	Inflation	Overnight rate	Repos/reverse repos	Government and mortgage securities	Interbank operations
Norway	Exchange rate	1-week rate	Deposits and loans	T-bills and government bonds	Foreign-exchange operations; repos; T-bill issues
Switzerland	Reserves ('M0')	Giro deposits	Foreign-exchange swaps	Treasury bills	Repurchase agreements; transfer of government deposits

Notes:
a Notes issued by the Asset Management Company Arsenal.
b Private securities introduced in May, 1998, as a step in preparation for stage 3 of EMU.
c Títulos de Invervenç ao Monetária (Monetary Intervention Bills).

Sources: Banco de Portugal, *Economic Bulletin* 1 and 2 1998, and *Annual Report* 1998; *Bank of Greece, Monetary Policy Interim Report* November 1998 and March 1999, and *Annual Report* 1998; Bank of Finland *Bulletin* 9/1998; Bank of Greece, *Monetary Policy Interim Report* November 1998 and March 1999, and *Annual Report* 1998; Borio (1997); Central Bank of Ireland, *Annual Report* 1998; Danmarks Nationalbank, *Monetary Review 2,* 1999; Norges Bank, *Penger & Kreditt* 1998/4, and *Annual Reports* 1997 and 1998.

Austria, the Netherlands and Denmark. In Switzerland, USD-CHF swaps were the principal market operation of the National Bank during the period between the early 1980s and the late 1990s.[9]

There was a clear trend from the mid-1990s onward in the EMU group of countries toward a 'non-spontaneous' convergence in the arsenal of instruments used by the central banks, in the explicit anticipation of adopting a unified operational framework. This becomes clear from studying which instruments were adopted by the central banks, and also from the motivations given for the specific reforms made to the national, pre-EMU operational frameworks by the monetary authorities themselves in annual accounts and other official documents. However, there is also a case for arguing that the choice of instruments for the Eurosystem to some extent reflected broader international trends in central-bank operations: an argument which is somewhat strengthened by the observation that the non-EMU countries in our sample have largely undergone similar changes in this respect (often prior to corresponding changes in the EMU countries, as in the case with the adoption of repos in Denmark and Sweden).

Changes of central-bank operating procedures: main drivers

Because financial market regulations were partly designed as monetary policy instruments, the deregulation process is in itself sufficient reason for reformation of the operational framework of central banks: as some policy instruments are taken away, others must replace them. Therefore, the main drivers of changes in central bank operating procedures largely coincide with those of financial deregulation in general. Beyond this somewhat trivial explanation, the literature and the central banks' own accounts offer five main reasons.

First, monetary-policy instruments were changed in several countries in order to adapt the operational frameworks of the respective monetary authorities to new regimes and/or new targets for monetary (and exchange-rate) policy. The examples are manifold: the Austrian central bank, on embarking on its new 'hard-currency' policy in the late 1970s, put weight behind the new policy formulation by entering (and keeping a permanent presence in) the foreign-exchange market (Glück 1994); the Bank of Finland's 1994 revision of intervention procedures and clearer focus on interest rates were motivated by the new inflation target for monetary policy (Kuosmanen 1996); the same goes for the new interest-rate management system adopted by the Swedish Riksbank the same year (Hörngren 1994) and that of the Swiss National Bank which has been in force since January, 2000.

Second, structural factors outside the central banks' control made some of the traditional instruments outdated and the adoption of new ones necessary. Such structural factors may be quite varied. One of the primary reasons, for instance, given by the Norwegian central bank for the revisions of its operational framework in the 1990s was the need to adapt to the change in the underlying structural liquidity position of banks (from a deficit throughout the 1980s and up to 1992–3

to a surplus in the years around 1995), which, in turn, was attributed primarily to the weakening government budget; see Norges Bank (1995) and various issues of the *Economic Bulletin* of the Bank of Norway. More important, however, were the structural changes resulting from the general transformation of the financial system — a trend affecting all countries. The expansion of the financial overhang in the economy occurred more or less entirely outside the central banks' balance sheets, and therefore reduced the share of the financial system over which monetary authorities could exert direct control. The result was an increasing need for indirect ways to exercise control over the non-monetary components of the money supply. In other words, the development produced (among other things) alternative liquid assets which continually challenged the precision and purpose of a policy relying heavily on, for example, regulating the growth rate of such or such a monetary aggregate. One consequence was that *interest rates* emerged as a more relevant operating variable (prominent exceptions to the rule were, importantly, countries with largely bank-based financial systems such as Germany and Switzerland). To that extent, this second reason for central banks to change their instruments is related to the first one: structural changes outside the central banks' control indirectly called for new instruments by requiring that policy operate on different variables.

A *third* factor relates both to the expansion and diversification of financial markets domestically and to the increasing international integration of financial markets. Greater interest-rate flexibility and narrowing differentials between rates of return in different currencies gave rise to the need for instruments whereby liquidity (and thereby interest rates) could be managed more *flexibly* in time and in magnitude, and with a greater measure of *accuracy* than that offered by, say, discounting, interest-rate controls, and lending ceilings.[10]

Fourthly, the increasing importance of *expectations* in a world of free financial markets favoured the adoption of instruments better suited for *signalling* the central bank's monetary policy stance. By this token, the need for the possibility of more flexibly adjusting short-term interest rates and the need for tools appropriate and effective for signalling medium- to long-term policy intentions were among the reasons mentioned for the change of operational targets in Sweden in 1994 (BIS 1997b; Sveriges Riksbank 1994). Similarly, on introducing repurchase transactions as one of its key operations and the lending rate for secured transactions as the new main policy interest rate, the Danish Nationalbank gave the motive that changes of the discount rate had become too 'powerful' (in other words, too blunt) to be a useful tool (Danmarks Nationalbank, *Monetary Review* 2, 1999).[11]

A *fifth* broad category of reasons relates to the wish more generally on the part of central banks to stimulate money-market activity and improve monetary-policy transmission, and to achieve a clearer separation of monetary policy implementation from government-debt management, and from other social-policy goals (favouring certain sectors in the economy by granting access to cheap credit etc.) which were auxiliary reasons for the imposition of financial-market regulations. Because financial regulations were often of a multiple-purpose variety, and because the central bank was typically responsible for the implementation of

the regulatory policy, the distinction between monetary policy and other 'types' of policy had previously not always been very clear-cut. For instance, the experience of the Portuguese central bank was that the controls used to attain monetary-policy goals up to around 1990 increasingly conflicted with other public-policy objectives and with the ambition to achieve effective policy transmission. The consequence was increased uncertainty and frequent unexpected changes of variables used to calculate credit ceilings and quotas, rendering credit control less and less useful or relevant (Pinto 1996). In Norway, the sentiment at the central bank around 1980 was that direct controls were no longer effective and, in fact, only made the credit market more difficult to control and the interpretation of information more problematic (Vale 1995).

Sources and effects of fluctuations in money-market liquidity and the scope for open market operations

In order to analyse broad changes in monetary-policy stances and instruments over the 20-year period from around 1980 up to the launch of EMU, we extracted the principal sources and uses of money-market liquidity as well as the main instruments used to influence liquidity from the central banks' balance sheets over three shorter periods: one in the early 1980s, one in the late 1980s (or early 1990s), and one period in the late 1990s. The general methodology closely follows that suggested by Borio (1997; Annex I). The frequency is weekly where available, otherwise monthly (see the notes to Table 6.8). This somewhat impedes comparability between periods and/or across countries. Still, we considered it better to use the weekly-frequency data where such were available. The lower-frequency (monthly) data may to an extent over-/understate some items because operations of central banks often have shorter maturities than one month.[12]

Table 6.8 shows the principal sources of liquidity in our survey countries over the three different periods. The variability of the autonomous position was consistently much higher than the average position. This indicates that autonomous factors did not generally have permanent 'structural' effects. More generally, it implies that we cannot make statistically significant conclusions about the average size of the positions.

Policy can be assumed to work against the autonomous position (to have the opposite sign), so as to offset its net effect on liquidity supply (banks' reserves at the central bank). This assumption is supported by the data but, as with the autonomous position, the *variability* of the policy position far exceeded its size, leaving little or no room for conclusions about the average stance of policy. Generally, policy appears to have offset autonomous influences imperfectly — that is, the average size as well as the standard deviation (variability) of autonomous factors are mostly higher than that of policy.

The resulting effect varies. Overall, fluctuations in net liquidity changes were comparatively low in Belgium and the Netherlands. Per contra, average net liquidity changes were more variable in Denmark and Norway. Comparing data

Table 6.8 Principal sources of liquidity

	Autonomous sources of liquidity			Policy position			Net liquidity		
	P1	P2	P3	P1	P2	P3	P1	P2	P3
AT	n.a.	0.32 (3.67)	0.56 (2.44)	n.a.	−0.30 (2.45)	−0.30 (3.21)	n.a.	0.02 (4.87)	0.26 (3.28)
BE	0.39 (2.90)	−0.69 (2.26)	0.19 (2.24)	−0.36 (2.83)	0.51 (2.45)	−0.17 (2.25)	0.03 (0.29)	−0.17 (0.70)	0.01 (0.16)
FI	−0.35 (4.96)	−0.14 (3.51)	−0.50 (6.54)	0.12 (9.99)	0.74 (3.36)	−0.08 (10.25)	−0.24 (9.05)	0.59 (1.72)	−0.59 (12.28)
GR	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
IE	2.83 (5.81)	0.63 (15.25)	1.57 (10.53)	−1.90 (6.21)	0.01 (13.05)	0.23 (6.67)	0.93 (3.78)	0.63 (4.79)	1.80 (7.75)
NL	−0.57 (5.22)	−0.31 (8.99)	−0.25 (1.21)	0.56 (5.20)	0.40 (8.19)	0.18 (1.61)	−0.01 (0.10)	0.10 (3.72)	−0.07 (1.18)
PT	2.31 (5.90)	2.08 (6.78)	−0.82 (15.51)	−0.47 (5.75)	1.44 (13.83)	1.09 (17.68)	1.85 (4.07)	3.52 (12.07)	0.27 (5.39)
DK	0.88 (24.77)	−0.83 (20.48)	−8.62 (32.04)	−0.97 (23.41)	1.92 (12.55)	6.77 (44.71)	−0.10 (3.40)	1.09 (15.41)	−1.85 (23.39)
SE	−1.54 (21.18)	−0.70 (8.57)	0.04 (5.30)	0.35 (17.47)	1.26 (8.13)	−0.10 (5.24)	−1.19 (9.67)	0.56 (2.96)	−0.05 (1.89)

NO[b]	n.a.	3.49 (40.40) n.a.	−2.77 (19.22) 0.54 (7.38)	n.a.	n.a.	−3.11 (38.40) n.a.	1.76 (11.90) −0.91 (11.41)	n.a.	0.39 (7.66) n.a.	−1.01 (14.64) −0.36 (6.43)
CH	n.a.								

The table shows average weekly (monthly)[a] changes/positions as a percentage of the average level of base money, and variability of positions (standard deviations) in parenthesis.

Positive positions ⇒ liquidity injection; negative positions ⇒ liquidity absorption.

Definitions:

In the central bank's balance sheet, the column headings in the table consist of the following summary items:

- Autonomous sources of liquidity (or autonomous position) = changes in net foreign assets + changes in net lending to the government + changes in other net assets – changes in outstanding currency (i.e. notes and coin);
- Policy position = changes in the central bank's net lending to the banking system;
- Net liquidity = changes in the amount of liquidity in the banking system (= autonomous position + policy position).

'Net lending to banks' comprises the net of claims on and liabilities to banks over which the central bank exerts control (except liabilities due to reserve requirements); the amount of liquidity in the banking system can be understood as any remaining liabilities to the banks (i.e., the banks' reserve holdings with the central bank, including deposits due to reserve requirements).

n.a.: data not available.

Notes:

a Weekly data were available for the following countries and periods: Austria P2 and P3; Belgium P1, P2 and P3; Finland P1, P2 and P3; Netherlands P1, P2 and P3; Sweden P3; and Switzerland P3.

The periods used are the following:

Austria P2: Oct. 31, 1989–Jan. 31, 1990; P3: Jan. 7, 1998–May 31, 1998.
Belgium P1: Jan. 7, 1980–June 30, 1980; P2: Jan. 2, 1989–June 26, 1989; P3: Jan. 5, 1998–May 29, 1998.
Finland P1: Jan. 8, 1980–May 30, 1980; P2: Jan. 6, 1989–May 31, 1989; P3: Dec. 31, 1997–May 29, 1998.
Ireland P1: 1979:12–1981:02; P2: 1988:12–1990:06; P3: 1997:12–1998:12.
Netherlands P1: Jan. 5, 1981–May 25, 1981; P2: Oct. 2, 1989–Feb. 26, 1990; P3: week 1, 1998–week 25, 1998.
Portugal P1: 1980:01–1981:12; P2: 1988:01–1989:12; P3: 1996:07–1998:06.
Denmark P1: 1979:01–1980:12; P2: 1988:01–1989:12; P3: 1997:12–1998:11.
Sweden P1: 1980:01–1981:10; P2: 1987:01–1988:10; P3:Dec. 31, 1998–May 31, 1999.
Norway P2: 1991:12–1992:12; P3: 1997:12–1998:12.
Switzerland P3: Sept. 30, 1999–Apr. 10, 1999.

b Balance sheets on a monthly or shorter frequency are only consistently available from 1992.

Sources: The figures are calculated on the basis of data from the respective central banks' balance sheets, mostly taken from annual and/or interim reports; in some cases obtained as spreadsheet documents directly from the central bank.

within countries but across periods, there also appears to have been an upward trend in liquidity fluctuation in these two latter countries, possibly along with Ireland. The opposite trend seems to apply to Sweden. In Finland, liquidity fluctuation dropped between periods one and two, then rose again. For Portugal, this pattern is inverted. These differences with regard to the variability of net liquidity changes reflect differences in the variability of the autonomous position fairly well. That can be taken as another indication that policy smoothed out liquidity fluctuations though only imperfectly.

Finally, the reasonable expectation of seeing more activist policy in latter years is not invariably borne out by the data; rather, the standard deviation of the policy position (which can be used as an indicator of policy activism) seems to have covaried strongly with that of the autonomous position. Taken together, this reinforces the indication that the job of the central banks in the sample was primarily to forecast and offset factors outside its direct control that influence the domestic market.[13]

The variability of the main autonomous factors is shown in Table 6.9. Note that Tables 6.9 and 6.10 contain only variability (standard deviations), not the average positions (again, these are generally statistically insignificant). Seen over all countries and periods, the two most important autonomous sources of fluctuation in money-market liquidity (and thus the major factors that the central banks have had to counter in their policies) were net foreign assets and net lending to the government. Of these, the latter in many cases almost ceased to be a source of fluctuation in the last period, since central-bank lending to the government was prohibited for members of the European Union. For these countries, this item continued to influence liquidity only through marginal holdings of government securities and through the government's deposits at the central bank.

Table 6.9 Autonomous sources of liquidity—contribution of different components

	Net foreign assets			Net lending to government			Other net assets			Currency		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
AT	n.a.	3.28	2.71	n.a.	0.08	0.19	n.a.	0.36	2.07	n.a.	2.19	1.29
BE	1.90	2.82	0.33	2.87	2.70	0.07	1.09	2.83	0.42	1.41	0.84	2.28
FI	3.92	3.51	6.45	1.43	0.72	0.01	1.30	0.96	1.00	1.63	0.35	1.16
GR	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
IE	7.00	10.45	10.77	6.30	12.05	8.38	2.89	1.27	5.05	2.48	3.21	3.11
NL	3.12	0.83	0.63	3.91	8.97	0.05	3.65	0.57	0.80	0.88	0.89	0.80
PT	5.00	6.11	7.64	6.75	5.88	12.28	3.21	3.34	3.57	2.38	1.69	2.69
DK	14.26	19.28	28.89	20.59	17.77	26.89	9.54	6.88	3.30	2.89	2.77	1.86
SE	3.93	5.12	4.64	20.75	13.57	0.85	2.74	6.21	1.16	2.82	3.11	1.76
NO	n.a.	30.89	13.09	n.a.	19.43	16.59	n.a.	4.28	6.44	n.a.	4.13	2.52
CH	n.a.	n.a.	4.38	n.a.	n.a.	6.31	n.a.	n.a.	0.95	n.a.	n.a.	3.48

The table shows the variability (standard deviations) of average weekly (monthly) changes as % of the average level of base money. Definitions, notes and sources, see Table 6.8.

Table 6.10 Policy position – contribution of different components[a]

	Standing facilities			Market operations		
	P1	P2	P3	P1	P2	P3
AT[b]	n.a.	0.64	0.18	n.a.	2.79	3.21
BE	2.83	2.45	1.09	0.00	0.00	2.56
FI	10.13	2.96	0.02	30.78	30.09	100.25
GR	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
IE	6.21	8.53	1.42	.00	11.77	6.40
NL	5.90	3.00	1.47	2.43	6.88	0.75
PT[c]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
DK	23.41	12.55	0.00	0.01	0.00	44.71
SE[d]	17.47	5.98	5.58	0.00	8.59	7.61
NO[c]	n.a.	30.52	n.a.	n.a.	19.79	n.a.
CH	n.a.	n.a.	0.33	n.a.	n.a.	11.39

The table shows the variability (standard deviations) of average weekly (monthly) changes as % of the average level of base money. Definitions and sources, see Table 6.8.

Notes:

a The precision of the designation of the various instruments used by the central banks to inject/withdraw liquidity into the categories of 'standing facilities' and 'market operations', respectively, is constrained by the limits of the information contained in the regularly published balance sheets of the respective central banks; no in-depth analysis of the de facto nature of the various instruments used has been possible.

b The 'Market operations' component includes certain types of foreign-exchange operation; operations in the domestic market were negligible until 1995.

c Lack of data due to the fact that the Central Bank's balance sheet does not discriminate among different policy instruments (NO, P3), or makes only a functional categorisation (liquidity-absorbing/-injecting assets/liabilities: PT, P1–P3).

d The series for Period 2 are not completely consistent due to changes in operating procedures in August, 1988; figures are estimates.

The net-foreign-assets portion of the autonomous position should – all else equal – be more variable in countries with far-reaching exchange-rate commitments, where the central bank was active in the foreign-exchange market or in other ways made more extensive use of foreign-exchange reserves to uphold that commitment (such as Austria and the Netherlands). Conversely, it should be less variable in countries where exchange-rate commitments were absent, or secondary to monetary policy (such as Switzerland, or Sweden in Period 3). However, no clear such pattern can be discerned, although Denmark fits well into the picture. For the other countries in the study there was a tendency for net foreign assets to be a more important source of liquidity fluctuation in 'weak-currency' countries – regardless of exchange-rate regime – and a less important one in 'hard-currency' countries. (This tendency, however, must be considered very tentative, given the imprecision of any categorisation of hard- and weak-currency countries; for evidence of the influence of exchange-rate regimes on short-term interest rates, see Forssbæck and Oxelheim 2006.)

In some countries (Denmark, Norway, and to some extent also Ireland, Portugal and Sweden), foreign influences along with net lending to the government were

consistently and by far and away the most important source of liquidity fluctuation (and thereby domestic short-term interest-rate fluctuations). The historical development of the foreign-assets position is varied: its contribution to liquidity fluctuations increased between the early 1980s and the late 1990s in Denmark, Finland (though at a lower level), Ireland, Portugal, and (slightly) in Sweden; it decreased in Belgium and the Netherlands. Similarly, it decreased between the late 1980s/early 1990s in Austria and Norway. Net lending to the government was particularly variable for the Scandinavian non-EMU countries (Denmark, Norway and Sweden). This might well be interpreted as an illustration to what has been said about the unclear separation of various forms of public policy; notably the unclear separation of the central bank function from other public-policy issues, such as financing of the government. It would, in that case, indicate that the Scandinavian central banks were among the least economically independent among those covered here. This corresponds rather well to the indicators of central-bank independence reported elsewhere (see Grilli *et al*. (1991) for one of the original contributions in this field).

Table 6.10 shows the respective contributions of standing facilities and market operations to the central banks' liquidity-policy positions. The data largely confirm the indications given earlier in this study, and results of earlier cross-country studies, of an increased market-orientation of monetary policy operating procedures. The variability of that portion of the policy position which is made up of standing facilities has decreased across the board, and in most cases this decrease finds a corresponding increase in the variability of the position stemming from market operations.

The results from Table 6.10 provided us with a measure of the extent, or intensity, of open market operations in the different countries at different periods. In order to test the hypothesis of a relationship between choice of instrument type and the degree of market development, we performed a series of tests, the results of which are reported in Table 6.11 and Figure 6.2. The dependent variable is given by the 22 observations of the variability of the market operations component of the policy position in Table 6.10; the independent variable is the relative size of the short-term securities market (as shown in Figure 6.1) at the periods corresponding to the observations of the dependent variable. In order to counteract the problem of a limited number of observations as much as possible we performed both least-squares and non-parametric regressions. Caveats are still warranted, both because of the imprecision and comparability problems of the data generated from the central banks' balance sheets, and because of the questionability of using the size of short-term securities markets as a yardstick for the feasibility of open market operations (as discussed above); finally because the limited number of observations still provide limited degrees of freedom for elaborating the model tested.

As seen in Table 6.11, a simple linear regression does not indicate any significant correlation between the two variables, but a quadratic specification provides some support for the notion of a positive, but marginally decreasing, association between the intensity of open market operations and market development. Given

Table 6.11 Results of regression of the intensity of market operations[a] on relative market size (*p*-values in parentheses)

	Least squares estimation		Wilcoxon non-parametric estimation	
	I	II	I	II
Intercept	5.644	−0.361	4.334∗∗	0.276
	(0.102)	(0.930)	(0.032)	(0.912)
Market size	0.094	1.725∗∗	0.038	1.046∗∗
	(0.707)	(0.040)	(0.789)	(0.040)
(Market size)^2		−0.058∗∗		−0.033∗
		(0.041)		(0.054)
Adjusted R^2	−0.042	0.123		
Wilcoxon robust R^2			0.004	0.208
F-statistic	0.146	2.470	0.080	2.489
	(0.707)	(0.111)	(0.781)	(0.110)
No. of obs.	22	22	22	22

Note:
a As measured by the variability in the policy position due to discretionary operations, see Table 6.10.

the limitations mentioned above, however, and some difficulty with the intuition of a quadratic specification to the right of the optimum (see Figure 6.2), the results must be considered tentative.

Conclusion

Up to the late 1970s and early 1980s, our case countries' money markets (as well as the financial sectors in general) were typically underdeveloped and highly regulated (possibly with a couple of exceptions). Since then, policy, primarily through the effect of a general deregulation of the financial sectors, has been one of the main determinants of money-market development. However, beyond motives and reasons for *financial deregulation* that are valid for the financial sector as a whole (such as technological advances, increasing internationalisation of business activities and financial innovation – the combination of which factors led to ever increasing opportunities to evade or circumvent existing national financial regulations and restrictions – an increasing realisation on the part of policy makers of the incompatibility of highly repressed financial systems with efficient resource allocation, and international 'peer pressure' in the context of international organisations and institutions for international economic cooperation), we would argue that there are also additional 'policy' motives for promoting the formation of efficient *money markets*, specifically. In particular, we found motives in terms of the need of the central banks for an arena in which to conduct open market operations and in other ways to control the supply of liquidity to the banking system, as regulations, controls and restrictions became increasingly ineffectual or unavailable as instruments for monetary-policy implementation.
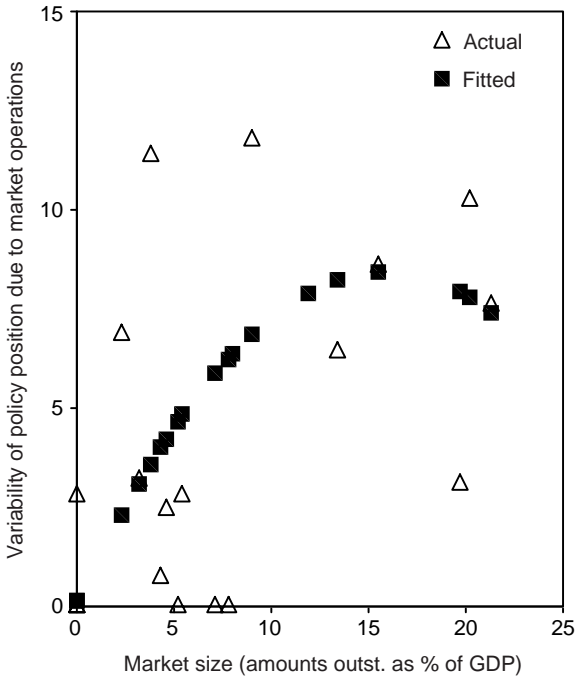
Figure 6.2 Estimated relationship between the intensity of open market operations and
the relative size of short-term securities markets (Wilcoxon non-parametric
estimates as in Table 6.11).

Such generalisations, however, cannot explain the significant differences in
the path of money market development among the countries we study. These
differences – in terms of the size of the market in total, as well as the structure
and relative importance of the main market segments – instead largely seemed
to persist during the entire period studied. A rough division, for instance, can
be made between countries with and countries without a significant short-term
securities segment. However, in those countries that do have such segments,
these segments still vary substantially with regard to size, liquidity and the rela-
tive importance of different types of securities. For example, the development of
Finland's short-term securities market was based on bank CDs, while most other
countries' markets were based on government bills; in Greece, the government
T-bill market, though large, did not give rise to a significant market for other types
of short-term paper, and the market long remained very illiquid; from a relatively
small market toward the late 1990s Ireland developed a market for commercial
paper which remains unparalleled in relative size in any of the other countries
(possibly with the exception of the Swedish CP market).

We therefore conclude that the development over time may best be characterised as a continuous interplay between policy decisions and market outcomes. The development process is thus highly *path-dependent*, and largely reflects *ad hoc* policy decisions, which are often, in themselves, responses to market developments. There may also be considerable spill-over effects from other policy areas, such as taxation and competition policy, to the extent that such policies may indirectly act restrictively, even in the absence of explicit financial-market regulations and controls, or impose certain – possibly unforeseen – incentives upon market participants.

Such country-specific, path-dependent interactions may also apply to the influence that central banks have had on the development of money markets in the respective countries. Financial-market innovation in general, and the emergence of increasingly sophisticated money-market instruments in particular, should, all else equal, weaken monetary policy transmission by the continuous supply of substitutes to central-bank money. In other words, our findings of a development towards more sophisticated and efficient domestic money markets should on balance weaken the effects of monetary policy. However, if there is anything to the story of an interplay between market formation and the operative framework of monetary policy – the simple mechanics that as markets change, central-bank operations change, and *vice versa* – then the timing and sequencing of financial deregulation/the abolition of direct controls, as well as more subtle aspects of central bank policy may bring home some important lessons.

We found five main reasons, or sets of reasons, why monetary-policy operating procedures changed during the period of study. First, monetary-policy instruments were adapted to changes in the targets or goals of monetary policy (for example, from an exchange-rate target to an inflation target). Second, central banks adapted their operative frameworks to structural changes outside their control (for example, the reliance on the part of central banks on certain types of regulation became outdated as innovation in the money market increased opportunities for market agents to circumvent such controls). Third, the development of money markets domestically as well as a stronger international integration of these markets increased the central banks' need for instruments that allowed them to manage liquidity supply more flexibly and with a greater degree of accuracy. Fourth, the growing importance of expectations in a deregulated financial system increased the need for instruments which could be used to signal the central bank's policy stance. The fifth set of reasons was a general wish to stimulate money-market activity in order to improve monetary-policy transmission, and to clarify the separation of monetary policy from other types of public policy (such as government financing).

These five broad categories, which account for the often substantial revisions of central-bank policy strategies in the focus countries over the period studied, are clearly not independent of each other, and often overlapping, but they do indicate that central banks had an influence on money-market development that was significant (in some cases it appears to have been decisive). However, the relationship goes the other way too. There seems to be some connection between comparatively radical changes in domestic money-market development (in terms

of innovation, market growth and regulatory changes) and greater changes in monetary-policy instruments. In addition, we also found tentative evidence in favour of the hypothesis of a correlation between market development and the intensity of open market operations.

Although the structure of money markets in the countries studied remained highly varied during the study period and the interplay between policies and market outcomes may have carved out different paths of development for the countries, in terms of the instruments which came to be increasingly favoured by central banks during the period, however, there are more signs of convergence from the mid-1990s onward: in the EMU countries as a matter of course (since they have, both *de jure* and *de facto*, adopted a unified operational framework) but also in the non-EMU countries, as well as many other industrialised countries. A salient feature of this particular development is that, in recent years, repurchase agreements and variations on collateralised lending/borrowing have become the dominant instrument used by central banks to implement monetary policy. A general explanation for this is that this type of instrument answers well to many of the needs of central banking – for example flexibility and the possibility to effectively signal the policy stance to financial markets. By and by, central banks have also typically broadened their collateral base (that is, the list of securities types that they will accept in a buy/sell-back operation), which diminishes the need for a large short-term securities market for repo transactions, thus making this type of operation feasible even in countries where the short-term securities segment is ill-developed.

If there are substantial similarities in the adoption and abandonment, respectively, of monetary-policy instruments, there seem to be larger differences in the sources and effects of fluctuations in money-market liquidity across the different countries. We studied changes in the sources and effects of fluctuations in money-market liquidity over the 1980s and 1990s in our focus countries by analysing the respective central banks' balance sheets. A general conclusion is that the greatest influence on liquidity fluctuations is factors outside the central banks' control, and that the main effect of monetary policy is to offset these factors (which central banks typically do imperfectly). The overall, as well as the relative, importance of the autonomous factors (primarily the influence of capital flows through net foreign assets and net lending to the government), however, vary considerably between the countries and periods although the net-foreign-assets component is the most important source in almost all our case countries. Based on our results, we argued that these differences could not be explained by simple institutional factors, such as the exchange-rate regime. Instead, our data indicate a credibility issue.

Notes

1 The cross-country comparisons of central bank operating procedures that exist – e.g., Kneeshaw and Van den Bergh (1989), Batten *et al*. (1990), Bernanke and Mishkin (1992), Kasman (1992), Goodhart and Viñals (1994), Hooyman (1994), Bisignano (1996), Borio (1997), BIS (1986; 2001), Kopcke (2002) – consistently indicate that

changes in the operative frameworks of central banks have been both effects and drivers of broader changes in financial markets. This is the link we focus on here. For more general considerations of the political economy of financial market development, see, e.g. Pagano and Volpin (2001) and Rajan and Zingales (2003).

2 The usual argument given for this sequence of events is that agents in wholesale markets are assumed to be more professional, thus better qualified to handle market-determined rates; see, for example, Mehran *et al.* (1996).

3 The 'empirical' relevance of implicit interest rate regulations is illustrated by Pech's (1994) estimation that in the early 1990s almost half of all credit extended to industry in Austria, though formally free from regulations, was in fact subsidised.

4 Temporary regulations have been resorted to in extreme cases even in recent years. The latest example is the imposition by the Bank of Greece of a 12% credit-expansion ceiling on commercial banks in 1999 after consumer credit had expanded more than 30% *p.a.* in 1998 and 1999 (Bank of Greece, *Monetary Interim Report, 1999*).

5 General references for this sub-section not cited elsewhere include BIS (1986; 1997a), and Aspetsberger (1996).

6 In Switzerland, for instance, the underdeveloped domestic money market, the unaccommodative attitude of the National Bank with regard to reserve imbalances (resulting from its long-standing reserves target – now abolished) and the comparatively high cost of Lombard (overdraft) facilities led Swiss banks to hold reserves substantially in excess of those required under reserve requirements (Kasman, 1992).

7 Several advantages are perceived with repos as an instrument for monetary policy relative to more orthodox cash instruments (Turner and van 't dack, 1996; BIS, 1999). One advantage is that they do not directly influence the underlying asset prices. A second is their flexibility: they break the link between the maturity of the asset and the transaction, and can essentially be tailored to suit prevailing liquidity conditions. Thirdly, because repo transactions are backed by (high-quality) collateral, the risk involved is typically very low. This also means that they convey relatively accurate information on the market's interest-rate expectations over the short term. Finally, repos are seen as appropriate for signalling the central bank's monetary-policy stance.

8 In Portugal, the decline in short-term paper as collateral refers primarily to T-bills, which decreased from initially very low levels (3%). In Finland, however, collateral paper mostly consisted of bank CDs, the use of which dropped from about 30 to 20% after the adoption of the common monetary-policy framework in the euro area. See Santillán *et al.* (2000).

9 By 1987, the National Bank's holdings of currency swap contracts amounted to approximately half of its foreign-currency assets, which in turn amounted (together with gold) to almost 90% of its total assets. Roughly that situation remained until 1998, when the Nationalbank began to broaden its arsenal of instruments (Banque Nationale Suisse, *Bulletin Trimestriel* 4, December, 1999). Also see Zurlinden (1996).

10 As financial integration between countries increases, the narrowing interest-rate differentials vis-à-vis other countries imply that even very small interest-rate movements can generate considerable cross-border capital flows, making exchange-rate or money-supply targets increasingly difficult to meet. Hence the increasing need for instruments which would enable the central bank to influence domestic short-term rates with greater flexibility and accuracy.

11 One additional motive for the Nationalbank to use secured transactions increasingly in its operations to extend liquidity to the banks was to lower the risk involved in these operations. A reason for wanting to do so may have been concern with the solvency of the banking system (Finland, Norway and Sweden experienced rather severe banking crises at the time).

12 The average size of the positions as well as their variability tend to increase with the total length of the period covered, and therefore tend to be higher for those countries

for which *monthly* rather than *weekly* data are used: an indication that the data should be interpreted with caution.

13 One potentially complicating factor here is that if we believe that the central bank's policy measures can in and of themselves give rise to 'innovations', we have an endo-geneity problem of the 'autonomous' factors: the central bank influences these factors *indirectly* through its own actions.

Discussion of Forssbæck and Oxelheim

Christian Ewerhart

The authors have done a tremendous job with this paper, but it is difficult to comment on such a rich set of results, whose form I summarise in Figure 6.3. I therefore focus on one specific country. My choice, maybe not surprisingly, fell on Switzerland. Thus, I discuss whether I can agree with the authors' conclusions in the case of this country. The approach led to three main comments on the paper.

Regulation: repressive or best practice?

Forssbæck and Oxelheim write that the 'general conditions for monetary policy-making were such that regulations were favoured and the scope for discretionary operations in the absence of developed money markets was severely limited.' However, is this really true for the liberal Switzerland? After all, there has been a usage of market instruments (FX swaps) for steering of monetary aggregates in Switzerland since 1978. Credit constraints in Switzerland had been an emergency
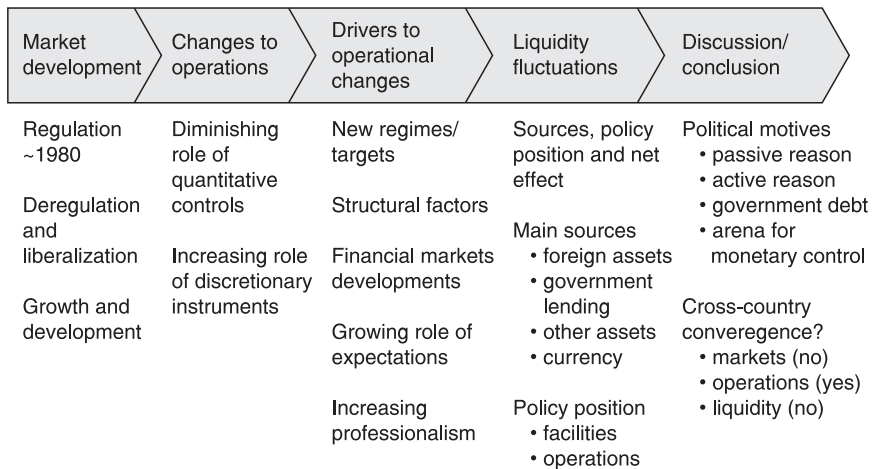
Market development	Changes to operations	Drivers to operational changes	Liquidity fluctuations	Discussion/ conclusion
Regulation ~1980	Diminishing role of quantitative controls	New regimes/ targets	Sources, policy position and net effect	Political motives • passive reason • active reason • government debt • arena for monetary control
Deregulation and liberalization	Increasing role of discretionary instruments	Structural factors	Main sources • foreign assets • government lending • other assets • currency	Cross-country convergence? • markets (no) • operations (yes) • liquidity (no)
Growth and development		Financial markets developments		
		Growing role of expectations		
		Increasing professionalism	Policy position • facilities • operations	

Figure 6.3 Steps of the argument.

instrument only during the fixed exchange rate regime, i.e. before 1973.[1] Moreover, as for every decision, policy making occurs under boundary conditions. Preferences can only be identified if these boundary conditions are taken into account. It may therefore be necessary, to arrive at the authors' conclusions, to look at the precise conditions under which policy makers came up with their decisions. For instance, one might want to look at issues such as central bank legislation and macroeconomic developments.

Definition of the money market

This is my main point. According to Stigum (1983), one salient feature of the money market is that it is not one market but a collection of markets. While the authors stress the difficulties with the definition of the money market, their analysis of the development of those markets is restricted to the discussion of the outstanding volumes of short-term securities. This may constitute a general problem for two reasons. Firstly, transaction volumes usually determine the size of a market, not outstanding volumes. Secondly, neither the unsecured market nor the derivatives market is considered.[2]

At least in the case of Switzerland, the approach chosen by the authors may lead to a misconception about the true growth and development of money markets in the considered countries. Forssbæck and Oxelheim define the Swiss money market as the market for short-term securities. As argued above, this definition may be too tight. For example, while a domestic market may have been underdeveloped in Switzerland, Euromarkets may have existed for quite some time.[3] Figure 6.4 shows the composition of the money market, as identified by Veyrassat (2004). It is apparent that a focus on outstanding volumes of short-term securities may tend

Volume of money market instruments

Market/instrument	Volume	Description
Foreign exchange swaps USD/CHF	CHF 899 billion	Outstanding amount. Up to 1 year. Average April 2001. Own estimate. Source: Bank for International Settlements (2002).
Deposits	Approx. CHF 100 billion[1]	Outstanding amount. Source: own estimate.
Repo transactions (interbank market)	CHF 22.6 billion	Outstanding amount. Average December 2003. Source: Eurex Repo.
Customer time deposits	CHF 46.1 billion	Outstanding amount. Residual maturity up to 1 year incl. call money. End of 2003. Source: SNB.
Fiduciary investments	CHF 14.8 billion	Outstanding amount. End of 2003. Source: SNB.
Money market debt register claims	CHF 10.7 billion	Outstanding amount. End of 2003. Source: SNB.
Tom-next index swaps	CHF 490.6 billion	Average outstanding book volume of 16 market makers. 2001. Source: Trauth (2002, p. 36)
Forward rate agreements	CHF 261.1 billion	Outstanding book volume. End of June 2001. Source: Bank for International Settlements (2002).
Interest rate futures	CHF 277.5 billion	Outstanding book value (open interest). End of January 2004. Source: Reuters.

Figure 6.4 Volume of money market instruments. There are no reliable data available on deposits. *Source*: Veyrassat (2004).

to convey an imprecise picture of the overall development of the Swiss money market. While the availability of data covering the considered period is clearly acknowledged as a major problem, the resulting limitations for the approach chosen in the analysis should be obvious.

The consequences of using an imprecise definition also include a distorted role of financial market regulation. For example, in which sense has issuing regulation been a binding constraint for the development of unsecured money markets and markets for derivatives? In a similar vein, the regulation of financial and banking markets is not tantamount to money market regulation. Specific forms of regulation, such as minimum maturities, market-entry regulation, branching regulation, line-of-business restrictions and foreign-bank entry, might have been less crucial for the development of interbank markets. In the case of Switzerland, the stamp tax has apparently played a more decisive role than any of the regulations mentioned in the chapter. This will become clear from the following case study.

The SNB's repo project 1997

Until the end of 1996, a stamp tax has been levied on securities sales, including repurchase transactions. From January 1 1997 onwards, the tax authorities decided to re-interpret repos as refinancing transactions, not securities transactions. This change in administrative behaviour goes back to a joint initiative of both the SNB and commercial banks. In November 1997, repos were included in the collection of instruments used by the SNB for monetary policy implementation, on the occasion of a revision of the national bank law. Since the introduction of the repo, the SNB has provided liquidity almost exclusively using repos. As a consequence, SNB repo volume increased rapidly to 20–25 bn SFR. Since then the Swiss repo market has grown continuously, reaching a volume of 60–70 bn SFR (thereof about 30 bn SNB repos).

Figure 6.5, taken from Jordan (2005), shows the take-off of the Swiss repo market (outstanding volumes in SFR m). According to central bank sources (which may have an incentive to give an incomplete picture), the SNB's motivation for promoting repo transactions has been twofold. First, there has been the desire to reduce risks in the money market, with the objective of improving the overall stability of the financial system: indeed, compared to the traditional FX swap and to unsecured interbank lending, credit risks operational risks and settlement risks are essentially eliminated. The second rationale for the SNB has been to enrich the collection of instruments available for implementation of monetary policy. And without question, compared to the exclusive use of traditional FX swaps, risks are decreased for the SNB, and the circle of potential counterparties could be increased in size from just a few to about 100 banks.[4]

I conclude that Forssbæck and Oxelheim have brought to the conference an interesting and well-written paper that reflects an impressive amount of institutional detail and suggests an essentially convincing story for small countries. However, in my view, the fact that the money market is a collection of markets
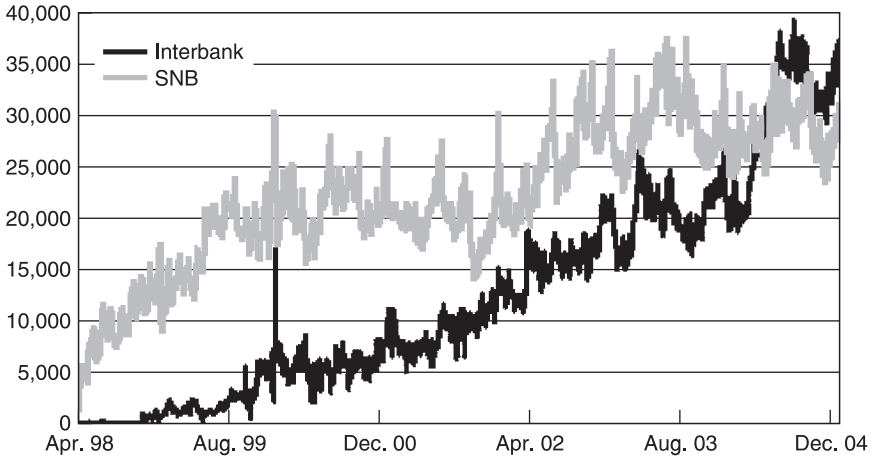
Figure 6.5 Take-off of the Swiss repo market (outstanding volumes in SFR m). *Source*:
        Jordan (2005).

should be accounted for much more explicitly: the market for short-term securities
may not be the only relevant segment of the respective money market. Moreover,
the analysis might have lost some of its power by trying to impose a common
structure on the developments of all the countries. As the example of Switzerland
may have illustrated, individual countries' operational frameworks may indeed be
quite special, and it may not be immediately obvious to the reader how well an
individual country fits into the common storyline.

Notes

1 See Böschenstein (1977) and Swiss National Bank (1982, 1983–2004).
2 For instance, the EONIA swap market, a segment of the derivatives market in the euro
   area, is one of the largest and most liquid financial markets worldwide (Remolona and
   Wooldridge 2003). Thus, in the case of the euro area, the focus on outstanding short-term
   securities would be misleading.
3 See Jenny (1973) for a description of the early Swiss money market.
4 For a more comprehensive account of the new monetary policy framework in Switzerland,
   see Jordan and Kugler (2004).

7 Open market operations in emerging markets

The Mexican experience

Noemi Levy Orlik and Jan Toporowski

This chapter discusses the experience of central bank open market operations in emerging countries that have become integrated into global financial markets and experience high international capital mobility. We argue that the operational procedures of central banks in emerging countries must allow for the weakness and shallowness of financial markets that are subject to large international capital movements. In such a situation open market operations remain central to the implementation of monetary policy, while non-market mechanisms are ineffective. This is explained in terms of the Latin American financial markets and the origins of inflation in these countries. The argument is developed using the example of Mexican monetary policy after the 1994 crisis. It is argued that in that period operational instruments had different results even though the objectives of central banks' monetary policy remained the same as in more financially advanced economies.

Introduction

In the last 35 years the structures, organization and operations of financial systems in developing countries have undergone dramatic changes. Bond and capital markets underwent a process of enlargement; commercial banks have internationalized; and central banks have adapted to the international financial market, undertaking objectives and operational instruments similar to those of central banks in more financially advanced countries. In the latter countries open market operations increased their importance, regulatory bonds and deposits in central banks as well as signalling policies were enforced to strengthen the transmission mechanisms of monetary policy, while operations in foreign currencies have become less frequent and less important.

   We argue that in emerging countries, even though open market operations are a relatively new monetary policy instrument, they have turned out to be central instruments in the enforcement of monetary policy. In this context, signalling policies, commercial bank regulatory deposits at the central bank and regulatory bonds are ineffective, or at least weak, monetary policy mechanisms. This needs to be understood within the context of high dependence on external capital

inflows, where international reserves play an active role in the monetary base, and a globalized financial market with a high level of external capital movements.

Another important feature of emerging financial markets of the Latin American region is the inability of financial and monetary authorities to pursue effective counter-cyclical policy due to structural current-account deficits. In this way financial crises can precipitate economic recessions that the authorities may be powerless to reverse. Stabilization of the exchange rate becomes a crucial intermediate target of anti-inflationary policy. But structural inflation is endemic among Latin America and emerging market countries. Such structural inflation induces current-account deficits when economic activity increases. Such deficits are less tractable by exchange-rate devaluation, so that external current-account disequilibrium requires accommodating capital account inflows for economic growth to be maintained. These in their turn require a correspondingly greater use of open market operations.

The rest of the chapter is in three sections. The first section discusses the operational procedures of central banks in the course of financial development. It shows that in the pre-1970 period, they could only be used in deep and broad financial markets to control liquidity (imposing the central bank's interest rates), while in countries lacking strong financial markets, governments imposed regulatory deposits. Once capital mobility increased open market operations became much more widely used and the control of inflation became the main objective of monetary policy, rather than government intervention in financial and product markets. It was subsequently acknowledged that open market operations required nonmarket mechanisms, which were not available in emerging countries. This leads on to an examination of the structures of financial intermediation in Latin American countries and the structural inflation that increased in the process of financial and commercial openness. The second section discusses Mexican monetary policy, highlighting the principal characteristics of its financial market (i.e. the working of the different financial market segments) and central bank operations, including its operational instrument and targets. The final section contains a discussion of the principal ideas and the main conclusions.

Financial development in Latin America

The commonly accepted definition of financial development is the creation of *more liquid* markets in longer-term securities. The classic statement of this was made almost fifty years ago in Gurley and Shaw (1960). However, it nowadays includes an increasing range of short-term securities, such as futures and foreign exchange contracts. By increasing the scale of financial transactions financial development increases the autonomous movements in reserves. By making financial markets generally more liquid, financial development reduces the impact that given central bank open market operations have on money market interest rates. Financial development also increases the amount of bank deposits in the system. If the money supply is divided up into 'outside' money that is the liability of the

central bank, and 'inside' money, that is made up of liabilities of commercial banks, financial development may be viewed as the expansion of 'inside' money relative to 'outside' money. (This is the origin of the now standard use of the ratio of M3 to M0 as an indicator of financial development, e.g., King and Levine 1993.) In turn, the increase in 'inside' money relative to 'outside' money makes it more difficult to enforce the official rate of interest in the money market. At the same time, the increased reserves that would have to be held against such deposits would tend to 'bring the money market into the central bank'.

Financial development has two effects on the autonomous movement of reserves in the banking system that are relevant here. On the one hand there is, with a constant value of individual transactions, a Jevons-type 'Law of Large Numbers' effect, tending to stabilize the net outflow of reserves from the banking system, as more transactions increase the tendency of outflows and inflows to cancel each other out. This effect stabilizes outflows most in the initial increase in the numbers of transactions, so that with financial development it is of diminishing importance. The other effect is the tendency with financial development for transactions to get larger, with the growing importance of money-centre activities and large-scale securities trading. This combines with secular trends and medium-term cyclical movements in transactions that directly involve large movements in bank reserves (for example, international movements in bank deposits or changes in the fiscal position of the government). This effect would tend to increase the scale of autonomous movements in bank reserves. (The other factor in the scale of autonomous movements in bank reserves has historically been banks' transactions in international reserves, namely gold, during the period of the gold standard, and foreign currency, in the case of emerging markets today. Capital market liberalization obviously increases the scale of open market operations necessary to keep monetary aggregates stable. As this chapter shows, small open economies still require large scale-open market operations in foreign assets to keep the exchange rate stable.)

In Patinkin's neo-classical Keynesian interpretation, financial innovation means that, for a given level of nominal aggregate demand, less money is demanded, because securities are more liquid: '…the result of developing nonbanking financial intermediaries is to provide ultimate lenders with the possibility of purchasing a security which is more attractive (more "liquid") than the primary securities issued by the ultimate borrowers' (Patinkin 1972, p. 46; Gurley and Shaw 1960, pp. 123–126). In a later postscript, Patinkin argued that the effect of this is to increase the amount of open market operations required to obtain a given *change* in the real rate of interest: '…the existence of [non-bank] financial intermediaries does not, in principle, impair the efficacy of open-market policy. Theoretically, it only affects the conditions under which the monetary authorities operate in the bond market: that is, it affects the volume of operations that the authorities must carry out in order to establish a given rate of interest.' (Patinkin 1972, p. 54.) In the non-stochastic static general equilibrium model that Patinkin was describing, open market operations were only necessary to *change* interest rates, after which a stable equilibrium would emerge. By contrast, the autonomous movements in the reserve

position of the banking system as a whole are usually modelled as being subject to stochastic shocks. Moreover, it should be pointed out that open market operations can only directly influence the *nominal* rate of interest. The eventual *real* rate of interest depends on the course of price inflation over the period *after* a security has been issued. The demand for money that Patinkin had in mind was the demand for real money balances, in relation to the real rate of interest. To put this in the context of the new consensus monetary policy, it is necessary to convert this demand, and supply through open market operations, as well as the real rate of interest, back into nominal values. This is easily done by multiplying through by the price level that was originally used to obtain real variables. With a flatter, more interest-rate-elastic demand curve for money, or for the reserves held against bank deposits, financial development requires a central bank to increase the amount of open market operations necessary to enforce a given change in the rate of interest. In the 'New Consensus' the policy of the central bank is oriented towards stabilising the overnight rate of interest around its official rate, by off-setting (through open market operations or standing facilities) autonomous movements in the reserves of the banking system as a whole. If those autonomous movements increase in scale, as they would with capital account liberalisation in emerging markets, or with the expansion of money centre activities, then the amount of off-setting that has to be undertaken by the central bank is correspondingly increased.

As has already been noted, financial development involves the more rapid expansion of 'inside' money, which is a liability of the banking system, relative to the 'outside' money (bank reserves plus cash) that remains a liability of the government, or of the central bank (Patinkin 1972). Financial development and the more rapid growth of 'inside' money obviously increase the range of credit activity that may be undertaken on the basis of a given quantity of bank reserves. At the same time, for any positive reserve requirements, actual reserves that have to be kept in the banking system rise with the *gross*, rather than the *net*, liabilities of the system. *Any* loan that is granted, for example, against the collateral of long-term securities, becomes on its use as payment a deposit against which additional reserves have to be set aside in a liability-based reserve system. This is true a fortiori of asset-based reserves, such as the Basel Accord system. (In this respect, the composition of household-sector financial assets may give a misleading impression of the changes taking place in the course of financial development. There is undoubtedly a reduction in the share of bank deposits in household-sector financial assets, but bank balance sheets in fact increase with the growth of money centre banking activity; see Palley (2004) and Toporowski (2007)).

Since the early years of central banking, open market operations have been a crucial instrument for stabilising the liquidity of the financial sector. Thornton, referring to Great Britain in the 1793 pre-crisis period, particularly to the Bank of England refusal to grant further liquidity accommodation leaving 'the unfortunate public to shift for itself' and 'unheard intensification of financial panic and the danger of universal failure', showed the importance of Treasury bills in liquidity provisions.[1] Even at that time there existed, besides standing facilities, open market operations based on government bond purchase and sale a means of regulating

the activity of financial markets is needed. A particular feature of open market operations is that central banks or governments rather than commercial banks retain the initiative.

Sayers (1957) in discussing different approaches of monetary policy (referring to England) argues that OMOs are a way for central banks to modify liquidity in the financial system. This is achieved by changing banks' reserves and thereby credit provisions. The buying and selling of government bonds also modifies the interest-rate structure as well as bank reserves. The conditions for OMOs to operate are deep and broad financial markets and central bank willingness to mop-up any liquidity surplus and, if it is needed, to create liquidity by adding assets to its balance sheet. Initially the objective of open market operations was to enforce the Bank Rate Policy, by influencing the position of the market (credit looseness or tightness) that modifies commercial banks reserves. Operations can also affect the term structure of interest rates by changing the liquidity of medium and long-term markets, because the central bank can discount bonds of the different sections of the financial market (Sayers 1957, chapter 5).

Until recently, open market operations were used only in developed economies due the narrow, or even non-existent, financial markets in developing economies. If OMOs were used in weak financial markets only the interest-rate structure would be affected, with no impact on liquidity. Hence central banks' open market operations were substituted by decrees, which could be effective in markets insulated from international capital movements (Sayers 1957, chapter 9). In his words: 'if ratios (*cash relations related to deposit liabilities*)' are raised by decree of the central bank (or other authorities) the tightening effect on the commercial banks is exactly the same as a given amount of open-market sales by the central bank' (p. 129). Compulsory reserves under the legal reserve requirement regime were dominant in emerging countries for guaranteeing liquidity and even for financing economic growth led by public spending.

The legal reserve requirement and government intervention in general became less effective in the 1970s due to higher capital mobility. Banks and non-bank financial institutions were considered to be alike and required to compete for deposits. Therefore extra 'costs' – such as the legal reserve requirement – (Schwartz 1998) were difficult to impose on banks, and the practice emerged of allowing interest rates to be solely determined by market mechanisms with no government interference in terms of special or general deposits. The financial system (particularly of developing economies) necessitated two big modifications to adapt to the new financial environment: negotiable government bonds and financial markets for bonds to circulate. These institutional changes took place in Latin America during the 1970s and 1980s, as government finance switched from using bank credits to a reliance on bond finance, an essential stage in financial market development.

Under these conditions the central bank operational procedures of the developed world became increasingly standard throughout the world market. Legal reserve requirements and government interference in the financial (and non-financial) markets also became more difficult to enforce. The result of these changes was that emerging and industrial countries began to operate with the same monetary

instruments and similar objectives, principally the control of inflation. However, as will be argued below, the effects of such operations have been different in the emerging markets.

The use of open market operations in the control of inflation was neatly explained by Goodfriend and King (1988) in their classic article 'Financial deregulation, monetary policy, and central banking' argued that monetary policy could solely rely on OMO to accomplish monetary and banking objectives and also could fulfil the central bank function of lender of last resort (LLR, hereafter). In their terms: 'To illustrate that banking regulations are not essential for monetary policy, consider how a central bank prevents a temporary increase in the real demand for currency from decreasing the price level. It simply acquires securities temporarily in the open market, providing sufficient nominal currency to satisfy the higher real demand without a price level fall. Alternatively, suppose a central bank wants to restore a lower price level after an inflationary period. It does so by selling securities in the open market to reduce the stock of currency' (p. 5). Open market operations were also supposed to be used to sterilize discount window lending, a crucial means to fulfill the LLR function. In this way a 'loan to individual banks is merely substituted for government paper' (Goodfriend and King 1988, p. 9). The principal outcome of this period was the widespread use of open market operations in financially advanced and emerging countries, reducing the importance of Central Bank' discount window lending and standing facilities, (Toporowski 2006). As the Bank of England's Executive Director admitted 'With no deposit facility … the OMO rate was a natural way to express policy and we slipped into thinking of it as how we actually implemented policy too. That was a fallacy' (Tucker 2004), cited in Toporowski (2006).

Goodfriend and King along with monetarists such as Milton Friedman rejected monetary policy interventions not founded on market mechanisms in the belief that direct controls distort price signals. Once it was acknowledged that monetary variables could not be controlled directly, the LLR function that had acquired an important consensus among the different streams of economic thought was to be implemented through open market operations.

The extensive capital mobility that occurred from the 1970s after the demise of the Bretton Wood System induced monetary instability, which forced central banks to switch from monetary aggregates to interest rates. Alan Blinder put it in the context of differential real (IS) and monetary (LM) shocks. 'Large LM shocks militate in favor of targeting interest rates while large IS shocks militate in favor of targeting money supply … Ferocious instabilities in estimated LM curves in the United States, United Kingdom, and many other countries, beginning in the 1970s and continuing to the present day, led economists and policy markers alike to conclude that monetary supply targeting is simply not a viable option' (Blinder 1999, p. 2). This belief was summarized by a former governor of the Bank of Canada who said 'we didn't abandon the monetary aggregates, they abandoned us' (Blinder 1999, p. 28).

Once the interest rate became the operational target, its monetary nature was recognized. Consequently central banks could determine its price. Although it

could affect real variables in the short run, it was considered to remain neutral in the long run – for critical views see Dalziel (2002). Consequently, even if the mainstream of economic thought rejected the prevalent monetarist view of the second half of the last century, money continued to be regarded as non-neutral and inflation considered a result of demand pressures. Thus, the interest rate became related to demand variables which can increase real income so long as the potential demand is different from the observed demand (a short-term real effect of monetary policy). The interest-rate movement is related to the output gap and its task is to close the gap to keep inflation under control. A major shortcoming of this discussion is the estimation of potential demand, vital for the output gap determination, that undermines the effect of money in the supply conditions of the economy; see Dalziel (2002).

The acceptance that interest rates won over monetary aggregates as instruments to keep inflation under control posed another problem, which is how to implement central bank operations. According to the New Monetary Consensus[2] non-market mechanisms had to be revived, which would operate with fewer OMOs, with the aim of 'bringing banks to the central bank' (Toporowski 2006). Standing facilities would operate alongside signalling policies that announce interest rates beforehand and penalty rates for additional liquidity demanded by commercial banks. Thus, monetary policy instruments have reverted to central banks' direct interventions, to modify net internal credit whenever inflation may move out of central bank target level. Summing up, at present, interest rates dominate monetary policy instruments. They affect the interest-rate structure and reserve positions through combining mechanisms. Standing facilities are offered with upper and lower interest-rate limits; open market operations merely exist to reduce market liquidity, forcing commercial banks to become indebted with the central bank, thereby modifying commercial and central bank balance-sheet composition. The importance of open market operations depends on having reserve requirements that oblige financial institutions to hold deposits in the central bank (including regulatory bonds).

However, the discretion of central banks' interest rate policy has been restricted by international capital mobility creating a world-wide financial market. Latin American financial markets have undergone a rapid process of capital account liberalization. Financial as well as economic crises became more frequent than in other regions of emergent countries, such as East Asia, and in comparison to the previous periods; see French-Davies (2005), Stallings with Studart (2006). Moreover, Latin American financial systems remained bank-based with limited banks credits. Third, the financial system did not experience accelerated long-term growth as was expected and had small effect or even nil results in terms of financial intermediation for financing economic growth. Finally, but not less important, bond markets have remained dominated by government bonds.

Between 1990 and 2003 Latin American financial resources in terms of GDP increased from 63% to 112% (see Table 7.1, section C); while the East Asian financial resources in terms of GDP increased from 141% to 236% of GDP, correspondingly. However, the Latin American stock and bonds market share increased

Table 7.1 Latin American composition of domestic financial sources, 1990–2003

	Latin America			Mexico**	
	1990	1995	2003	1990	2003
SECTION A					
Absolute size (billions of $)*	**542.9**	**1199.9**	**1735.3**	**176.2**	**525.9**
Bank Claims	340	500	639	83.9	258.4
Bonds Outstanding*	81.9	316.9	533.3	59.6	144.9
Stock Market capitalization	121	383	563	32.7	122.5
Share of total finance					
Bank Claims	63	42	37	47.6	49.1
Bonds Outstanding	15	26	31	33.8	27.6
Stock Market capitalization	22	32	32	18.6	23.3
SECTION B					
Total size in terms of GDP	63	79	112	67	86
Bank Claims*	34	33	41	32	42
Credit to the private sector	23		22	15	16
Bonds Outstanding	17	21	37	23	24
Bonds for the private sector***	2		8	1	3
Stock Market capitalization	12	25	34	12	20
Turnover ratio	30		20	44	21
No. Listed Companies	1624		1237	199	159
Price index	326		1288	761	2145

	Latin America	Mexico
SECTION C		
Holders of domestic debt securities, 2000		
Central Bank	10	0
Commercial Bank	31	57
Institutional Investor	33	13
Other financial Institutions	29	29
Non residents	0	1
Others	6	0

Source: Stallings with Studart 2006, table 5.1, 5.2, 5.3, 5.4 and 5.5, IMF and BIS

* The data for total outstanding bonds (1990 and 2003), total size of the market in nominal terms (1990); Banks claims in terms of GDP for Mexico (2003) differs from the Stallings and Studart original tables.
** The data obtained for Mexico is based on the cited sources by Stallings with Studart.
*** Considered 1993 for private debts. The exchange rate used to convert banks claims and GDP was the annual average exchange rate.

more rapidly, each representing nearly a third of the financial market in 2003, while in 1990 they were 22% and 15%, respectively (see Table 7.1, section B). The expected outcome was the shrinkage of the banking sector, which halved its participation. In 1990 it represented 63% of total resources, whereas in 2003 it was only 37% (see Table 7.1, section B).

The evolution of the different financial market segments in terms of GDP shows that the bond market became stronger in relation to the stock market and bank shares. Specifically the Latin American bond market represented 37% of GDP in 2005, while in 1990 it only amounted to 17% of GDP; the stock market reached 34% of GDP, showing higher growth since it was highly underdeveloped in 1990 (12% of GDP). Banking claims had the lowest growth rate, from 34% in 1990 to 41% of GDP in 2003. This was due to the continued and increased government absorption of financial resources, which (partially) shifted from the banking sector to the bond market. Consequently, the public sector was the principal bond issuer, inhibiting private bond issues – even deterring commercial banks' bond issuance for financial intermediation purposes. This meant that open market operations can be highly effective in modifying institutions' reserves and market interest rates (almost all central banks acquired the autonomy to do this in the period).

Another important trend is that the emergence of the bond market did not induce financial market depth or breadth. In Latin America, domestic debt securities (mainly government bonds) are still largely held until maturity. This is made easier because government bonds are mainly short-term. But in this way the development of a secondary market is inhibited. Commercial banks hold 31% of outstanding bonds despite the reduced participation of banks in financial intermediation. Institutional investors (private pension funds, insurance companies and investment funds of various kinds) hold 33% of domestic bonds also largely up to maturity because they guarantee higher income with minimal financial risk. Other financial institutions, with 29% of bonds, follow the same strategy. The category of 'others' – that represent individual investors and corporations – is very small (6%) (Table 7.1, section D). They are the only segment of the market that could develop the depth of financial markets since they buy bonds to sell them. Therefore in spite of the increased proportions of bonds in circulation the financial market remains thin and shallow.

The capital market is also unrelated to new finance, since new stock issuances are rare and the stock market turnover contracted (i.e. market liquidity fell, which means the secondary market size shrank) increasing the possibility of 'incorrect' prices. In fact, index prices multiplied four times, explained primarily by external capital flow movements; see Table 7.1, Section C. Moreover, the process of company delisting corroborates the weak nexus between capital market shares and financing investment spending. This can be explained because of the increased dominance of national enterprises and multinationals throughout the region. These companies prefer to operate in the international market rather than the domestic financial market and their investment finance relies on internal resources (Levy 2005). Finally, it needs to be stressed that credit for the private sector fell by 1% as a share of GDP over the period (see Table 7.1, section C). This indicates that commercial banks became unimportant for economic growth.

External capital flows have played a major part in the expansion of Latin American financial markets, even after the 1995 Mexican crisis (and even

in Mexico). Most importantly outstanding bonds in the external market became the principal component of external flow movements and were mainly issued by the public sector (they are reported to be responsible of nearly two-thirds of total outstanding bonds issued abroad, leaving the remaining 16% to non-financial corporations (Stallings with Studart 2006, p. 127). The same source (p. 126, Table 5.6) indicates that external capital flows in terms of GDP increased from 20% in 1995 to 50% in 2003, while international bonds grew from 4% (1995) to 19% (2003). International bank loans only doubled their share (in 1995, 15% of GDP, and in 2005, 29%); and equity share rose from 1% to 2% of GDP.

The importance of external capital flows in Latin America can be explained in terms of the region structural inflation (a term coined by ECLAC). This means a magnified response to exchange-rate variations, explained by price inelasticity (and income elasticity) of exports and imports. Developing economies historically have been highly dependent on the international market.[3] Under these conditions exchange-rate devaluations raise the cost of imports and, with imperfect competition, prices rise with a complete (or even magnified) pass through, only neutralized by lower salary levels. Conversely, external capital inflows induce exchange-rate overvaluations, reducing the cost of external goods and services. Central banks lower interest rates, the debt burden drops, and investment spending rises. The demand for credits increases and economic growth takes place. This process puts pressure on the external current account, which will eventually induce a debt deflation process à la Minsky, although unrelated to economic activity and to deep and strong financial markets (i.e. *financial innovations*).

Summing up, the main characteristic of Latin American developing countries is that the capital market does not provide finance for investment, and stock and share price indices are strongly related to external portfolio capital movements. Bond markets have increased their share of financial intermediation but remain disconnected from bank funding or finance provisions for non-financial enterprises. This is explained in terms of government dominance in the bond market, used to balance the external account deficit. Latin America is also very different from more financially advanced countries in that inflation is caused by exchange-rate variations. Hence monetary policy in developing economies requires increased open market operations to stabilize the exchange rate and keep inflation under control. However, this does not mean that such operations can provide economic stability. Emerging market countries have weak domestic currencies. Financial instability does not induce financial investors to switch from the market for stocks to the bond market with risk-free Treasury bonds, as would happen in a strong financial system such as the one in the United States (Toporowski 2005).

Open market operations: the Mexican experience

Mexico followed a similar pattern of financial deregulation and globalization to the rest of the Latin American region. The major institutional changes took place

during the 1980s so that banks' claims, bond market participation and stock market capitalization did not undergo drastic changes during the 1990s (see Table 7.1, section B and C). Private-sector issues took up an extremely low share of the Mexican domestic bond market in 2003, reaching barely 3% of GDP, well below the Latin American average (8% in terms of GDP). The ratios for Argentina, Brazil and Chile were 10%, 11% and 28%, respectively (Stalling with Studart 2006). This suggests that in Mexico the dominance of the public sector in the domestic bond market is greater in relation to other Latin American countries. The reason for this behaviour is that government bonds played a central role during the 1980s in the process of elimination of the legal reserve requirement[4] and in the development of securities houses (Minushkin 2005). After 1989 with the international integration of financial markets, government bonds (e.g. Tesobonos) became the most important financial instruments for attracting external capital flows and from 1995 onwards they were essential for stabilizing government finances after the 1994 financial crisis. They were also widely used to reduce the high levels of liquidity in the banking system that resulted from the increased external capital flows in the form of FDI that came with the inauguration of NAFTA (mainly cross-border acquisition and mergers as opposed to greenfield investment (Levy 2005)) and for bringing commercial banks into the central bank. Government bonds continue to be an important instrument although monetary policy revived reserve requirements, as will be discussed later.

Even though bonds in the international market ceased to be an important source of finance, as in other countries they were relevant in terms of reducing portfolio risks. In 1995, Mexico's outstanding bonds in the international market totalled 9% of GDP, well above the Latin American average (4%); while in 2003 this total reached 12% of GDP, below the regional average of 19% (Stalling with Studart 2006). In fact international bonds were issued disproportionately, relative to capital account liabilities, in the second half of the 1980s by the Mexican government to induce external capital inflows and to reduce internal liquidity (see Table 7.2). As financial markets became more integrated internationally, bond issuances in international markets increased substantially. Notable issuers

Table 7.2 Bond issues by Mexico in the external market %

	BIE/BoPL	*BIEPuS/BoPL*	*BIEBan/BoPL*	*BIEPri/BoPL*
1980–1984	1.21	1.21	–	–
1985–1989	−9.90	−6.89	–	−3.01
1990–1994	22.43	10.28	1.60	10.53
1995–1999	31.88	18.95	0.11	12.82
2000–2005	9.08	−8.95	−2.37	20.40

BIE: Bonds issued in the external market; BoPL: Capital account liabilities of the Balance of Payments; BIEPUS: Bonds issued by the public sector; BIEBan: Bonds issued by the banking sector; BIEPri: Bonds issued by the private sector, excluding banks.

Source: Our estimation based on BANXICO, data on line.

were the private non-banking sector and the public sector seeking an alternative finance source. After the 1994 Mexican crisis the public sector, as well as private non-banking institutions, continued to rely on foreign currency bonds to raise external capital. In practice banks did not participate in the external market after the sector was restructured during that period: banks were sold to foreign investors. After 2000, the public along with the banking sector began to diversify portfolios of financial assets through bond acquisition in the external market. This capital outflow came at the same time as the private sector continued to use externally issued bonds in order to reduce their portfolio risk (see Table 7.2).

During this period, stock market capitalization rose relative to GDP. But as elsewhere in Latin America countries, Mexico experienced a liquidity shrinkage in the secondary market. Thus despite undergoing profound changes, Mexican financial markets remained shallow and weak, dominated by the government sector that inhibited private bonds and shares issuance in the domestic markets.

These developments had a significant impact on the balance sheet of the Mexican central bank. On the asset side, international reserves stand out as the major element. Between 1980 and 1990 external reserves doubled their share of assets, and by the year 2000 represented half of central bank assets, in 2005 reaching 71% of total central banks assets (see Table 7.3), while investment securities and credits contracted dramatically. This was complemented by fairly constant levels of non-monetary liabilities (particularly when 1980 is compared with 2005). Although the legal reserve requirement disappeared and commercial banks were supposed to be freed from compulsory reserves, they were re-imposed through regulatory deposits at the central banks and holdings of government and central bank regulatory bonds. In 1980 they reached 67% of total assets, diminishing to 41% in 1990. In the year 2000 the trend was reversed, amounting to 57% of total assets, reaching in the year 2005 nearly the same share as in 1980, when the legal reserve requirement was a central instrument of monetary policy.

International reserves became the main element of the monetary base from 1985 onwards, especially after 1994, while net internal credits turned negative (except for a few years). These jointly affected the annual growth rate of the monetary base: see Figure 7.1. In effect net internal credits were obliged to off-set movements in international reserves to limit monetary base movements. This was managed through commercial banks and government deposits[5], in addition to credits granted to these sectors.

In this situation, repurchase agreements turned out to be an important new monetary mechanism that modifies liquidity temporarily (commercial bank overdrafts are limited by sales of bonds to commercial banks, reversed at a future date). Despite higher monetary liabilities overall, the ratio of M1 (coins, notes and chequeing accounts) to broad money (M4) has remained relatively constant, excluding the period 1990–1995.

After the 1994 crisis central bank operating procedures in Mexico were modified. Government bonds were channelled to residents, mainly to banks and subsequently to institutional investors (pension funds) and the issue of these bonds increased enormously. A significant proportion of them were non-negotiable, and used to

Table 7.3 Structure of Banco de Mexico balance sheet* (%)

	1980	*1990*	*2000*	*2005*
Assets	**100**	**99.99**	**99.49**	**99.66**
International Reserves	**11.6**	**35.16**	**52.06**	**71.13**
Investment Asset (Securities)	**71.66**	**47.31**		
Public Trust**	70.97			
Non-financial Public Sector***		46.45		
Credits	**9.18**	**8.69**	**31.95**	**13.64**
Credit Institutions	4.95			
Financial Intermediaries		7.4		
Official Trusts (incl. IPAB)			16.59	
Debtors for Securities repos				**6.38**
Other Concepts	**7.56**	**8.83**	**15.48**	**8.51**
Liabilities	**100**	**100**	**100**	**100.01**
Monetary Liabilities	**25.99**	**31.46**	**33.72**	**37.02**
Non-Monetary Liabilities (deposits)	**66.69**	**41.43**	**56.67**	**65.04**
w/ Credit Institutions	62.6			
w/ financial institutions		14.89		
w/ external sector		22.27		
Monetary Regulation Bonds (BREMs)			3.53	25.23
Net Monetary Regulatory Deposits			22.57	
Fed. Gov. Regulatory Deposits			20.57	12.2
Commercial Bank deposits			7.6	22.3
Other Concepts	**7.26**	**27.05**	**9.61**	**−2.05**
Capital	**0.06**	**0.06**		

* Spaces means that the data do not exist or are unimportant.
** Institutions that received central bank finance for productive investment.
*** Financial resources provided by the central bank to pay previous credit commitments.

Source: Our calculations based on Banco de Mexico web site.

finance government schemes to rescue the banking sector as well as large private national enterprises. This reinforces the idea that governments bonds are unrelated to broadening and deepening the financial market.[6] The main function of non-negotiable government bonds was to restore the balance sheets of troubled institutions, but with the distinctive feature that such bonds could not be resold into the secondary market. Holders of non-negotiable government bonds received returns based on the treasury bond rate that yielded extremely high financial margins for banks, with returns over twice the cost of borrowing.[7]

Moreover, after the 1994 crisis the discount window was used to signal interest rates to the money markets (Schwartz 1998). Discount-window rates form an interest-rate corridor, limited at the top by the central bank lending rate (funding rate) and in the lower limit by central bank deposit rates, announced in advance.

A third change introduced in 1995 was the introduction of an averaging period of 28 days for the average gross reserve requirement, with the requirement that commercial bank reserve accounts at the central bank on the 28th day should be zero. Under the new regime commercial banks could overdraw up to the
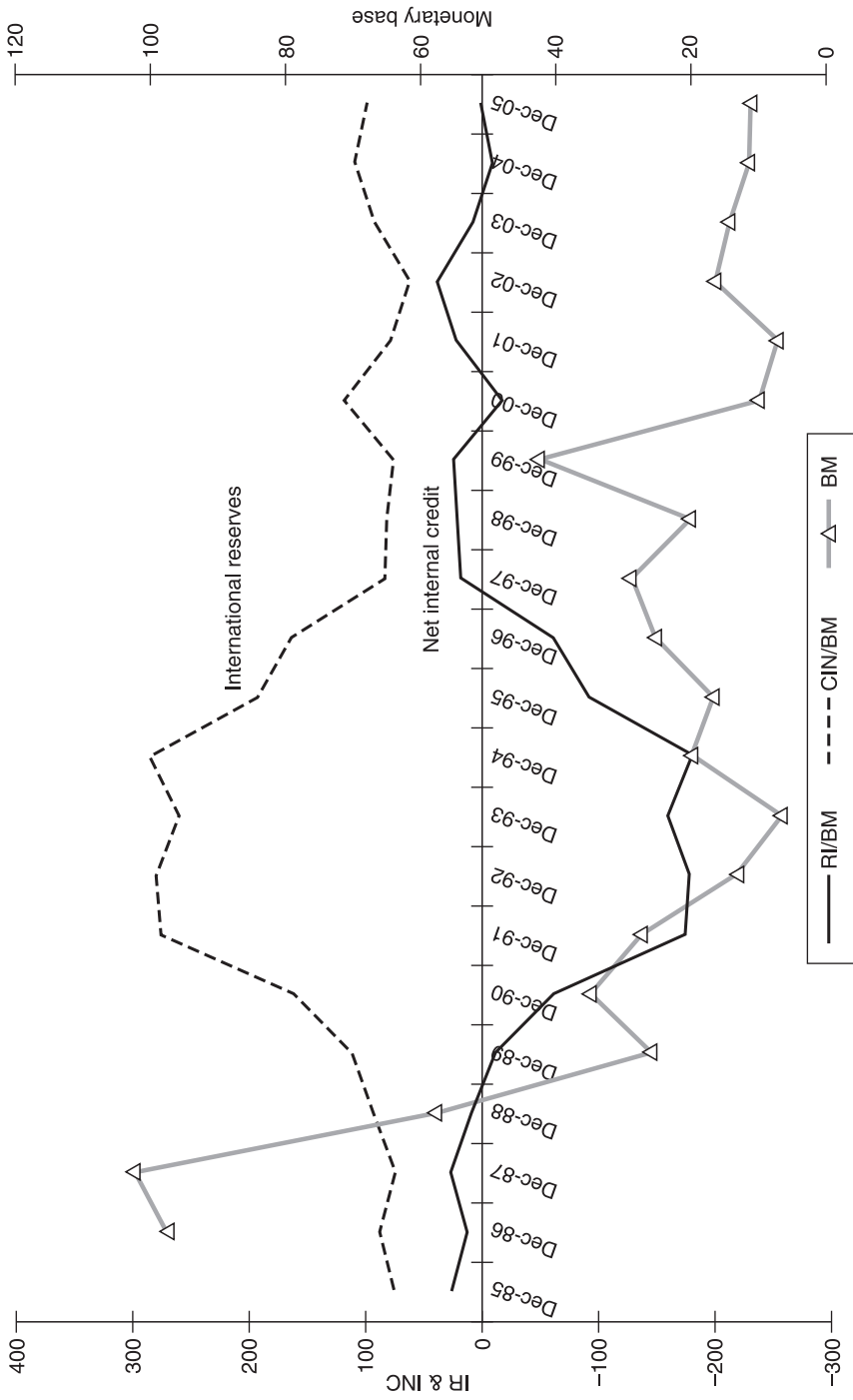
Figure 7.1 Monetary Base composition and the rate of growth of the monetary base. RI: International Reserves, BM: Monetary base: CIN: Net Internal Credit. *Source*: Own calculation based on Banco de Mexico data.

amount of bonds held as security at the central banks (using *repos* for this purposes). If bank overdrafts were not settled, a penalty of twice the treasury-bond rate on the negative accumulated stock was imposed (Banco de Mexico, *Informes Anuales 1999*). Open market operations for this purpose became important just before the end of each period to guarantee that banks would have enough liquidity.

After this, in 1996, the Central Bank moved to negative stocks requirements (Castellanos 2000) by shorting the financial system. 'The [central bank] establishes or increases the negative target for the consolidated balance of the current accounts it holds for banks. This tends to raise temporarily short-term interest rates, which limits the effect of existing inflationary pressures on prices' (p. 93). Through this mechanism the central bank induces a deficit in bank current accounts that causes the banking system to be 'short'. (p. 79). Thus, the central bank covers all the needs of commercial bank reserves at different interest rates, supplying through public bond auction the part that the central bank wishes to reduce. Shorting is effective when central banks are in a creditor position.

Subsequently, in 1998 the monetary instruments were further strengthened through imposing a minimum for funding rates. This was due to the changing position of the central bank in the money market from creditor to debtor, as a result of the increased international reserves in the previous year (Banco de Mexico, *Informes Anuales* 1998). Higher international reserves indicated excess of liquidity in the money market at the beginning of daily operations, which are reduced by open market sales of bonds. The institutions that offer the lowest interest rates hand over their excess reserves to the central bank, thereby reducing short (one day) interest rates, which undermines the central bank's shorting policy of inducing a higher level of interest rates, when financial instability prevails. Thus, when the central bank faces difficulties in increasing interest rates to stabilize the exchange rate, a floor to interest rates is imposed to prevent subsequent reductions. This was reinforced by imposing regulatory deposits (September 1998) that received interest linked to the inter-bank interest rate. Between 1997 and 2003 inter-bank rates were significantly higher than the treasury bond rate, so the system ensured high financial margins for commercial banks. Regulatory bonds were also used sporadically during the 1990s, especially before the 1994 crisis, to mop up the increased liquidity resulting from external capital inflows. Initially they were based on treasury bonds and by the year 2000 they were replaced by central bank regulatory bonds (BREMs).

Thus Mexican monetary policy was similar to that in financially advanced countries in terms of operational instruments and objectives. However, there was an additional intermediate objective of exchange-rate stabilization. This required increased volumes of open market operations to neutralize external capital surges coming in and out of the Mexican financial market. In effect this made the central bank pursue pro-cyclical monetary polices. Interest rates have not been negatively correlated with the output gap, especially after 1998 when the international financial market integration increased. As Figure 7.2 shows, interest-rate changes have been unrelated to the output gap after the 1995 crisis. In contrast to the
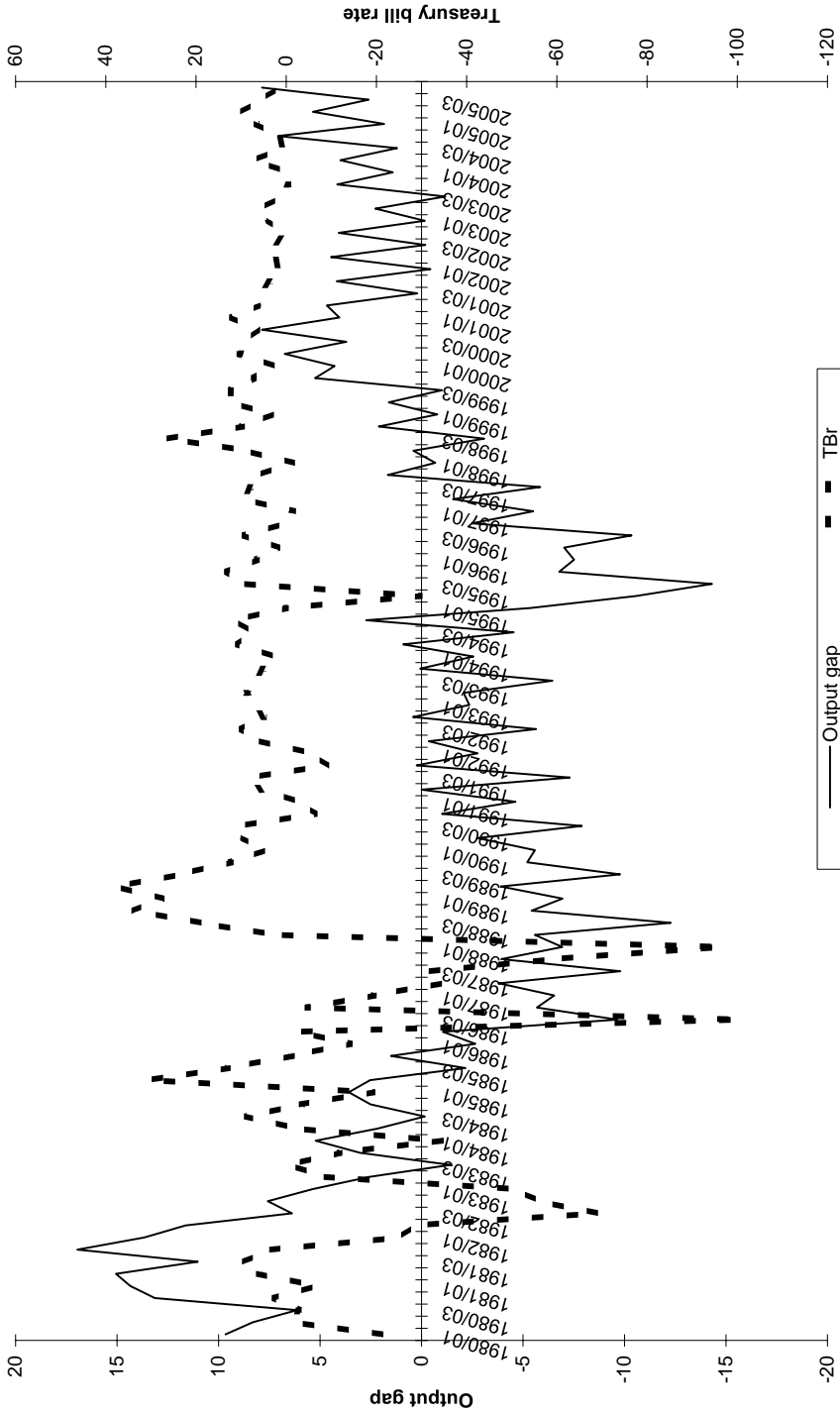
Figure 7.2 Relation of interest rate and the output gap. The output gap was determined through Hodrick filter. *Source:* Own calculation based on Banco de Mexico data.
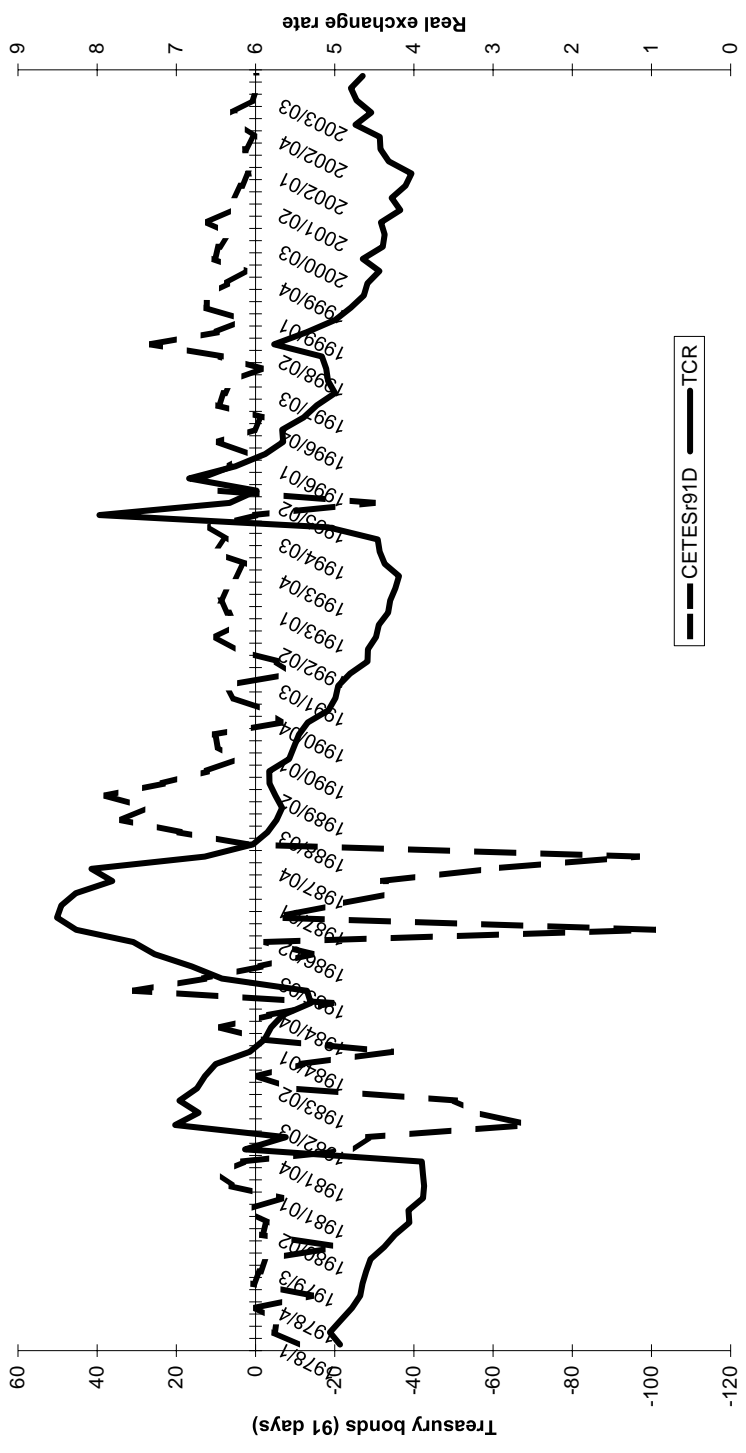
Figure 7.3 Relation of interest rate and exchange-rate movement.
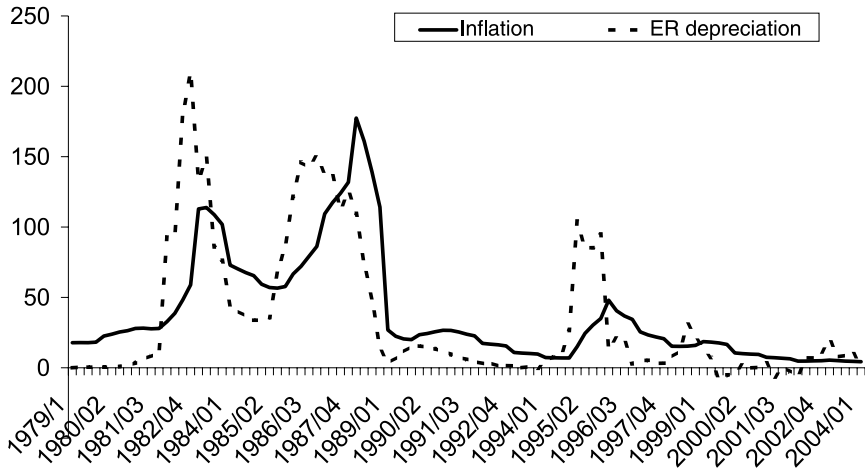
Figure 7.4 Relation of exchange rate and inflation.

New Monetary Consensus, Mexico's monetary policy cannot affect the demand side of the economy, because the main objective in the central bank's reaction function is to stabilize the exchange-rate to attain price stability. Interest rates are correlated to exchange-rate movements (Figure 7.3). The central bank reduces the interest rates when the exchange rate is overvalued and raises them when the exchange rate depreciates. Thus, the central bank reaction function is focused on exchange-rate movements.

Finally, exchange rates and prices (Figure 7.4) follow very similar movements, with causality going from exchange rates to prices. Structural inflation imposes an intermediate target of exchange-rate stabilization on the central bank, independently of economic growth. When the exchange rate stabilizes, interest rates fall, inflation diminishes, investment spending increases and economic growth increases (Figure 7.5).

Conclusion

Under a system of monetary globalization, financial institutions and particularly commercial banks cannot operate solely under central bank regulation (BIS-I, BIS-II).[8] Open market operations are insufficient to impose central bank interest rates and alter financial institutions' reserves. In Mexico, regulatory deposits (and bonds) had to be reinforced along with signalling policies for 'bringing commercial banks into the central bank'. These non-market mechanisms meant that central banks can compel commercial banks and other financial institutions (as well as governments) to make deposits at the central bank, thereby reducing government bond issues and commercial banks' freedom. However, this reinforcement of
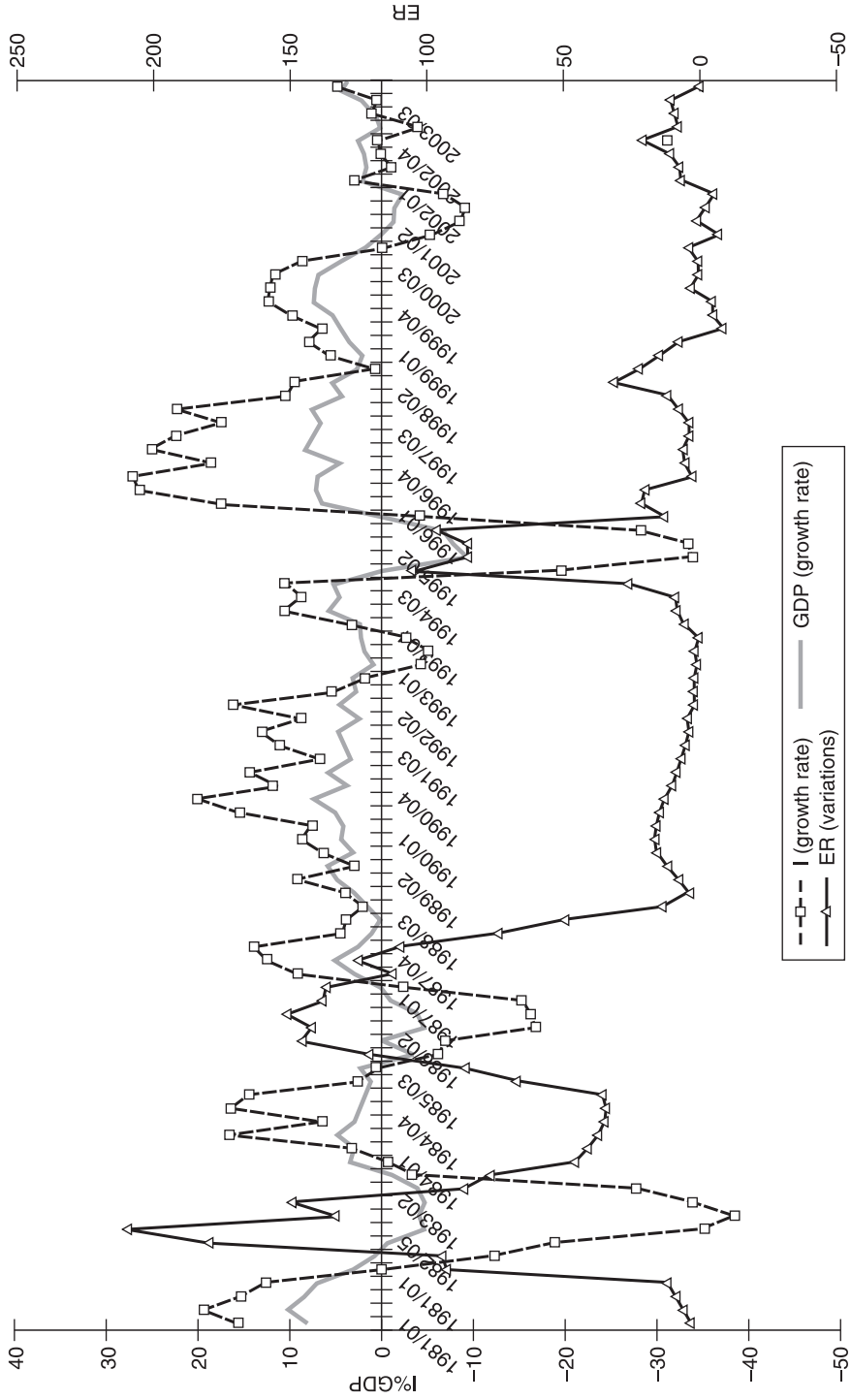
Figure 7.5 Investment, GDP rate of growth and exchange-rate variations. I: investment; GDP: Gross Domestic Product; ER: Exchange-rate variations. *Source*: Own calculation based on Banco de Mexico data.

non-monetary mechanisms has been accompanied by a shift of intermediation into dollar markets.

New Consensus policies have been followed by emerging countries, as illustrated by Mexico. From 1995 onwards signalling policies have determined the lower and upper limits of money market interest rates, average gross reserve requirement, minimum interest rate, and regulatory bonds along with regulatory deposits for financial (bank and non-bank) institutions at the central banks. The new monetary policy scheme has shown several shortcomings in the Mexican economy. Non-market mechanisms as well as signalling policies have been criticized for having little effect on the interest-rate structure and especially on the liquidity positions of the financial institutions. This can be explained by Mexico's external capital flow dependence, and mainly by the central bank's policy reliance on international reserves to stabilize the exchange rate and therefore keep inflation under control. Monetary policy, as in other emerging markets, is overridingly committed to stabilizing the exchange rate, for which OMOs are highly effective. However, monetary policy is then also pro-cyclical, because economic growth requires a stable and even overvalued exchange rate that entails external capital inflows, which reduces or stabilizes prices. Under those conditions interest rates can be reduced and investment spending can increase.

Finally a distinct monetary policy feature of emerging countries such as Mexico is that interest-rate movements are unrelated to demand pressure. Inflation is explained in terms of cost variables rather than demand pressure, therefore interest-rate movements are unable to close the output gap as mainstream thinking suggests. In Mexico interest rates are related to external capital flow, consequently the central bank's reaction function is not linked to economic growth.

We may conclude by stating that non-market mechanisms were vital monetary policy transmission mechanisms before capital account liberalization occurred because of the underdeveloped nature of financial markets, especially the bond market. The Mexican financial market expansion was achieved through the bond market, mainly Treasury bonds. Although these impeded bond market diversification, the Treasury bond market became functional in terms of monetary policy operational instruments. However, financial and economic stability still depend on external capital movements.

Notes

1 Thornton (1802/1962) 'After the pressure by the government on the Bank to relax its attitude had failed to produce any result, a rapidly appointed committee of the House of Commons recommended that Exchequer bills to the amount of £5,000,000 should be issued (….) to provide the mercantile community with the means to raise cash. The mere announcement that this step would be taken went far to stay the panic and, in fact, only a fraction of the authorized amount of the Exchequer's bills had to be issued before normal conditions were restored' (p. 39).
2 This discussion is based on Toporowski (2006a), third section 'The optimum level of open market operations'.

3 Kregel (2004) argues that since the Latin American countries became independent they have been subjected to open markets and unequal terms of trade.

4 Negotiable treasury bonds in Mexico appeared as late as 1982 and their operation activated the money market.

5 The Mexican government has given fiscal support to the central bank (Banco de Mexico) since 1993; see Mantey and Levy (1999).

6 Non-negotiable government bonds in the first quarter of 1996 amounted to 60% of total government bonds and by the third quarter of 2003 they had fallen to only 30% of total government bonds issued.

7

Financial Margin (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
TB/DR	106	102	112	125	113	139	189	227	244	232	250	274

TB: Treasury bill rate (28 days), DR: deposit rates (28 day). The yearly data are the average of the four quarterly ratios.

8 After the elimination of the legal reserve requirement the Bank for International Settlements suggested that banks should hold 8% of their total capital as a reserve (known as the BIS-I regulation). The 1994 Mexican crisis showed that this regulation was very ineffective and suggested that the 8% capital reserve should account for different risk assets, thereby becoming a weighted reserve ratio in terms of bank assets.

8 Open market operations and the federal funds rate

*Daniel L. Thornton**

The conventional view is that the Fed controls the federal funds rate by altering the supply of liquidity in the overnight market by changing the supply of reserves relative to demand through open market operations (Taylor 2001; Friedman 1999). Open market operations are conducted by the Trading Desk of the Federal Reserve Bank of New York (the Desk). While the procedure that the Desk follows has evolved and continues to do so, the fundamental procedure has remained largely the same since at least the mid-to-late 1970s. Specifically, the Desk estimates (*a*) the demand for reserves that are required to achieve the FOMC's operating objective and (*b*) the quantity of reserves that would be available if the Desk did nothing. If (*a*) exceeds (*b*), the procedure indicates that reserves be added through an open market purchase of government securities. If (*a*) is less than (*b*), the procedure suggests that the Desk drain reserves through an open market sale.

It is important to note that the operating procedure is intended only to provide the Desk with guidance in conducting daily open market operations. It was never intended to be strictly adhered to. Specifically, frequent, yet informal, adjustments to the estimate of excess reserves were made.[1] Moreover, the Desk behaviour is also guided by other factors, such as its estimate of free reserves, in determining the day's open market operations.

This chapter uses daily data compiled by the author from the records of the Trading Desk of the Federal Reserve Bank of New York to analyse the effect of open market operations.[2] The chapter addresses two issues: the use of the operating procedure in implementing monetary policy and the extent to which open market operations affect the federal funds rate – the liquidity effect. In so doing, it provides some evidence on the relative importance of Fed operations in supplying liquidity to the federal funds market.

The first section presents the Desk's operating procedure in detail and analyses the Desk's use of the procedure. The next section investigates the relationship between open market operations and the federal funds rate. An analysis of these findings, as well as the conclusions, is presented in the final section.

The Desk's operating procedure

The equilibrium federal funds rate is determined by the demand for and supply of total reserves. Hence, the Desk's operating procedure under a federal funds targeting procedure is simply to equate the supply of reserves with the expected demand, conditional on the target for the federal funds rate. To illustrate the procedure, assume that the demand for total reserves (TR^d) is given by

$$TR_t^d = f(ff_t, \mathbf{x}_t) + \eta_t \tag{1}$$

where ff_t is the federal funds rate, $\mathbf{x}_t$ is a vector of other variables that determine reserve demand, and η_t is a random *i.i.d.* demand shock. Implicitly, the demand for reserves includes the demand for excess reserves – reserves in excess of those needed to satisfy Federal Reserve-imposed reserve requirements.

The quantity of total reserves supplied if the Desk conducts no open market operations is determined by the Fed's holding of government securities, B_t, borrowing by depository institutions, BR_t, and what the Desk refers to as autonomous factors that affect reserve supply, F_t, e.g., currency in circulation, the Treasury's balance at the Fed, the float, etc.[3] That is,

$$TR_t^s = B_t + BR_t + F_t. \tag{2}$$

In practice, the Desk knows the magnitude of none of the variables on the right-hand-side of (2) at the time that it conducts open market operations; however, because the errors are very small for B_t, for the sake of this analysis B_t is assumed to be known exactly.[4] The Desk makes an estimate of the autonomous factors that affect reserve supply, i.e., $E_{t-1}F_t = F_t + v_t$, where E_{t-1} denotes the expectation operator conditional on information available before that day's open market operation, and v_t the forecast miss. The Desk does not estimate borrowing, but rather applies the FOMC-determined borrowing assumption, called the initial borrowing assumption (IBA_t).[5,6] Given these assumptions and definitions, the estimate of reserve supply if the Desk conducts no open market operations is given by

$$E_{t-1}TR_t^s = B_t + E_{t-1}F_t + IBA_t. \tag{3}$$

The amount of the open market operations suggested by the Desk's operating procedure, which I call the operating-procedure-determined open market operation ($OPDOMO_t$), is given by

$$OPDOMO_t = E_{t-1}f(ff_t^*, \mathbf{x}_t) - (E_{t-1}NBR_t + IBA_t) \tag{4}$$

where ff_t^* denotes the Fed's target for the federal funds rate and $E_{t-1}NBR_t = B_t + E_{t-1}F_t$ is the expected level of nonborrowed reserves.[7] If $OPDOMO_t$ is positive, the procedure directs the Desk to purchase government securities to keep the funds rate at the targeted level. If it is negative, the procedure indicates government securities should be sold.

An evaluation of the Desk's operating procedure

The Desk's use of its operating procedure is analysed using daily estimates of $OPDOMO_t$ during the period March 1, 1984, to December 31, 1996. In practice, the staffs of the New York Fed (NY) and the Board of Governors (BOG) made separate estimates of the maintenance-period demand for reserves and the supply of nonborrowed reserves. Hence, there are two separate estimates of procedure-determined open market operations for the day. Because there are more observations available for the BOG estimates, only the BOG's estimates are used here.[8] However, the qualitative conclusions are essentially unchanged when the NY estimates are used. This not surprising because the correlations between these alternative estimates of reserve supply and demand are 0.9986 and 0.9996, respectively.

Reserve requirement changes

There were two major changes in reserve requirements during the sample period. The first occurred on December 13, 1990, when reserve requirements on non-personal time and saving deposits and net Eurocurrency liabilities were reduced from 3 per cent to zero over two maintenance periods. The second occurred on April 2, 1992, when the reserve requirement on transactions deposits was reduced from 12 per cent to 10 per cent. The first of these was a surprise move. It took time for banks to adjust to the lower level of operating balances, and the funds rate became more volatile for a period. Consistent with the New York Fed's assessment of the impact of these changes, preliminary analysis indicated that the Desk did not follow the operating procedure closely during maintenance periods affected by these reserve requirement changes.[9] Consequently, these maintenance periods were deleted in order to avoid biasing the results. Finally, there are days when some of the observations are missing because of incomplete records. These observations also have been deleted. The final number of daily observations is 3,176.

Table 8.1 summarizes, by day of the maintenance period, whether the procedure suggested the Desk add or drain reserves and what the Desk actually did. The reserve maintenance period ends on every other Wednesday. This is called settlement Wednesday, and denoted by *sw*. There were four instances in the sample period when the maintenance period effectively ended on Tuesday because the normal reserve settlement day was a holiday. In these instances, the preceding Tuesday was designated *sw* because banks settled their reserve accounts on that day.[10] Hence, all but four settlement Wednesdays are Wednesdays. All other days in the maintenance period are recorded on their corresponding calendar day.

Table 8.1 shows that for all days, the procedure indicated that reserves be added more often than drained. This is due in large part to the fact that the primary government security dealers, with whom the Desk conducts daily open market operations, prefer to sell rather than purchase securities from the Desk. Hence, the operating procedure is designed so that, more often than not, there is a need to add rather than drain reserves. It is also due to the fact that the currency grew at a

Table 8.1 Distribution of $OPDOMO_t$ and OMO_t by day of the maintenance period

Day of maintenance period	No. obs.	OPDOMO$_t$		OMOMPA$_t$			OMOD$_t$			Percent positive		
		Pos.	Neg.	Zero	Pos.	Neg.	Zero	Pos.	Neg.	OPDOMO$_t$	OMOMPA$_t$	OMOD$_t$
D1	318	254	64	41	233	44	59	228	31	0.80	0.73	0.72
D2	326	259	67	83	173	70	97	165	64	0.79	0.53	0.51
D3	285	219	66	45	197	43	51	203	31	0.77	0.69	0.71
D4	327	254	73	70	182	75	78	186	63	0.78	0.56	0.57
D5	325	258	67	84	169	72	98	153	74	0.79	0.52	0.47
D6	321	256	65	54	205	62	65	196	60	0.80	0.64	0.61
D7	327	264	61	84	167	76	101	157	69	0.81	0.51	0.48
D8	296	231	65	38	214	44	45	214	37	0.71	0.72	0.72
D9	323	229	94	51	187	85	54	189	80	0.71	0.58	0.59
SW	328	221	107	36	219	73	37	219	72	0.67	0.67	0.67
Totals	3,176	2,445	729	586	1,946	644	685	1,910	581	0.76	0.61	0.60

fairly constant rate over most of this period. Hence, reserves needed to be added more often than drained to accommodate currency growth.

The need to add reserves is particularly acute on the first day of the maintenance period. This is a consequence of the fact that estimates of reserve demand and reserve supply are maintenance-period-average estimates – they are daily estimates of the demand for or supply of reserves on average over the maintenance period. Consequently, the procedure automatically accounts for repurchase agreements (RPs) that were executed during previous maintenance periods, but are scheduled to mature some time during the current maintenance period.

Table 8.1 compares $OPDOMO_t$ with two measures of actual daily open market operations, $OMOD_t$ and $OMOMPA_t$. $OMOD_t$ is the net of open market purchases and sales of government securities on the day. This is probably what most people think of when discussing open market operations. In contrast, $OMOMPA_t$ reflects the effect of the net operation on the supply of reserves over the maintenance period. For example, assume that the Desk purchases exactly as much as it sold on the day, but sold overnight and purchased with a multiple-day term. In this instance, $OMOD_t$ would be zero but $OMOMPA_t$ would be positive. $OMOMPA_t$ reflects the net effect of the day's open market operation on reserves over the maintenance period, while $OMOD_t$ indicates the net amount of purchases and sales on the day. Consequently, one measure may indicate a purchase and the other a sale. Indeed, there are 102 days when this occurred. There are another 102 days when $OMOD_t$ is zero, but $OMOMPA_t$ is not. There are only three instances when the reverse is true, however. Despite these differences, these measures are highly correlated (0.75).

Both measures indicate that Desk actions frequently had no impact on the supply of reserves. On nearly 22 per cent of the days $OMOD_t$ was zero, while on nearly 19 per cent of the days $OMOMPA_t$ was zero. The decision not to affect the supply of reserves either on the day or over the maintenance period appears to be influenced, in part, by the magnitude of $OPDOMO_t$. $OMOD_t$ and $OMOMPA_t$ are more likely to be zero when $OPDOMO_t$ is relatively small and are almost never zero when $OPDOMO_t$ is relatively large.

While the data in Table 8.1 suggest that the Desk follows the operating procedure relatively closely, it did not follow the procedure mechanically. The correlation between $OPDOMO_t$ and $OMOMPA_t$ is 0.61.[11] Figure 8.1 presents a scatter plot of these variables with $OPDOMO_t$ on the horizontal axis and $OMOMPA_t$ on the vertical axis. These data indicate that the Desk generally added less than the procedure indicated when the procedure suggested that reserves be added and drained less than the procedure suggested when it suggested reserves be drained. This behaviour is due in part to the fact that the Desk often does nothing when the procedure suggests a relatively small need to add or drain reserves.

It is also due, in part, to the fact that the Desk underestimated reserve demand on average. The average forecast error is $0.07 billion, with a standard deviation of $0.37 billion. The forecast errors are slightly skewed upward, as the median is $0.06 billion, and are highly serially correlated (0.83).[12] While the mean and median forecast errors are both significantly different from zero at
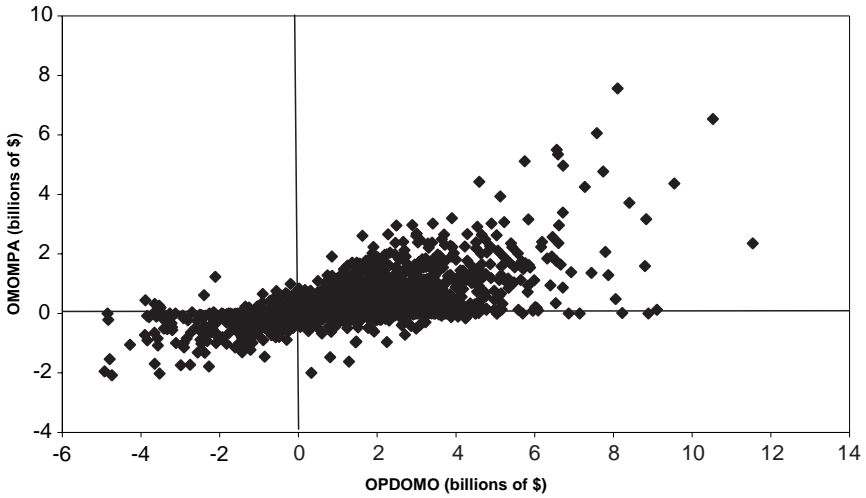
Figure 8.1 Comparison of OPDOMO and OMOMPA March 1, 1984 – December 31, 1996.

the 5 per cent significance level, they are small relative to the mean ($54.6 billion) and median ($56.8 billion) levels of total reserves. Hence, the Desk did a good job of forecasting reserve demand.

How well did the Desk follow its operating procedure?

The extent to which the Desk followed its operating procedure and the extent to which the Desk responded to other factors in conducting daily open market operations are formally investigated by estimating the equation

$$OMOMPA_t - OPDOMO_t = \alpha + \beta \mathbf{z}_t + \varepsilon_t \tag{5}$$

where $\mathbf{z}_t$ denotes a vector of factors that might cause the Desk to deviate from its operating procedure and ε_t denotes the effect of all factors not reflected in $\mathbf{z}_t$. If the Desk followed the operating procedure perfectly, then $\alpha = \beta = \varepsilon_t = 0$.

Factors that may have caused the Desk to respond differently

There are a number of factors that might cause the Desk to deviate from its operating procedure. For example, demand for reserves is determined by banks' reserve requirements over a two-week period ending on the Monday, two days before settlement Wednesday. Hence, on the last two days of the maintenance period, the demand for reserves is perfectly interest-inelastic. Because the demand for reserves is fixed on these days, the Desk might behave somewhat differently on

these days. The Desk may also behave differently on various days of the year, such as the first and last days of the month, quarter, or year, or the day of the maintenance period. Indeed, Hamilton (1997), Thornton (2001a), Carpenter and Demiralp (2005), and Demiralp and Farley (2005) report statistically significant day-of-the-maintenance-period and day-of-the-year effects for various aspects of open market operations. These possibilities are investigated by including dummy variables for each day of the maintenance period and for the first and last days of the month, quarter, or year, and by partitioning $OPDOMO_t$ by the day of the maintenance period.

Table 8.1 suggests that the Desk may follow the operating procedure more closely when it indicates that reserves should be added than when it indicates that reserves should be drained. To investigate this formally, the day-of-the-maintenance-period dummy variables are partitioned according to whether $OPDOMO_t$ is positive or negative.

Because of the difficulty in estimating reserve demand, the Desk might look to the recent behaviour of the funds rate or other signals of current market conditions in conducting daily open market operations. The Desk takes a reading on the funds rate just prior to the *morning call*. The morning call is a telephone conference among the staffs of the Board of Governors, the Desk, and one of Federal Reserve Bank presidents. All parties have access to the reserve projections, and the Desk outlines its intentions for that day's open market operation. One element of the call is where the funds rate is trading 'at the time of the call'. There are no transcripts of these calls; however, Thornton (forthcoming) documents that the rate at the time of the call was used as a check on the Desk's estimates of reserve demand. Hence, it is reasonable to conjecture that the Desk might respond differently depending on the difference between the funds rate at the time of the call and the funds rate target, *call – fftar*.

It seems likely that the Desk does not follow its procedure on days when the funds rate target is adjusted. Conceptually, the Desk's operating procedure is conditional on the funds rate target. Consequently, a change in the target should have an effect on the estimate of the quantity of reserves demanded; however, it may be difficult to estimate the effect of a target change on the quantity of reserves demanded. Moreover, because the demand for reserves is fixed on the last two days of the maintenance period, exactly how the Desk would behave relative to the operating procedure on those days is uncertain.

Finally, Hamilton (1997) has argued that the Fed responds to forecast misses in one of the components of v_t, the Treasury's balance with the Fed. Specifically, Hamilton suggests that if the Treasury's balance were $400 million lower than expected, the Desk would add x for each of the n remaining days in the maintenance period to make up for that day's error in forecasting the Treasury's balance. If the forecast errors are serially correlated, this information could be used in making today's estimate of F_t. To my knowledge the forecast errors were never saved and analyzed. Consequently, it seems unlikely that the Desk engaged in the explicit error-correction behaviour that Hamilton describes. In any event, if it did, it should have also responded to the previous day's difference between actual

bank borrowing and the *IBA* because borrowing is highly serially correlated and the *IBA* was changed relatively infrequently.

Empirical results

Equation (5) was estimated accounting for the factors noted above. Estimates of v_t are those used by Carpenter and Demiralp (2005) and were provided by the authors. These data are available only beginning in January 1986; consequently, the estimation period is January 2, 1986, to December 31, 1996. There is only an estimate of the net forecast error for all components. There is a separate estimate for the Treasury's balance at the Fed. Hence, the Board of Governors' forecast error for Treasury balances on the previous day ($FE(Tbal)_{t-1}$) is also included. With this addition, the coefficient on v_{t-1} should reflect the explicit error-correction behaviour of the Desk for the remaining factors, while the coefficient on $FE(Tbal)_{t-1}$ reflects the explicit error-correction behaviour with respect to Treasury balance forecast errors.

Finally, at its first meeting in 1994, the FOMC began announcing policy actions upon taking them. Because of this, and because banks began implementing deposit sweep programmes that reduced the demand for reserves about the same time, estimates of (5) are presented for periods both before and after 1994. Also, the announcement came later in the day after the Desk had conducted that day's open market operations. Consequently, for analyses of the effect of changes in the funds rate target on Desk operations, the change in the funds rate target are aligned to the first day that the Desk could have responded to the FOMC's action.

The estimates are presented in Table 8.2. The equation was estimated using a Newey-West estimator of the covariance matrix. The coefficient estimates are reported in one column and the significance level associated with the null hypothesis that the coefficient is zero is reported in the adjacent column. While a formal test of the null hypothesis of temporal stability is easily rejected, the results for the two periods are remarkably similar. Consistent with Table 8.1, during both periods the Desk adds less than the procedure indicates when the procedure indicates that reserves should be added and drains less when the procedure indicates reserves be drained. Moreover, during both periods, the absolute value of the coefficients on the day-of-the-maintenance-period dummy variables decline nearly monotonically from the first to the last day of the maintenance period. Moreover, the Desk does not systematically deviate from its operating procedure at the beginning or end of the quarter, or year, during either period. The Desk's responses on the first and last days of the month are similar during both periods; however, the response at the end of the month is clearly not statistically significant for the post-1994 period.

There are some differences in the Desk's response to other information. Specifically, during the pre-1994 period the Desk deviated from the operating procedure on days when the funds rate was changed – except on the last two days of the maintenance period when reserve demand was fixed. In contrast, after 1994, there is no statistically significant deviation from the operating procedure when the

Table 8.2 The Desk's use of the operating procedure: February 2, 1986 –
December 31, 1996

Variable	Pre-1994		Post-1994	
	Coeff.	S.L.	Coeff.	S.L.
bom	0.272	0.014	0.313	0.051
eom	0.277	0.050	0.182	0.242
boq	−0.198	0.365	−0.308	0.446
eoq	−0.150	0.533	−0.504	0.188
boy	−0.401	0.229	0.314	0.447
eoy	−0.244	0.559	0.538	0.214
1st Thursday pos	−2.135	0.000	−3.087	0.000
1st Friday pos	−1.943	0.000	−2.905	0.000
1st Monday pos	−1.590	0.000	−2.477	0.000
1st Tuesday pos	−1.503	0.000	−2.212	0.000
1st Wednesday pos	−1.434	0.000	−1.941	0.000
2nd Thursday pos	−0.923	0.000	−1.188	0.000
2nd Friday pos	−0.837	0.000	−0.943	0.000
2nd Monday pos	−0.345	0.000	−0.365	0.000
2nd Tuesday pos	−0.297	0.000	−0.329	0.000
sw pos	−0.223	0.000	−0.148	0.002
1st Thursday neg	1.532	0.000	1.576	0.000
1st Friday neg	1.501	0.000	1.118	0.000
1st Monday neg	1.081	0.000	1.007	0.000
1st Tuesday neg	0.904	0.000	1.096	0.001
1st Wednesday neg	0.757	0.000	1.103	0.001
2nd Thursday neg	0.609	0.000	0.360	0.008
2nd Friday neg	0.374	0.000	0.330	0.041
2nd Monday neg	0.187	0.002	0.182	0.249
2nd Tuesday neg	0.208	0.000	0.149	0.087
sw neg	0.198	0.000	0.194	0.002
Δ*fftar* 2nd Tuesday and sw	−0.393	0.446	−0.084	0.786
Δ*fftar* all other days	−1.166	0.043	1.575	0.113
$Call_t - fftar_t$	0.237	0.094	0.532	0.028
v_{t-1}	−0.016	0.585	0.000	0.996
$FE(Tbal)_{t-1}$	−0.016	0.080	0.014	0.823
$BR_{t-1} - IBA_{t-1}$	−0.016	0.124	−0.249	0.313
No. obs.	1680		743	
S. E.	0.972	–	0.956	–
$\bar{R}^2$	0.515	–	0.635	–

funds rate target is changed. This finding is consistent with Taylor (2001) and
Thornton (2001a). There was no attempt to alter the supply of reserves immediately
after the FOMC began the practice of announcing policy actions.[13]

   The estimates also suggest that the Desk relied more on the behaviour of the
funds rate at the time of the call after 1994 than it did before 1994. The point
estimate indicates that on average the Desk added about $0.5 billion more than the

operating procedure suggested for every percentage point deviation of the funds rate from the target at the time of the call. While the estimate is small given the size of the daily market for federal funds, it nevertheless indicates that the Desk behaved in a manner consistent with keeping the funds rate close to the target after 1994.

Finally, there is no evidence of explicit error correction by the Desk during either period. The coefficient on v_{t-1} is negative but not statistically significant at the 5 per cent level for either period. The coefficient on $FE(Tbal)_{t-1}$ is negative for the pre-1994 period, but again not statistically significant. Likewise, the coefficients on $BR_{t-1} - IBA_{t-1}$ are negative but not significantly different from zero in either period.

The liquidity effect

The liquidity effect – the decline in nominal interest rates associated with an exogenous, central-bank-engineered increase in the monetary base – has received relatively little empirical support historically (Pagan and Robertson 1995; Thornton 1988b, 2001a,b, 2006). The Desk's open market data provide a unique opportunity to investigate the extent to which Fed actions influence the federal funds rate. If the Fed acts to change the equilibrium funds rate through open market operations, there should be a marked change in open market operations on days when the funds rate target is changed.

The estimates reported in Table 8.2 suggest that the Desk behaved in a manner consistent with the liquidity effect prior to 1994, but not after. Specifically, the Desk added about $0.3 billion fewer reserves than the procedure suggested when the funds rate target was increased by 25 basis points before 1994.[14] This estimate suggests that the demand for federal funds is very interest-inelastic – a very small exogenous change in reserves generates a relatively large change in the funds rate. If the demand for reserves is this inelastic, however, one has to wonder why the liquidity effect has been so elusive. Hence, the remainder of this section investigates the liquidity effect in a variety of ways.

Changes in estimates of reserve demand

Consistent with the conventional view, the results in Table 8.2 suggest that, before 1994 but not after, the Desk drained more reserves than the operating procedure suggested when the funds rate target was increased and added more when the target was reduced. The size of the estimated coefficient for the pre-1994 period is relatively small, however. A potential explanation for the small coefficient is that, because the Desk's estimates of reserve demand are conditional on the funds rate target, the Desk reduces its estimate of the quantity of reserves demanded on days when the target is increased and increases its estimate on days when the target is reduced. There were 88 changes in the funds rate target during the sample period (43 increases and 45 decreases). Of these, 78 occurred prior to 1994 and 10 after. Figures 8.2 and 8.3 present the revisions to reserve demand
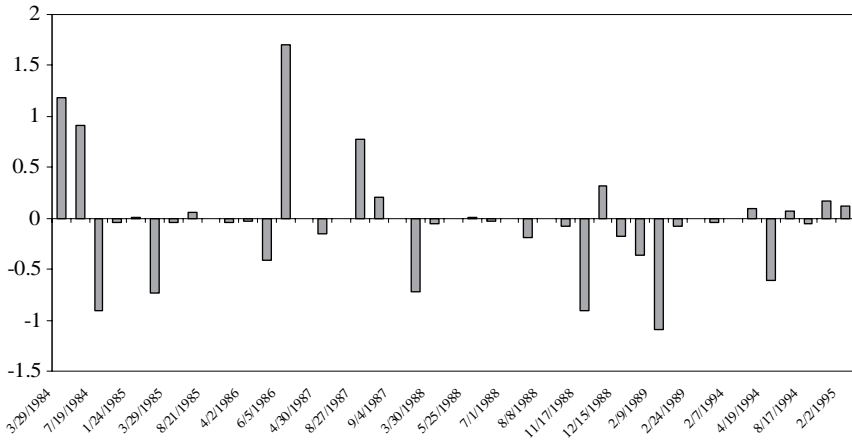
Figure 8.2 Revisions to reserve demand when the target was increased.

when the funds rate target was increased or decreased, respectively. These data are not consistent with the idea that the Desk revises its estimate of reserve demand systematically in response to a change in the target. Figure 8.2 shows that there were only six occasions when reserve demand was revised down by $0.5 billion or more when the target was increased, while there were four days when it was
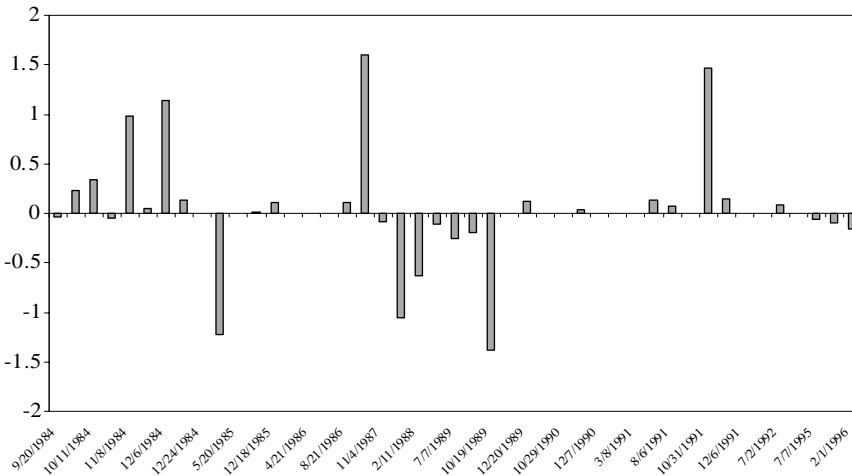

Figure 8.3 Revisions to reserve demand when the target was decreased.

revised up by a corresponding amount. Likewise, Figure 8.3 shows that estimates of reserve demand were not systematically revised up in response to a decrease in the target. Indeed, most often the estimates were essentially unrevised, despite the change in the target. Hence, the relatively small estimated coefficient in Table 8.2 is not the consequence of systematic revisions of reserve demand.

The Desk's behaviour when the funds rate target is changed

The results in the previous section indicate that the Desk deviated significantly from its operating procedure when the target was changed, at least prior to 1994. This result is investigated more fully in Figures 8.4 and 8.5, which show scatter plots of *OPDOMO* vs. *OMOMPA* on days when the funds rate target was decreased and increased, respectively. If the Desk causes the funds rate to fall, there should be many more observations above the 45-degree line than below in Figure 8.4. This is not the case, however. Likewise, if the Desk causes the funds rate to rise, there should be many more observations below the 45-degree line than above in Figure 8.5. While this is the case, as we have already noted, the procedure was skewed toward adding rather than draining reserves. Moreover, Figure 8.1 shows that the Desk generally added significantly less than the procedure suggested on all days when the procedure indicated reserves should be added. Consequently, it is not clear whether Figure 8.5 represents a significant change in the Desk's behaviour on days when the target was increased.

To investigate whether the Desk behaved significantly differently when the funds rate target was changed, 10,000 samples (sizes 43 and 45) were obtained by bootstrapping the 3,088 observations of *OMOMPA* − *OPDOMO* on days when the target was not changed. Table 8.3 reports the 90 per cent coverage intervals for
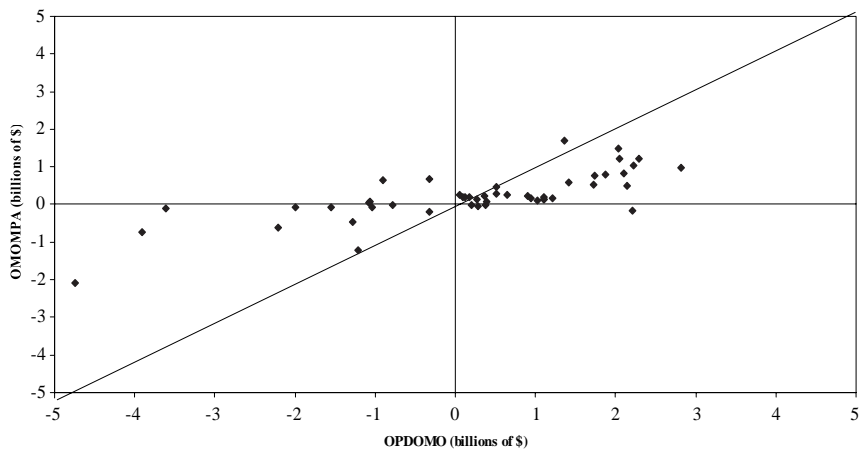
Figure 8.4 OPDOMO and OMOMPA on days when the target was decreased.
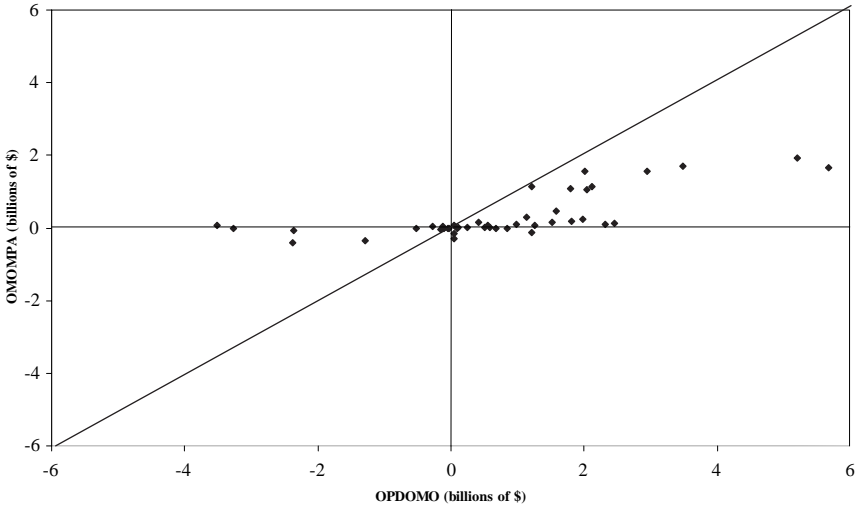
Figure 8.5 OPDOMO and OMOMPA on days when the target was increased.

the mean, median, and standard deviation of these samples along with the same sample statistics for days when the funds rate target was changed. The results suggest that the Desk did not change its behaviour significantly when the funds rate target was increased. Five of the six sample statistics are well within the corresponding 90 per cent coverage intervals. The sample mean of the 45 days when the target was decreased lies outside the 90 per cent coverage interval, suggesting that the Desk added significantly more reserves on average than the operating procedure indicated when the target was decreased. Because the distributions of *OMOMPA − OPDOMO* are skewed, the median is a better measure of

Table 8.3 The desk's behaviour when the target is changed

	90% coverage interval	*Sample results*
mean		
43	−0.397 − −1.079	−0.454
45	−0.414 − −1.081	−0.056
median		
43	−0.168 − −0.727	−0.490
45	−0.171 − −0.733	−0.231
s.d.		
43	0.990 − 1.776	1.436
45	1.006 − 1.770	1.234

central tendency. The sample statistic for the median is well within the coverage interval, suggesting that the Desk did not behave differently when the target was decreased. Hence, there is weak evidence that suggests the Desk attempted to engineer decreases in the funds rate.

Implementing a target change over time

It might be the case that the Desk does not take all the operations necessary to change the funds rate on the day the target is changed. Instead, the Desk may add or drain reserves over several days to bring about the change in reserves necessary to sustain the funds rate at the new target level (Taylor 2001).

This possibility is investigated by comparing the five-day averages of $OMOMPA - OPDOMO$ for five days before each target change and for the day of the target change and four days after the change. The five-day averages are plotted in Figures 8.6 and 8.7 for increases and decreases in the funds rate target, respectively.[15] If the Desk pursued the increase in the funds rate, there should be more observations below the 45-degree line than above in Figure 8.6. Similarly, if the Desk pursued the decrease in the funds rate, there should be more observations above the 45-degree line than below in Figure 8.7. This is not the case. In both instances, the numbers of observations above and below the 45-degree line are nearly equal. Moreover, simple tests of the equality of the means, medians, and variances of the distributions before and after target changes cannot reject the null hypothesis of equality at even the 10 per cent significance level for either positive or negative target changes. Consequently, there is no evidence that the Desk
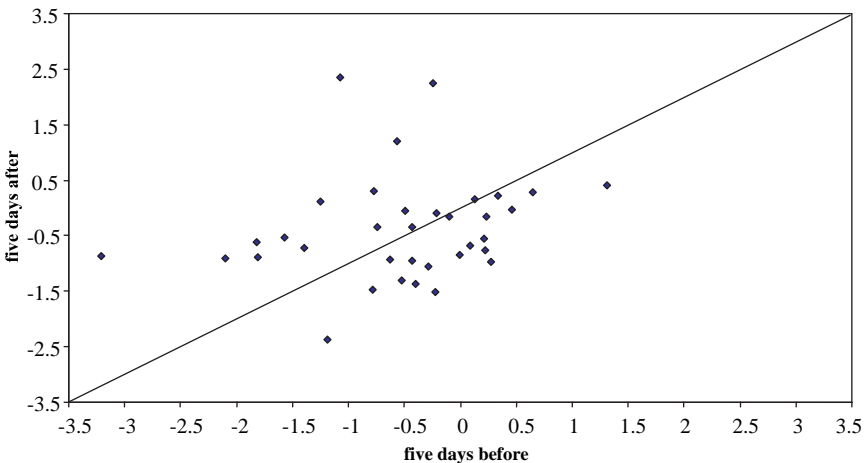
Figure 8.6 Scatter plot of OMOMPA – OPDOMO five days before and five days after for target increases.
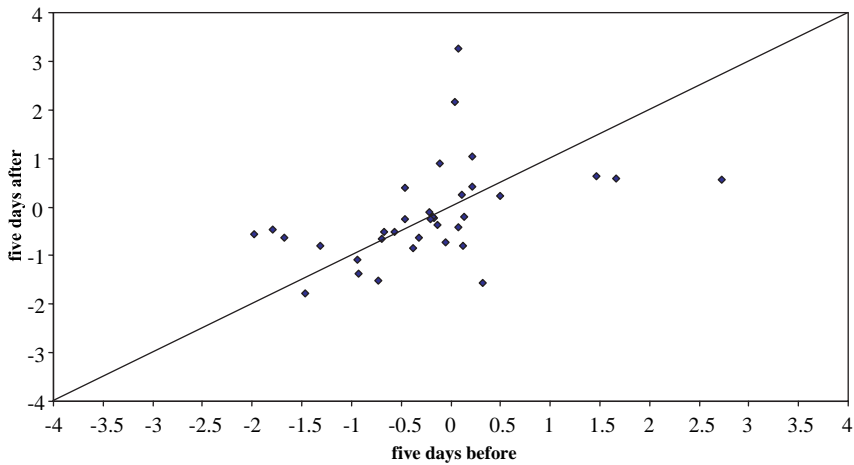
Figure 8.7 Scatter plot of OMOMPA – OPDOMO five days and five days after for target decreases.

implemented target changes over a period of five days. It is important to note that the conclusion is the same for both increases and decreases in the target. Hence, if the Desk engineered increases in the funds rate target, it completed the operations necessary to effect these changes quickly.

Estimating the liquidity effect directly

The conventional way to estimate the liquidity effect is to regress changes in the interest rate on a variable that represents an exogenous change in reserves or monetary policy. Hamilton (1997) used this approach and found evidence of a statistically significant liquidity effect of exogenous changes in reserves on the federal funds rate. His measure of a supply shock was his estimate of the forecast error the Desk makes in forecasting the Treasury's balance with the Fed. Hamilton found the liquidity effect to be statistically significant, but only on settlement Wednesdays. Thornton (2001a) notes three problems with this analysis. First, the slope of the reserve demand function (and, therefore, the liquidity effect) cannot be estimated on settlement Wednesdays because of the two-day lag in the Fed's reserve accounting system. Second, what matters on the last day of the maintenance period is the imbalance of reserve supply and demand on average over the maintenance period. Because a 1-day error in forecasting the Treasury's balance contributes only one-fourteenth of the average error, it would take a very large shock to the Treasury's balance on the last day of the maintenance period to generate a large maintenance-period-average reserve imbalance. Finally, Thornton notes that Hamilton used an estimate of the Desk's forecast error, not the actual

forecast error.[16] Thornton (2001a) goes on to show that Hamilton's settlement-Wednesday liquidity effect was idiosyncratic to his sample period and, even during Hamilton's sample period, it is attributable to just six observations when the funds rate changed by a large amount on settlement Wednesdays.

Carpenter and Demiralp (2005) attempt to overcome some of the data shortcomings of Hamilton's analysis by using a more comprehensive measure of a reserve supply shock. Specifically, they use an estimate of v_t based on the Board of Governors' estimate of F_t.[17] They find a statistically significant liquidity effect on six of the ten days during the maintenance period over the period May 18, 1989–January 30, 2004. As with Hamilton's findings, the estimated liquidity effect is largest on settlement Wednesday when, contrary to Carpenter and Demiralp's assertion, the slope of the demand for reserves cannot be estimated.[18]

The effects of shocks to reserves on the funds rate is investigated here using Carpenter and Demiralp's data. Figure 8.8 presents a scatter plot of the $(ff - fftar)_t$ and the Board of Governors' estimate of v_t over the period January 2, 1986, to December 31, 1996. Days when v_t was not available and the last two days of 1986, when $(ff - fftar)_t$ was more than 8 percentage points, are deleted, leaving 2,676 daily observations. While not obvious from Figure 8.8, there is a weak negative relationship between v_t and $(ff - fftar)_t$. The correlation is -0.124. Carpenter and Demiralp (2005) suggest that the relationship between supply shocks and the funds rate is non-linear, finding that their statistically significant liquidity effect is due to large supply shocks ($\geq$ \$1 billion). Hence, the relatively low correlation could be due to the fact that most often supply shocks are relatively small. There is some
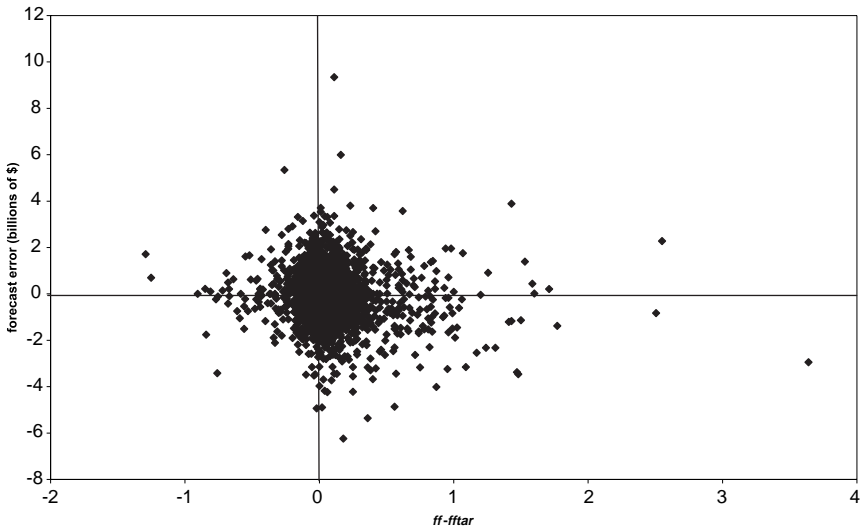
Figure 8.8 Scatter plot of *ff – fftar* and errors in forecasting autonomous factors (January 2, 1986 – December 1, 1996).

evidence of this. When only days for which the absolute value of the supply shock is greater than \$2 billion (180 observations) are considered, the correlation doubles to -0.215. Nevertheless, even for large reserve supply shocks the relationship between reserve supply shocks and the funds rate appears weak.

To investigate this possibility further, Table 8.4 presents the results for a regression of $(ff - fftar)_t$ on day-of-the-year and day-of-the-maintenance-period dummy variables, $(OMOMPA - OPDOMO)_t$, and v_t, over the period January 2,

Table 8.4 Estimate of $ff_t - fftar_t$, February 2, 1986 – December 31, 1996

Variable	Coeff.	S.L.	Coeff.	S.L.
lg	–	–	0.492	0.000
med	–	–	0.379	0.000
sm	–	–	0.361	0.000
eom	0.165	0.000	0.160	0.000
bom	0.084	0.003	0.077	0.006
eoq	0.287	0.001	0.283	0.002
boq	0.093	0.326	0.099	0.278
eoy	0.178	0.803	0.161	0.818
boy	0.253	0.027	0.200	0.087
1st Thursday	0.106	0.000	−0.266	0.000
1st Friday	−0.013	0.252	−0.376	0.000
1st Monday	0.080	0.000	−0.289	0.000
1st Tuesday	0.040	0.000	−0.331	0.000
1st Wednesday	0.000	0.964	−0.370	0.000
2nd Thursday	0.013	0.244	−0.358	0.000
2nd Friday	−0.069	0.000	−0.439	0.000
2nd Monday	0.080	0.000	−0.292	0.000
2nd Tuesday	0.045	0.237	−0.330	0.000
sw	0.245	0.000	−0.131	0.000
$(OMOMPA - OPDOMO)_t^{\Delta fftar}$	−0.058	0.021	−0.025	0.106
$(OMOMPA - OPDOMO)_t^{No\Delta fftar}$	−0.002	0.673	0.000	0.926
$v_t^{\Delta fftar}$	−0.077	0.012	–	–
$v_t^{No\Delta fftar}$	−0.032	0.005	–	–
$v_t^{l,\Delta fftar}$	–	–	−0.102	0.020
$v_t^{l,No\Delta fftar}$	–	–	−0.045	0.031
$v_t^{m,\Delta fftar}$	–	–	−0.083	0.055
$v_t^{m,No\Delta fftar}$	–	–	−0.010	0.255
$v_t^{s,\Delta fftar}$	–	–	0.008	0.847
$v_t^{s,No\Delta fftar}$	–	–	−0.034	0.076
No. obs.	2678	–	2678	–
S. E.	0.344	–	0.342	–
$\bar{R}^2$	0.102	–	0.111	–

1986 – December 31, 1996. Like shocks to reserve supply, one might expect that if the Desk adds more reserves than the operating procedure indicates, the funds rate might fall, and vice versa. Given the previous results, $(OMOMPA - OPDOMO)_t$ and v_t are partitioned into days when the funds rate target was and was not changed. Consistent with Carpenter and Demiralp's finding, there is a negative and statistically significant relationship between $(ff - fftar)_t$ and v_t. Surprisingly, the absolute value of the estimate is nearly twice as large on days when the funds rate target was changed than when it was not.[19]

The results also suggest that the funds rate will decline if the Desk adds or drains more reserves than the operating procedure indicates is necessary. The coefficients are not statistically significant, however.

Following up on Carpenter and Demiralp's finding of non-linearity in the effect of supply shocks on the funds rate, v_t is partitioned into days when the corresponding shocks are large ($l, \geq \$2$ billion), medium ($m, > \$1$ billion but $< \$2$ billion), and small ($s, \leq \$1$ billion). In order to guarantee that the effect is due to non-linearity and not to an intercept shift, dummy variables are included for each of these partitions. The estimates, also presented in Table 8.4, confirm Carpenter and Demiralp's finding.[20] Specifically, while the effect of v_t on the funds rate is nearly always negative, it is statistically significant only for large supply shocks. Moreover, it is only on days when the target is not changed. The coefficient is larger for days when the target was changed, but not statistically significant at the 5 per cent level. It is important to note that it takes a relatively large supply shock to have a statistically significant impact on the funds rate. Consequently, in contrast with the implications of the estimates from Table 8.2, these estimates suggest that the demand for reserves is relatively interest-elastic. As noted above, shocks this large are relatively rare events. However, it is worth noting, that when v_t is partitioned by size, with the exception of settlement Wednesday, day-of-the-maintenance-period differences in the behaviour of the funds rate are significantly reduced and become statistically significant. Hence, there appears to be some relationship between large supply shocks and days of the maintenance period.

There are two reasons these findings do not support Carpenter and Demiralp's assertion that the response of the funds rate to supply shocks provides 'strong evidence of a liquidity effect at the daily frequency'. First, consistent with Figure 8.8, reserve supply shocks account for very little of the daily variability of the funds rate from the target. Indeed, if v_t is omitted from the equation, $\overline{R}^2$ declines by less than one one-hundredth of a percentage point. Second, and most important, while the estimates suggest that large shocks to reserves are associated with changes in the equilibrium funds rate, such estimates provide no evidence for the more interesting and policy-relevant question of whether the Fed brings about permanent changes in the funds rate through open market operations. Indeed, the estimates suggest that it is unlikely that the Fed does this. There were only 554 days in the entire sample of 3,176 daily observations when the Desk deviated from its operating procedure by $2.0 billion or more. Moreover, the estimates suggest that the largest deviation ($-\$9.19$ billion) would have generated about a 42-basis-point rise in the funds rate. Hence, these estimates suggest that it would take a series of

relatively large open market operations in one direction to bring about the kind of changes in the equilibrium funds rate that the Fed is often credited with engineering. As we have already noted, there is no evidence that the Desk engaged in such open market operations upon changing the funds rate target.

The liquidity effect and the federal funds market

As a general rule, the larger a single market participant's activities are in the market, the larger should be the effect of such activities on equilibrium price. Indeed, the hypothesis of atomistic market participants is a cornerstone of the competitive market model. As a general rule, one would expect the Fed's ability to influence the federal funds rate to be positively related to the relative importance of its activities in the federal funds market – the more liquidity the Fed provides to the market, the larger should be its ability to affect the equilibrium federal funds rate. Hence, some additional evidence on the potential for a liquidity effect can be obtained by investigating the relative importance of open market operations in the federal funds market.

Despite the importance of the federal funds rate in the conduct of monetary policy, surprisingly little is known about it. Federal funds transactions involve the purchase or sale of deposit balances at the Fed. Hence, direct market participation is limited to entities that hold deposits at the Fed. For the federal funds market, this means banks, Fannie Mae, Freddie Mac, and Federal Home Loan Bank.[21] There are both brokered and non-brokered transactions in the market.[22] Until recently relatively little was known about the overall size of the market. Using estimated data from Fedwire funds transfers during the first quarter of 1998, Furfine (1999) estimates the average daily volume of federal funds transactions to be $144 billion. Recently, Demiralp *et al*. (2004) have used a modification of Furfine's methodology to estimate the size of the funds market over the period 1998–2003. They find that the average daily volume of transactions in the funds market in the first quarter of 1998 was $145 billion, and that the daily volume of federal funds transactions increased until 2001 and then declined slightly.

Knowledge of the division of the market between brokered and non-brokered trading is less well known. Stigum (1990) suggested that the brokered funds market was about $70 billion per day in the late 1980s; however, Furfine (1999) found that about 83 per cent of the identified federal funds transactions were brokered.

The published federal funds rate is a quantity-weighted average of transactions of a group of brokers that report their transactions daily to the Federal Reserve Bank of New York. The 30-day moving average of the total volume of federal funds transactions reported by these brokers for the period January 1, 1987, to December 31, 1993, is presented in Figure 8.9. The trading volume hovered around $53 billion from the beginning of 1987 to mid-1990 and then increased dramatically by about $10 billion. Trading volume peaked in October 1990 and then began to decline. The initial decline in trading volume coincides with the elimination of reserve requirements on non-personal time and savings deposits, which reduced reserve demand by about $13.5 billion. The sharp decline in 1992 also coincides reasonably
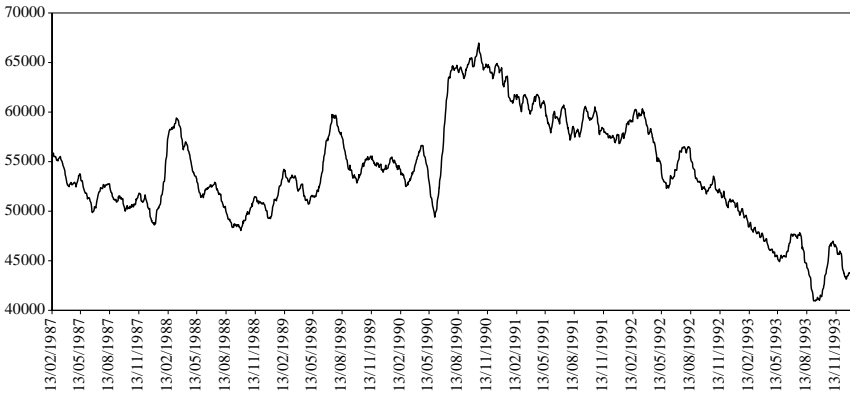
Figure 8.9 Thirty-day moving average of federal funds trading volume (data are plotted on the last day of moving average).

well with the reduction in percentage reserve requirements from 12 per cent to 10 per cent.[23] Why trading volume trends down beginning in 1991 is unclear, however.

In any event, these volume figures suggest that the brokers who report daily to the Federal Reserve Bank of New York account for a relatively small share of the brokered market, and an even smaller share of the total market. Indeed, based on Furfine's and Demiralp *et al*.'s estimates, the brokers that report daily to the Fed account for roughly about a third of the federal funds market.

Despite the possibility that the brokered transactions appear to represent a relatively small share of the federal funds market, these are the correct data for analysing the relative importance of open market operations because these data are used to calculate the effective federal funds rate – the rate used in virtually all analyses of monetary policy.

The day-to-day variation in the volume of trading among these brokers is relatively large. There are only four days in this sample when the daily change in the trading volume is $5 billion or less. In contrast, there were only 267 of the 3,176 days where the absolute value of *OMOD* was larger than $5.0 billion. It is hardly surprising, therefore, that *OMOD* accounts for almost none of the daily variation in the volume of federal funds transactions.

The relatively small size of open market operations alone may account for the results presented above. But there are other reasons for suspecting that the impact of open market operations on the funds rate is small. While seldom discussed in analyses of open market operations and the federal funds rate, in reality the link between open market operations and the funds rate is second-order. Open market operations do not directly affect the supply of federal funds. Rather, they directly affect the supply of reserves available to banks. Banks need not automatically

increase or decrease federal funds trading when open market operations alter the availability of reserves. Nevertheless, because the initial effect of open market operations is on the reserves of large banks, some of whom may act as brokers in the federal funds market, simultaneously buying and selling funds (Furfine 1999), it is reasonable to assume that open market operations are likely to impact the availability of funds in the market.

Nevertheless, it is important to remember that the volume of federal funds trading is determined by a variety of factors that are independent of daily open market operations. For example, Meulendyke (1998) notes that beginning in the 1960s, when short-term rates rose above Regulation Q interest rate ceilings, large banks began financing their longer-term lending in the overnight market. It is now recognized that many banks finance a significant part of their loan portfolio in the overnight markets. It is also well known that large banks tend to be net demanders of funds, while small banks tend to be net suppliers. Hence, daily changes in the volume of federal funds transactions are likely to be affected by changes in the distribution of deposit and reserve flows unrelated to daily open market operations.

Not only is the daily volume of federal funds transactions large relative to daily open market operations, it is many times larger than the overnight reserve balance at the Fed – the commodity being traded (Taylor 2001). While the exact source of the disparity between the flow of federal funds transactions and the stock of the commodity being traded is unclear, there can be little doubt that the flow of federal funds transactions is only weakly linked to the stock of the commodity being traded.[24]

Finally, since the early 1980s the Desk has followed the practice of entering the market once per day – before January 1987 this occurred about 11:30 EST. Federal funds transactions occur continuously throughout the day. Indeed, spikes in the funds rate that are often associated with settlement Wednesdays are thought to be due to trading that occurs later in the day. In any event, if open market operations were to have a significant effect on the funds rate, one might expect the effect to occur around the time that the Desk is in the market. Hence, the extent to which these activities would affect the transactions-weighted-average of transactions rates over the day is difficult to say.

While the effect of open market operations on the funds market and, consequently, the funds rate, is indirect and uncertain, their effect on total reserves is not. Moreover, conceptually, open market operations affect the funds rate by causing banks to buy or sell funds when the supply of reserves is decreased or increased, respectively, through open market operations. Hence, the relative importance of open market operations can be gauged by seeing how much of the variation in daily changes in total reserves they account for. To this end, changes in total reserves are regressed on changes in the Desk's estimate of reserve demand and reserve supply, changes in borrowing, errors in forecasting autonomous factors that affect reserves, and daily open market operations. The results, reported in Table 8.5, show that changes in total reserves are positively and significantly related to daily open market operations. Indeed, when $OMOD_t$ is deleted from the equation, $\overline{R}^2$ decreases from 0.2602 to 0.1736, suggesting that $OMOD_t$ accounts

Table 8.5 The daily change in total reserves: January 2,
1986 – December 31, 1996

Variable	Coeff.	S.L.
Const.	−0.461	0.000
$\Delta E_{t-1} f(ff_t^*, \mathbf{x}_t)$	0.688	0.000
$\Delta E_{t-1} NBR_t$	0.558	0.000
v_t	0.672	0.000
ΔBR_t	0.846	0.000
$OMOD_t$	0.373	0.000
No. obs.	2677	–
S. E.	2.7542	–
$\bar{R}^2$	0.2602	–

for nearly 10 per cent of the daily changes in total reserves. This simple analysis suggests that, while important, $OMOD_t$'s contribution to changes in total reserves is quantitatively small. Given their relatively small effect on total reserves, it is not surprising that open market operations have an even smaller effect on federal funds.

Analysis and conclusions

Our analysis of the Desk's use of its operating procedure over the period March 1, 1984, to December 31, 1996, indicates that the Desk relied on the operating procedure in conducting daily open market operations. Indeed, the operating procedure alone accounts for nearly 40 per cent of open market operations conducted during this period. The operating procedure and other factors – such as day-of-the-maintenance-period and day-of-the-year effects, differences between the funds rate and the funds rate target just prior to open market operations, and changes in the funds rate target – account for more than 50 per cent of the variation in daily open market operations. Although large, these estimates indicate that there are other important factors that cause the Desk to deviate from its operating procedure.

Contrary to conventional wisdom – that the Fed controls the federal funds rate through open market operations – we have found little support of an important liquidity effect at the daily frequency. While there is some evidence of a statistically significant negative relationship between reserve supply shocks and the funds rate, the relationship is weak. Consequently, to move the funds rate by 25 basis points or more, it appears that the Desk would have to conduct considerably larger open market operations than it has in fact conducted.

One possible reason for this finding is that changes in the funds rate target were anticipated. However, after conducting an extensive analysis of press reports, Poole *et al*. (2002: 73) found 'little indication that the market was aware that the Fed was setting an explicit objective for the federal funds rate before 1989'. This is not surprising in that Thornton (2006) shows that the FOMC was reluctant to

acknowledge that it was targeting the funds rate. Moreover, Poole *et al*. (2002) show that the market frequently did not know that policy had changed when the Fed changed the target during 1989 and 1990 and that the target changes prior to 1994 were generally not predicted. Furthermore, prior to 1994, most funds rate target changes occurred during the intermeeting period (the period between consecutive FOMC meetings) and, hence, would have been difficult to predict exactly even if the market knew the Fed was targeting the funds rate and was expecting a target change. Consequently, it is extremely unlikely that rational expectations accounts for the lack of evidence of a liquidity effect.

Another possible explanation for the lack of evidence of a liquidity effect is that target changes are implemented over a period of several days, not immediately (Taylor 2001). Our analysis provides no support for this explanation, however.

Yet another explanation for this finding is that open market operations account for a very small proportion of the variation in the equilibrium quantities in the reserves and federal funds markets. This explanation is supported by the fact that open market operations explain relatively little of the maintenance-period variation in total reserves and an extremely small amount of the daily variation in daily volume of federal funds transactions.

One explanation not investigated here is that some, and perhaps many, changes in the funds rate target are endogenous. Economic theory suggests that the Fed cannot control the natural rate of interest. Hence, when market forces bring about changes in inflation expectations or the real rate, the Fed can either change its target or permit policy to become inadvertently tighter or easier, depending on whether market forces are driving interest rates down or up. In any event, if target changes represent a response of the Fed to changing conditions that affect nominal interest rates rather than an exogenous change engineered to achieve some policy objective, the Desk would not necessarily have an incentive to add or drain reserves aggressively when the target is changed. Elsewhere (Thornton 2004), I have presented evidence that many of the target changes identified in an influential paper by Cook and Hahn (1989) were endogenous. A proper investigation of this possibility during this period is left for future research.

Finally, I would note that evidence that the liquidity effect is small and statistically unimportant does not mean that the Fed could not move interest rates if it desired. It merely suggests that the Fed has not done so. Given their direct effect on reserves and the corresponding effect of changes in reserves on banks, one can understand why the Fed might be reluctant to engage in large open market operations. This reluctance would be particularly strong if the Fed is a small enough player in the credit market that it would take very large open market operations to generate significant changes in the equilibrium short-term rates.

Notes

* The views expressed here are the author's and do not necessarily reflect the views of the Board of Governors of the Federal Reserve System or the Federal Reserve Bank of

1 These informal adjustments were stated in the morning call and depended upon estimates of the distribution of cumulative excess reserves holding to date. These informal adjustments were particularly important on the last two days of the maintenance period.

2 The Federal Reserve Bank of New York and the Board of Governors of the Federal Reserve jointly control the access to and the use of these data. I thank Jonathan Albrecht and Joanna Barnish for their valuable assistance in gathering these data and John Partlan for helping me understand the nuances of the Desk's operating procedure.

3 Borrowing (and later, the initial borrowing assumption, IBA) refers to seasonal plus adjustment borrowing. Extended credit borrowing was treated separately, as one of the autonomous factors affecting reserve supply.

4 The reason is that the Desk assumes that there would be no purchases or sales on foreign accounts that day. The foreign desk, however, has permission to make sales during the day up to some specified amount. The foreign desk is not permitted to make purchases on the System account, however. Purchases are executed in the secondary market to neutralize their impact on reserves.

5 Thornton (2006) shows that borrowed reserve targeting was a euphemism for federal funds rate targeting. He also notes that the *IBA* was last mentioned in discussing monetary policy during a conference call on January 9, 1991. Despite this fact, the FOMC never formally announced it was no longer targeting borrowed reserves and a borrowing assumption remained part of the Desk's formal operating procedure until at least the end of our sample period, but is no longer used today. Also, compare the discussion of 'operating procedures' in Sternlight (1991) with Sternlight (1992).

6 The *IBA* is changed relatively infrequently and often when the funds rate target is changed; see Thornton (2001b) for an analysis of the connection between the *IBA* and changes in the funds rate target. Separate estimates of the demand for required and excess reserves are made. Like the *IBA*, the estimate of the demand for excess reserves is changed infrequently. In contrast, the estimate of the demand for required reserves is typically changed six times during each maintenance period.

7 This terminology stems from the fact that, before June 1995, the borrowed reserves assumption was presented in each of the policy alternatives voted on by the FOMC. The borrowing assumption was frequently stated in terms of a range for borrowed reserves, rather than a specific level. The level used by the Desk was often (but not always) the mid-point of the range voted on by the FOMC. Moreover, the borrowing assumption was often changed during the intermeeting period without a specific vote of the FOMC. Beginning with the June 30, 1995, meeting, the FOMC dropped the explicit reference to the level of seasonal plus adjustment borrowing that it believed was consistent with the policy alternatives being considered.

8 There are 19 missing observations for the BOG and 586 missing observations for NY. Also, there are seven days when daily open market operations are missing.

9 See Sternlight (1991).

10 Reserve balances held on that day counted for two days.

11 Because the operating procedure is directed at the quantity of reserves over the maintenance period, it is not surprising that the correlation between $OPDOMO_t$ and $OMOD_t$ is considerably lower, 0.46.

12 Daily total reserves are available only for the period January 2, 1986–December 31, 1996. These statistics are based on the official measures of required and excess reserves for the period.

13 I do not say 'announcing changes in the funds rate target' because the FOMC had not formally acknowledged that it was targeting the funds rate at this time. See Thornton (2005) for details.

14 Demiralp and Jorda (2002) investigate the liquidity effect using a similar methodology. Specifically, they estimate the response of open market transactions of various types to surprise changes in the funds rate target for a sub-period of the period April 25, 1984 to August 14, 2000. They find evidence that they interpret as being 'broadly consistent with the traditional liquidity effect' prior to 1994 but not after. Recently, however, de Jong and Herrera (2004) have re-evaluated Demiralp and Jorda's work. Consistent with the findings presented here, they find no evidence consistent with a liquidity effect over the entire sample period, but find evidence consistent with a liquidity effect for a sub-period after August 18, 1998, when lagged reserve accounting was reintroduced.

15 There were 14 occasions (eight for positive and six for negative changes in the target) when there were fewer than 5 days between successive target changes. These changes were deleted so as not to bias the results.

16 See Thornton (2004) for analysis of the Desk's forecast error and comparison of those errors with Hamilton's estimates.

17 They kindly provided me with these forecast errors, which cover the period January 2, 1986, to June 30, 2000, for the Board of Governors' estimates and December 23, 1993, to June 30, 2000, for the New York Fed's estimates.

18 The slope of the demand curve cannot be estimated during any of the days of the maintenance period after August 1998, when the Fed returned to lagged reserve accounting.

19 The results are very similar if the sample ends on December 31, 1993; hence, the results for the shorter sample are not presented here.

20 The equation was also estimated allowing for corresponding shifts in the intercept. The qualitative results were unchanged, so only the results that do not include corresponding shifts in the intercept are presented here.

21 Fannie Mae, Freddie Mac and Federal Home Loan Bank were major players in the federal funds market and often had zero or near zero balances with the Fed at the end of the day.

22 See Stigum (1990), Furfine (1999), and Demiralp *et al.* (2004) for discussions of various aspects of the federal funds market.

23 It is also the case that the number of brokers has changed over time. Unfortunately, there is no precise dating of changes in the number of participating brokers.

24 The large flow of federal funds relative to the daily volume of balances at the Federal Reserve would appear to be inconsistent with Demiralp and Farley's (2005, p. 1132) characterization of open market operations and the equilibrium federal funds rate. They suggest that open market operations 'are used to bring the supply of balances at the Federal Reserve in line with the demand for them at an interest rate (the federal funds rate) near the level specified by the Federal Open Market Committee (FOMC)'.

Comment on Thornton*

*Natacha Valla**

Central banks use monetary policy 'procedures' to steer money market interest rates and manage domestic liquidity conditions. In practice, it is often the case that the implementation of monetary policy is delegated to an entity within the bank – most often the market operations department – which is then in charge of taking actions in the market in order to achieve a level of interest rates in line with the monetary policy stance decided by the governing body of the central bank. In the US, this task is delegated by the Federal Open Market Committee (FOMC) to the trading desk of the Federal Reserve Bank of New-York (the 'Desk'). In this context, Thornton (2005) asks two important questions:

(1) Did the Desk follow its 'implementation procedures' to conduct open market operations (OMOs)?
(2) Do we find evidence of a liquidity effect of OMOs in the Federal Funds market?

The remarks are structured as follows. After presenting Thornton's supply and demand approach to the Federal funds market, I review selected elements of the US monetary policy operational framework that are particularly relevant to the understanding of Thornton's results. Comments on Thornton's results follow with a discussion of issues associated with autonomous factors forecast errors, changes in the operational framework and frequency, before the conclusion.

A supply and demand approach to the Federal funds market

In order to assess the Desk's liquidity policy between the mid 1980s and the mid 1990s, Thornton uses estimates of the daily demand and supply for reserves to construct a counterfactual measure of what the Desk would have done, had it followed the Procedure to the letter. This measure is then compared to an ex-post measure of injections or withdrawals in the Federal funds markets actually effected by the Desk through its realized purchases and sales.

The daily demand and supply for reserves in the Federal funds Market (TR^{demand} and TR^{supply}) are defined as

$$E_{t-1}\left(TR_t^{\text{demand}}\right) = E_{t-1}(RR_t + XR_t) = E_{t-1}[f(i_t, \mathbf{x}_t) + \eta_t] \qquad (1)$$

and

$$E_{t-1}\left(TR_t^{\text{supply}}\right) = E_{t-1}(NBR_t + IBA_t) = B_t + F_t + \eta_t + IBAT_t \qquad (2)$$

respectively, where RR_t stands for required reserves, XR_t excess reserves, i_t the interest rate and $\mathbf{x}_t$ a vector of 'exogenous' variables and η_t a forecast error. In (2), NBR_t represents the non-borrowed reserves equal to government securities held by the Federal Reserve, B_t, plus autonomous factors F_t (typically currency in circulation, government deposits, float), IBA_t the initial borrowing assumption which is a measure of banks' borrowing.

The procedure-based OMO is defined as the difference between demand and supply, as estimated on the day. This difference is then regressed on a constant and a vector of exogenous variables $\mathbf{z}_t$:

$$E_{t-1}\left(TR_t^{\text{demand}} - TR_t^{\text{supply}}\right) = \alpha + \beta \mathbf{z}_t + \varepsilon_t. \qquad (3)$$

Supply and demand functions are based on three fundamental estimates provided by the Federal Reserve (the Board of Governors or the FOMC): the total demand for reserves (required and in excess of requirements), the total supply of reserves, which includes non-borrowed reserves, and the rather infrequently changed borrowing assumption, called the 'initial borrowing assumption'.

On the demand side, the estimate of required plus excess reserves in (1) certainly depends on the level of interest rates, a range of exogenous factors $\mathbf{x}_t$, and produces a quasi-systematic forecast error. While required reserves are in principle easy to forecast (in particular in a reserve requirement system which is based on lagged information, as is the case for the Federal Reserve), it is very difficult to rationalize why and to what extent banks choose to hold non-remunerated reserves in excess of requirements. The period average and daily pattern of this component are therefore difficult to forecast. They are typically volatile, may differ for small and large banks and depend on the level of interest rates.

On the supply side, forecasting autonomous factors is also a difficult exercise due to the sometimes erratic behaviour of the banknote circulation in the economy. This issue will be discussed again below in comparison with the euro area.

Useful elements on the Federal Reserve's operational framework

The Federal Reserve's conduct of open market operations relies on a number of instruments and procedures; see e.g. Borio *et al.* (2001). Some of them turn out to be crucial to understand the specifics of the Federal Funds market and therefore the implications of (1) and (2).

To say the least, the Federal Reserve System's approach to monetary policy implementation has evolved in the recent past. In the 1970s, monetary aggregates served as an intermediate target and the Federal funds rate was the operational target. In the early 1980s, the Federal Reserve moved to short-term monetary control where non-borrowed reserves became the operational target. This experience ended with two changes. First, discretion was to some extent officially restored; second, the non-borrowed reserves target was replaced with borrowed reserves. In the 1990s, Federal funds rate targeting became increasingly explicit. A number of implementation changes have occurred since then. In particular, one may think that 1994 constituted a major break. From then on, the Federal funds rate target was announced immediately after FOMC meetings by means of a press release. This announcement aimed at getting rid of expectational inferences about monetary policy moves on the basis of the liquidity operations conducted by the Desk. In 1994, a sweep account system was also introduced, which strongly reduced the demand for excess reserves. Further along, in 1998, contemporaneous reserve accounting (i.e. reserve accounting based on the contemporaneous, and not lagged, reserve base) was abandoned; in 1999, it was decided that the discount rate would follow the moves of the Federal funds rate target with a fixed penalty. This set of changes has to be kept in mind.

Among the specifics of the Federal Reserve's operational framework, three elements are particularly relevant to Thornton's study: the Desk's procedure, reserve requirements and OMOs, and the supply of reserves. The Desk's procedure is defined in the FOMC's internal directive to the Desk, which is asked to seek conditions in reserve markets consistent with maintaining the Federal funds rate around the Federal funds target. Reserve requirements have to be met over maintenance periods of two weeks. When fulfilling them, banks may average-out daily holdings during the period, implying that in practice only end-of-period liquidity conditions are really binding. One would therefore expect to identify a liquidity effect – if any – at this time. However, overnight credit on current account holdings is not allowed and penalties are applied if requirements are not met at the end of the period, while excess reserves are not remunerated. Overall, banks have therefore an incentive to manage liquidity carefully. Turning to the supply of reserves, the Desk is on the market daily and a discount window is at the disposal of counterparties that may need extra liquidity at the end of the day. One may therefore think a priori that liquidity supply is frequent enough to contain the volatility of money market rates and to avoid large quantity-driven swings in rates.

The Desk's implementation procedure and the liquidity effect

The Desk's implementation procedure

Keeping in mind the elements described above, recall Thornton's two basic questions:

(1) Do data suggest that the Desk followed its procedure, as defined by (1)–(2)? In particular, did the 1994 policy regime change matter for the behaviour of the Desk?
(2) Is there evidence of a liquidity effect in the Federal funds market at a daily frequency?

The chapter provides the following answers.

On the basis of daily data, the Desk followed its procedure 'fairly' closely. A number of factors are identified to explain deviations from the procedure. First, they are found to be related to calendar (day-of-the-week) effects. It seems that deviations are stronger at the beginning of the maintenance period, and that such deviations dominate other seasonal effects such as end-of-months, quarters or years. Second, asymmetries seem to arise between liquidity withdrawals and injections, interest rate increases and decreases. Third, and quite interestingly, real-time market conditions, as summarized at the Federal Reserve's daily 'morning call' where main market and economic events are summarized, also cause the Desk to deviate from its procedure. Reasonably, this effect has become more pronounced after the monetary policy changes implemented in 1994.

The forecast of autonomous factors

Thornton also finds that a number of factors, that could have caused deviations from procedures did not turn out to be significant, contrary to what could be expected. This is the case for the changes in the Federal fund target and, even more surprisingly, for the previous day's autonomous factors forecast errors, including government deposits and borrowed reserves. This is a strong result that contradicts Hamilton's (1996) statements.

Stating that autonomous factor errors are neutral and do not affect the Desk's liquidity injections and withdrawals is not a light statement and may be counterintuitive. On the one hand, it makes sense in the case of excess reserves, which exhibit a strongly seasonal pattern that may itself be already captured by the maintenance-period-day dummies included in the regression. In addition, the estimate of the total supply of reserves already adjusts ('endogenously' in a sense, e.g. via judgmental elements) for previous autonomous factors forecast errors. This would create an endogenous link between $\mathbf{x}_t$ and $\mathbf{z}_t$, which is arguably difficult to capture when estimating an equation like (1). On the other hand, it is quite surprising to observe that such errors in forecasting borrowed reserves, and in particular excess reserves, are not systematically corrected by the Desk.

Forecast errors of other variables, in particular autonomous factors, are also of importance. To that respect, there seems to have been a systematic error in the forecast of the currency component (as documented in Thornton, Table 8.1), which shows that according to the procedure, reserves would have needed to be added more often than drained in order to keep the Federal funds rate close to its target. If this is true, it is surprising to find that although a systematic forecast error has been identified, it did not lead to a correction of the quantities of cash injected in the market.

Those remarks raise the issue of forecast errors bias and/or autocorrelation, creating statistical problems associated with autocorrelation. The difficulty in assessing the distribution of liquidity imbalances arising from the revisions of autonomous factors forecasts is not specific to the Federal Reserve. In the euro area, for example, daily estimates are constructed by summing up daily revisions, where neighbouring bi-cumulated revisions make use of a common information set. This overlap in information sets creates a degree of correlation, which depends, when forecasts are updated on a daily basis, on whether daily forecasts may be really considered independent of each other. If they are not, forecast revisions themselves are likely to reflect part of the same information set.

Stability of the coefficients over the sample period

Thornton shows that after 1994 the Desk started to respond to real-time market developments (the 'morning call effect') by deviating from the procedure when the latter suggested to do so. This is quite interesting and confirms the success of the new communication approach of the Federal Reserve. Because policy announcements became extremely explicit, inferences about the policy stance stopped being derived from OMOs themselves.

While 1994 is indeed a good candidate for a structural break, a number of other events took place between 1986, the beginning of Thornton's sample period, and 1994. Until around 1988, the Federal Reserve more or less explicitly targeted borrowed reserves via recourses to the discount window (Cosimo and Sheenan 1994). Borrowed reserve targets were frequently adjusted during that period. These changes, together with developments in the banking sector, may have created some instability in the relation between the discount window borrowing and the Federal funds target rate, and certainly affected the effectiveness of OMOs in stabilizing the Federal funds rate. Overall, in order to capture these effects, it could be interesting to look at the impact of discount window borrowings on the Desk's actions and their consequences on the money market.

A vanishing liquidity effect

A few years ago, Hamilton (1996) investigated the effect on the Federal funds rate of an open market operation, having in mind that it had proved very difficult to find convincing evidence that the immediate short-run effect of a liquidity

injection would be a decrease in the nominal interest rate (the liquidity effect). Unlike many earlier studies that concentrated on the liquidity effect at monthly frequency, Hamilton sought to develop an 'instantaneous' (namely daily) measure of the liquidity effect. In doing so, Hamilton recognized that an OMO is not the only reason that could induce fluctuations in the supply of reserve deposits in the domestic banking system. He therefore placed autonomous factor fluctuations (in particular government deposits) at the centre of his analysis to develop a model of daily fluctuations in the Treasury balance with the Federal Reserve. Dynamically, the errors made in forecasting government deposits were found to have significant effects on the supply of reserves available to the banking sector. Changes in the supply of reserves may in turn trigger a liquidity effect when at least one of the two following conditions arises. First, even if reserve shortfalls are temporary, the interest rate will tend to rise because banks dislike large discrepancies in their reserve fulfilment path. Second, liquidity shocks that affect aggregate liquidity beyond the maintenance period horizon will – quite intuitively – have a far bigger effect on the interest-rate level.

Thornton's results challenge this view somewhat and provide little evidence for a liquidity effect at daily frequency. The idea that market expectations of changes in the Federal funds target explain the absence of liquidity effect is discarded, because target changes were generally not predicted by the market during that period (Poole *et al*., 2002). Other explanatory factors are suggested: the relatively small size of OMOs relative to the volumes traded daily in the market, and the endogeneity of policy changes in the Federal funds target to market forces that bring about changes in inflation expectations. On the former factor, it seems that, as monopoly supplier of liquidity, the Federal Reserve should remain able to influence the Federal funds rate, even with very small quantities, at the end of the maintenance period when liquidity demand is inelastic. In addition, the turnover of reserve holdings themselves is quite high. The latter factor coincides with Hamilton's suggestion that 'the correlation between … policy innovation and the future level of output … mixes together the effect of output forecasts on policy'. However, even if the policy-induced changes in the Federal funds target exhibit some endogeneity, one may think that this endogeneity is unlikely to appear at a frequency as high as the daily one.

Hamilton concluded that at the daily frequency, the liquidity effect is real, allowing the Federal Reserve to target the Federal funds rate. One may wonder whether Thornton's and Hamilton's views could not be reconciled by looking for a liquidity effect at higher frequencies. Even when accepting the argument that endogeneity played a role at the daily frequency, it is very likely that endogeneity would disappear when looking at trading in real time. At the intraday level, endogeneity issues of the kind raised above are very much likely to be dominated by micro-market mechanisms. Such mechanisms may even lead to a reversal of the liquidity effect. For example, a low (daily average) overnight money market rate has sometimes been associated with a scarce (daily) liquidity situation in the euro money market. Ewerhart *et al*. (2004a) suggest that such a reversal of the liquidity effect may happen in the presence of information inefficiencies,

when unsophisticated banks (who simply trade away their current account imbalances) and sophisticated banks (who act strategically in the money market) coexist, because sophisticated banks may find it optimal to delay the balancing of their reserve accounts.

Conclusions

As Campbell (1987) argued, it is very likely that the Federal funds rate does not aggregate private information perfectly. This may explain some puzzling features of Federal funds rate pattern within the maintenance period. The evidence provided by Thornton may therefore be applied in a high-frequency micro-founded analysis of money market structures.

Note

9   On the optimal frequency of the central bank's operations in the reserve market

*Beata K. Bierut**

We address an issue in central bank policy making which has largely been taken for granted in the literature so far[1] – the *frequency* of open market operations (OMOs). However, in reality the frequency of central banks' operations in the reserve market is far from uniform. Our objective therefore is to assess the effects of different frequencies in terms of achieving the central bank's operating target, i.e. controlling short-term interest rates.

We therefore narrow our interest to the link between the frequency of open market operations and the volatility of overnight interest rates. Hence we will focus on controlling interest rates through an appropriate management of liquidity in the reserve market.[2] Let us note that the overnight liquidity can be managed by establishing standing facilities as well. However, open market operations are carried out on the initiative of the central bank, whereas standing facilities are activated on demand by market participants. As a result, central banks tend to steer liquidity mainly through open market operations and to utilize standing facilities only as 'safety valves' for end-of-day imbalances. The central bank can furthermore introduce required reserves, an obligation for financial institutions to hold a certain level of liquidity over a specified period, which act as a 'buffer' to stabilize overnight interest rates in the face of unexpected liquidity shocks (e.g. due to autonomous factors, such as net foreign assets, net lending to the government, cash in circulation, etc.). Averaging provisions, which allow for an averaged fulfillment of reserve requirements, foster the stabilization function of required reserves by providing extra flexibility in the face of fluctuations in market interest rates.

Table 9.1 summarizes actual operating frameworks applied in four monetary areas: the euro area, United States, Japan and United Kingdom.[3] All central banks use the interest rate as the main operating target.[4]

As Table 9.1 shows, the applied frequency of open market operations varies considerably among the countries. These differences, however, do not necessarily translate into diverging accuracy of controlling short-term interest rates, which we measure with the level of the overnight interest-rate volatility. Table 9.2 presents the average volatility, defined as the average of squared deviations from the target rate, of the overnight market rates in the euro area and the United States, Eonia

Table 9.1 Selected central bank operating frameworks

	Euro area	*UK*[1]	*USA*	*Japan*[2]
Lending facility	Applied	Applied	Applied but not important	Applied but not important
Deposit facility	Applied	Applied	–	–
Outright OMOs	Applied	Applied	Applied	Applied
Reverse OMOs	Applied	Applied	Applied	Applied
Frequency	*Weekly*	*Weekly*	*Daily*	*More than once a day*
Required reserves	Applied	Applied[3]	Applied but not important	Applied
Averaging provisions	*Applied*	*Applied*	*Applied*	*Applied*

Notes:
1. The framework as from 2006. Before the framework did not include the deposit facility and required reserves. OMOs were carried out more than once a day.
2. As described in Maeda *et al.* (2005).
3. With a target for voluntary reserves.

Table 9.2 Average overnight volatility in the euro zone and the USA

	Eonia	*FF rate*	*F-statistic*
1999	0.037	0.028	1.394
2000	0.033	0.015	8.141
2001	0.059	0.040	0.771
2002	0.021	0.003	11.058

and the federal funds (FF) rate. Average levels of the overnight volatility in the two monetary areas do not always differ in a statistical sense, even though the Federal Reserve intervenes daily whereas the European Central Bank only does weekly.

We therefore conclude that more frequent interventions in the reserve market do not automatically translate into more stable interest rates. This suggests that other instruments at the disposal of the central bank must play an important role. We proceed by investigating the three-way relation between the frequency of open market operations, the volatility of overnight interest rates and the design of other central bank instruments.

In the following two sections we introduce our setup: a general specification of the central bank's liquidity management problem and a specific model for the 2-day reserve maintenance period. We then present the results: the optimal liquidity provision through open market operations and the resulting volatility of overnight

interest rates. We conclude by interpreting the results and providing empirical support for our findings.

Our work comes closest to the contribution of Bartolini *et al*. (2002), who present a positive analysis of the effects of the Fed's 'intervention' that is unlimited and limited-size open market operations, on the volatility of the FF rate. Contrary to the study of Bartolini *et al*. (2002), the analysis presented below is fully normative.

Analytical setup

We assume that the central bank's operational framework is designed to deliver the desired level (i) of the overnight interest rate (i_t), therefore the objective of the central bank is to minimize the following loss function:

$$L = \mathrm{E}\left[\sum_{t=1}^{T}(i_t - i)^2\right] \tag{1}$$

where E denotes the expectations operator and T is the length of the maintenance period. The model of the reserve market consists of two equations:[5]

- the supply equation, derived from the central bank's balance-sheet identity:

$$r_t = m_t + s_t - a_t \tag{2}$$

  where r_t denotes reserves held by the banking sector, m_t, open market operations,[6] s_t, net standing facilities (i.e. the difference between the lending facility and the deposit facility) and a_t, net autonomous factors (outside the control of the central bank).[7]

Autonomous factors constitute an exogenous stochastic element in the supply of liquidity. We assume that in each sub-period t their expected value $\mathrm{E}(a_t)$ is equal to the central bank's forecast, which we denote as a_t^f.[8] The size of open market operations is determined by the central bank, based on publicly available information. Consequently the size of open market operations is deterministic. The recourse to standing facilities of the central bank is assumed to represent errors made by commercial banks in the management of reserve funds. Assuming that these errors are non-systematic, the expected size of the net facilities is zero: $\mathrm{E}(s_t) = 0$.

- the demand equation, derived from an inventory theoretical model of reserve management (see appendix):

$$r_t = -\alpha_t r_{t-1} - \beta_t r_{t+1}^e + \gamma_t R - \delta_t i_t + \varepsilon_t \tag{3}$$

where r^e_{t+1} denotes the expected reserves to be held in the sub-period $t + 1$, R is the level of required reserves, i_t is the overnight rate and ε_t is the (white noise) disturbance in the demand for reserves (which may correspond to the demand for reserves necessary to settle transactions with other banks etc.).

The demand equation (3) has two important characteristics. First of all, we assume that banks manage their reserve holdings based on the cost of obtaining the funds (i_t) on the one hand and the compulsory level of reserves imposed by the central bank (R) on the other hand. Furthermore, the specification emphasizes the intertemporal character of funds' management: commercial banks are supposed to analyse their reserve position in the context of several sub-periods within the reserve maintenance period (sub-periods $t - 1$, t and $t + 1$). To be more specific, if all model parameters are non-negative, the weighted average of reserves that commercial banks are willing to hold over three consecutive sub-periods $(r_t + \alpha_t r_{t-1} + \beta_t r^e_{t+1})$ is assumed to be positively related to the level of required reserves[9] and negatively related to the overnight interest rate. The imposed parameter assumptions result in the behaviour of reserves driven by interest-rate expectations as described in the literature: in order to minimize the cost of holding reserves, commercial banks try to front or back-load reserves if they expect interest rates to increase or decrease later on in the maintenance period.[10]

We estimated equation (3) for the euro area.[11] This exercise provided us with the following indicative values for the model parameters, as presented in Table 9.3.[12] These results corroborate our assumption of non-negativity for all model parameters. Moreover, the estimated values will be useful for evaluating the results of our analysis. It is therefore important to take note of the following relations: $0 < \alpha_t < 1, 0 < \beta_t < 1$, and $\gamma_t > 1$.

In the remainder of the chapter we will investigate in detail the simplest case for a 2-day reserve maintenance period $(T = 2)$. This case is of interest, as it combines analytical tractability with policy-relevant features. Our framework differs considerably from the existing literature, which focuses on the reserve market in *either* the euro area[13] or the US.[14] Our approach can be applied to both monetary areas as it captures an (intertemporal) dependency between liquidity and interest rates and does not represent interest rates as weighted averages of the rates on standing facilities.[15]

Table 9.3 Calibrated model coefficients

t	1	2
α_t	0.38	0.69
β_t	0.78	0.18
γ_t	2.15	1.69
δ_t	0.22	0.05

Interest rates over a 2-day reserve maintenance period

We solve for interest rates on both days of the maintenance period using (3) written for $t = 1, 2$:

$$r_1 = -\alpha_1 r_0 - \beta_1 r_2^e + \gamma_1 R - \delta_1 i_1 + \varepsilon_1 \tag{4}$$

$$r_2 = -\alpha_2 r_1 - \beta_2 r_3^e + \gamma_2 R - \delta_2 i_2 + \varepsilon_2. \tag{5}$$

The first equality implies

$$i_1 = \frac{1}{\delta_1}\left(\gamma_1 R - \beta_1 r_2^e - r_1 - \alpha_1 r_0 + \varepsilon_1\right) \tag{6}$$

and the second

$$i_2 = \frac{1}{\delta_2}\left(\gamma_2 R - r_2 - \alpha_2 r_1 - \beta_2 r_3^e + \varepsilon_2\right). \tag{7}$$

Equations (6) and (7) reveal that a central bank will be able to steer interest rates through liquidity provision if and only if the following conditions hold: $\delta_1 \neq 0$ and $\delta_2 \neq 0$. Otherwise market interest rates are uncontrollable.

Using the supply equation (2) we can write the above expressions in terms of open market operations, autonomous factors and standing facilities:

$$i_1 = \frac{1}{\delta_1}\left[\gamma_1 R - \beta_1\left(m_2 - a_2^f\right) - (m_1 - a_1 + s_1) - \alpha_1 r_0 + \varepsilon_1\right] \tag{8}$$

$$i_2 = \frac{1}{\delta_2}\left[\gamma_2 R - (m_2 - a_2 + s_2) - \alpha_2(m_1 - a_1 + s_1) - \beta_2 r_3^e + \varepsilon_2\right] \tag{9}$$

where we have made use of the assumptions regarding the non-stochastic character of open market operations and the zero expected value of net standing facilities made in the previous section.

Overnight interest rates are lower if there is more liquidity available in the market due to open market operations, net liquidity-providing autonomous factors (negative a_ts) and net standing facilities. Lower required reserves also reduce market interest rates.

In subsequent sections we will calculate the size of open market operations necessary to keep interest rates given by expressions (8) and (9) as close as possible to the target rate i. We will do this first under the assumption that the central bank intervenes in the reserve market twice – that will be our frequent (multiple) intervention benchmark. Secondly, we will explore the consequences of intervening less frequently, i.e. only once, within the maintenance period.

Multiple versus single open market operations

The central bank that wants to use open market operations to minimize the volatility of interest rates around the operating target has to solve the following stochastic optimization problem:

$$\text{Min}_{m_1,m_2} L = \text{E}\left[(i_1 - i)^2 + (i_2 - i)^2\right] \tag{10}$$

subject to conditions (8), (9) and $r_0 = r_3^e = 0$.

The last constraint is added to improve the transparency of the analysis and is justified if we restrict our attention to the relationship between interest rates and reserves held within a single maintenance period.[16]

The sequence of events is as follows: before the beginning of the maintenance period the central bank calculates its forecasts of autonomous factors for both days and makes them public. The level of required reserves as well as the target interest rate are also known to market participants. The central bank has to decide on its operations before it observes the realization, the autonomous factors and the reserves' demand disturbance on the first day of the maintenance period.

If the operational framework of the central bank presumes open market operations only on one day of the maintenance period, it implies that the size of one of the open market operations m_t in expressions (8) and (9) should by assumption be set to zero. Carrying out open market operations towards the end of the reserve maintenance period raises issues related to the availability and usefulness of information on liquidity conditions at the beginning of the maintenance period. If midway through the maintenance period data on the actual level of autonomous factors, the recourse to standing facilities and the actual shock to the demand for reserves on the first day of the reserve maintenance period (i.e. a_1, s_1 and ε_1) become available, the subsequent optimal provision of the central bank's liquidity should take these factors into account.

If required reserves are imposed, with the averaging provision in place, then it is natural that the optimal liquidity provision open market operations should ensure a smooth fulfillment of the reserve requirements. In the case of a 2-day reserve maintenance period, that implies the following condition[17] $[(m_1 - a_1^f) + (m_2 - a_2^f)]/2 = R$ or the set of conditions: $\partial(m_1 + m_2)/\partial R = 2$, $\partial(m_1 + m_2)/\partial a_1^f = \partial(m_1 + m_2)/\partial a_2^f = 1$, $\partial(m_1 + m_2)/\partial i \to 0$.

Under the multiple-operations' strategy, the optimal provision of liquidity reads as follows:

$$m_1^* = a_1^f + \frac{\beta_1 \gamma_2 - \gamma_1}{\beta_1 \alpha_2 - 1} R + \frac{\delta_1 - \delta_2 \beta_1}{\beta_1 \alpha_2 - 1} i \tag{11}$$

$$m_2^* = a_2^f + \frac{\alpha_2 \gamma_1 - \gamma_2}{\beta_1 \alpha_2 - 1} R + \frac{\delta_2 - \alpha_2 \delta_1}{\beta_1 \alpha_2 - 1} i. \tag{12}$$

If the frequency of open market operations is limited, then the optimal provision of liquidity is given as:

$$m_1^{**} = a_1^f + \frac{\delta_2^2 \beta_1 + \alpha_2 \delta_1^2}{\delta_2^2 + \alpha_2^2 \delta_1^2} a_2^f + \frac{\delta_2^2 \gamma_1 + \alpha_2 \delta_1^2 \gamma_2}{\delta_2^2 + \alpha_2^2 \delta_1^2} R - \delta_1 \delta_2 \frac{\delta_2 + \alpha_2 \delta_1}{\delta_2^2 + \alpha_2^2 \delta_1^2} i \quad (13)$$

if open market operations are carried out on the first day of the reserve maintenance period and

$$m_2^{**} = a_2^f + \frac{\beta_1 \delta_2^2 + \delta_1^2 \alpha_2}{\beta_1^2 \delta_2^2 + \delta_1^2} a_1^f + \frac{\delta_1^2 \gamma_2 + \beta_1 \delta_2^2 \gamma_1}{\beta_1^2 \delta_2^2 + \delta_1^2} R - \delta_1 \delta_2 \frac{\beta_1 \delta_2 + \delta_1}{\beta_1^2 \delta_2^2 + \delta_1^2} i \quad (14)$$

or

$$\widehat{m}_2^{**} = a_2^f + \frac{\alpha_2 \delta_1^2 + \beta_1 \delta_2^2}{\beta_1^2 \delta_2^2 + \delta_1^2} (a_1 - s_1) + \frac{\beta_1 \delta_2^2}{\beta_1^2 \delta_2^2 + \delta_1^2} \varepsilon_1 + \frac{\delta_1^2 \gamma_2 + \beta_1 \delta_2^2 \gamma_1}{\beta_1^2 \delta_2^2 + \delta_1^2} R$$

$$- \delta_1 \delta_2 \frac{\beta_1 \delta_2 + \delta_1}{\beta_1^2 \delta_2^2 + \delta_1^2} i \quad (15)$$

if the operations are carried out at the end of the reserve maintenance period. Equation (14) describes the provision of funds if data on liquidity conditions are available with considerable lags. If data are timely, the optimal size of day-2 operations should be calculated according to (15). Relative to m_2^{**}, $\widehat{m}_2^{**}$ is determined based on the actual level of outstanding autonomous factors after day-1 $(a_1 - s_1)$ instead of the absolute forecast a_1^f. Moreover, $\widehat{m}_2^{**}$ is adjusted in response to the realization of the shock in the demand for liquidity ε_1.

Our calibrated coefficient values indicate the following derivatives in the euro area:[18]

	$m_1^* + m_2^*$	m_1^{**}		m_2^{**} or $\widehat{m}_2^{**}$	
a_1^f [19]	1	1		$\dfrac{\alpha_2 \rho^2 + \beta_1}{\beta_1^2 + \rho^2} =$	$\begin{array}{l}0.69 \text{ if } \rho \to \infty \\ 0.71 \text{ if } \rho = 4.4\end{array}$
a_2^f	1	$\dfrac{\beta_1 + \alpha_2 \rho^2}{1 + \alpha_2^2 \rho^2} =$	$\begin{array}{l}1.45 \text{ if } \rho \to \infty \\ 1.38 \text{ if } \rho = 4.4\end{array}$	1	
R	2.25	$\dfrac{\gamma_1 + \alpha_2 \gamma_2 \rho^2}{1 + \alpha_2^2 \rho^2} =$	$\begin{array}{l}2.45 \text{ if } \rho \to \infty \\ 2.42 \text{ if } \rho = 4.4\end{array}$	$\dfrac{\rho^2 \gamma_2 + \beta_1 \gamma_1}{\beta_1^2 + \rho^2} =$	$\begin{array}{l}1.69 \text{ if } \rho \to \infty \\ 1.72 \text{ if } \rho = 4.4\end{array}$
i	$\begin{array}{l}0 \text{ if } \delta_t = 0 \\ -0.17 \text{ if } \delta_t \neq 0\end{array}$	$\begin{array}{l}0 \text{ if } \delta_t = 0 \\ -0.09 \text{ if } \delta_t \neq 0\end{array}$		$\begin{array}{l}0 \text{ if } \delta_t = 0 \\ -0.06 \text{ if } \delta_t \neq 0\end{array}$	

The calibrated coefficients of the optimal provision of liquidity through multiple open market operations correspond very well to the numbers implied by the smooth

fulfillment of averaged required reserves. If the central bank limited the frequency of the liquidity provision through OMOs, then the smooth fulfillment conditions would hold, if commercial banks adjusted their behaviour, so that α_2 and β_1 came closer to unity and γ_1 would be roughly equal and would approach 2.

Let us now consider the behaviour of market interest rates. If the central bank employs multiple open market operations, then it is able to keep market interest rates on average equal to the target rate.[20] Not surprisingly, if we reduce the frequency of interventions,[21] then overnight interest rates may not equal the target rate, even on average. In formal terms: under multiple open market operations, the market interest rates are given as follows:

$$i_1(m_1^*, m_2^*) = i + \frac{1}{\delta_1}\left(a_1 - a_1^f - s_1 + \varepsilon_1\right) \tag{16}$$

$$i_2(m_1^*, m_2^*) = i + \frac{1}{\delta_2}\left[a_2 - a_2^f - s_2 + \alpha_2\left(a_1 - a_1^f - s_1\right) + \varepsilon_2\right]. \tag{17}$$

As a result

$$\mathrm{E}\left[i_1\left(m_1^*, m_2^*\right) - i\right] = \mathrm{E}\left[i_2\left(m_1^*, m_2^*\right) - i\right] = 0. \tag{18}$$

If the central bank implements the open market operations only on the first day of the reserve maintenance period, interest rates in the reserve market are given by:

$$i_1\left(m_1^{**}\right) = \frac{\delta_2^2 + \alpha_2\delta_1\delta_2}{\delta_2^2 + \alpha_2^2\delta_1^2}i + \frac{\alpha_2\delta_1(\beta_1\alpha_2 - 1)}{\delta_2^2 + \alpha_2^2\delta_1^2}a_2^f + \frac{\alpha_2\delta_1(\gamma_1\alpha_2 - \gamma_2)}{\delta_2^2 + \alpha_2^2\delta_1^2}R$$
$$+ \frac{1}{\delta_1}\left(a_1 - a_1^f - s_1 + \varepsilon_1\right) \tag{19}$$

$$i_2\left(m_1^{**}\right) = \frac{\delta_2\delta_1\alpha_2 + \alpha_2^2\delta_1^2}{\delta_2^2 + \alpha_2^2\delta_1^2}i - \frac{\delta_2(\beta_1\alpha_2 - 1)}{\delta_2^2 + \alpha_2^2\delta_1^2}a_2^f - \frac{\delta_2(\gamma_1\alpha_2 - \gamma_2)}{\delta_2^2 + \alpha_2^2\delta_1^2}R$$
$$+ \frac{1}{\delta_2}\left[a_2 - a_2^f - s_2 + \alpha_2\left(a_1 - a_1^f - s_1\right) + \varepsilon_2\right]. \tag{20}$$

Therefore:

$$\mathrm{E}\left[i_1\left(m_1^{**}\right) - i\right] = \frac{\alpha_2\delta_1}{\delta_2^2 + \alpha_2^2\delta_1^2}\left[(\delta_2 - \alpha_2\delta_1)i + (\beta_1\alpha_2 - 1)a_2^f + (\gamma_1\alpha_2 - \gamma_2)R\right] \tag{21}$$

$$\mathrm{E}\left[i_2\left(m_1^{**}\right) - i\right] = -\frac{\delta_2}{\delta_2^2 + \alpha_2^2\delta_1^2}\left[(\delta_2 - \alpha_2\delta_1)i + (\beta_1\alpha_2 - 1)a_2^f + (\gamma_1\alpha_2 - \gamma_2)R\right]. \tag{22}$$

Contrary to the case of multiple open market operations, the average control errors $E\left[i_t(m_1^{**}) - i\right]$ are non-zero and depend on the relations between parameters of the model. The reasoning is analogous for the open market operations carried out only on the second day of the reserve maintenance period. The informational issues will have impact on the interest rate on the second day of the reserve maintenance period only. The interest rate $i_1(m_2^{**})$ depends on the information available at time $t = 0$ and is given by:

$$
i_1\left(m_2^{**}\right) = i_1\left(\widehat{m}_2^{**}\right) = \frac{\beta_1^2\delta_2^2 + \beta_1\delta_2\delta_1}{\beta_1^2\delta_2^2 + \delta_1^2}i + \frac{\delta_1(\gamma_1 - \beta_1\gamma_2)}{\beta_1^2\delta_2^2 + \delta_1^2}R
$$
$$
- \frac{\delta_1(\beta_1\alpha_2 - 1)}{\beta_1^2\delta_2^2 + \delta_1^2}a_1^f + \frac{1}{\delta_1}\left(a_1 - a_1^f - s_1 + \varepsilon_1\right) \tag{23}
$$

$i_2(m_2^{**})$ depends on the information available at $t = 1$ and will settle at:

$$
i_2\left(m_2^{**}\right) = \frac{\beta_1\delta_2\delta_1 + \delta_1^2}{\beta_1^2\delta_2^2 + \delta_1^2}i + \frac{\beta_1\delta_2\,(\beta_1\gamma_2 - \gamma_1)}{\beta_1^2\delta_2^2 + \delta_1^2}R + \frac{\beta_1\delta_2\,(\beta_1\alpha_2 - 1)}{\beta_1^2\delta_2^2 + \delta_1^2}a_1^f
$$
$$
+ \frac{1}{\delta_2}\left[a_2 - a_2^f - s_2 + \alpha_2\left(a_1 - a_1^f - s_1\right) + \varepsilon_2\right] \tag{24}
$$

or

$$
i_2\left(\widehat{m}_2^{**}\right) = \frac{\beta_1\delta_2\delta_1 + \delta_1^2}{\beta_1^2\delta_2^2 + \delta_1^2}i + \frac{\beta_1\delta_2\,(\beta_1\gamma_2 - \gamma_1)}{\beta_1^2\delta_2^2 + \delta_1^2}R + \frac{\beta_1\delta_2\,(\beta_1\alpha_2 - 1)}{\beta_1^2\delta_2^2 + \delta_1^2}\,(a_1 - s_1)
$$
$$
- \frac{\beta_1\delta_2}{\beta_1^2\delta_2^2 + \delta_1^2}\varepsilon_1 + \frac{1}{\delta_2}\left(a_2 - a_2^f - s_2 + \varepsilon_2\right). \tag{25}
$$

We have assumed that $E(a_t) = a_t^f$ for $t = 1, 2$, where a_t^f is the central bank's forecast, $E(s_t) = 0$ and ε_t is a white-noise disturbance. As a result the magnitude of the control errors does not depend on the data availability and is given by:

$$
E\left[i_1\left(m_2^{**}\right) - i\right] = E\left[i_1\left(\widehat{m}_2^{**}\right) - i\right]
$$
$$
= \frac{\delta_1}{\beta_1^2\delta_2^2 + \delta_1^2}\left[(\beta_1\delta_2 - \delta_1)i + (1 - \beta_1\alpha_2)a_1^f\right.
$$
$$
\left. + (\gamma_1 - \beta_1\gamma_2)R\right] \tag{26}
$$

$$\mathrm{E}\left[i_2(m_2^{**}) - i\right] = \mathrm{E}\left[i_2\left(\widehat{m}_2^{**}\right) - i\right]$$

$$= -\frac{\beta_1 \delta_2}{\beta_1^2 \delta_2^2 + \delta_1^2}\left[(\beta_1 \delta_2 - \delta_1)i + (1 - \beta_1 \alpha_2)a_1^f\right.$$

$$\left. + (\gamma_1 - \beta_1 \gamma_2)R\right] \tag{27}$$

which can deviate from zero.

However, the size of required reserves is also determined by the central bank, and here the importance of this instrument is clearly shown:

Proposition 1 *The control errors, i.e. average deviations of market interest rates from the target due to infrequent open market operations, can be reduced if required reserves are set according to:*

$$R(m_1^{**}) = \frac{(\delta_2 - \alpha_2 \delta_1)i + (\beta_1 \alpha_2 - 1)a_2^f}{\gamma_1 \alpha_2 - \gamma_2} \tag{28}$$

for the operations carried out at the beginning of the reserve maintenance period, and

$$R(m_2^{**}) = \frac{(\beta_1 \delta_2 - \delta_1)i + (1 - \beta_1 \alpha_2)a_1^f}{\gamma_1 - \beta_1 \gamma_2} \tag{29}$$

for the operations carried out at the end of the maintenance period.

Proof. See (12) and (13): $\mathrm{E}\left[i_1(m_1^{**}) - i\right] = \mathrm{E}\left[i_2(m_1^{**}) - i\right] = 0$ if $\delta_2 - \alpha_2 \delta_1 = \beta_1 \alpha_2 - 1 = \gamma_1 \alpha_2 - \gamma_2 = 0$ or $R = R(m_1^{**})$. Similarly ((17) and (18)): $\mathrm{E}\left[i_1(m_2^{**}) - i\right] = \mathrm{E}\left[i_2(m_2^{**}) - i\right] = 0$ if $\beta_1 \delta_2 - \delta_1 = 1 - \beta_1 \alpha_2 = \gamma_1 - \beta_1 \gamma_2 = 0$ or $R = R(m_2^{**})$.

Furthermore, an effective use of required reserves, i.e. setting the requirements at the appropriate level (given by (19) and (20)), affects the overnight volatility, and allows the central bank to limit the frequency of interventions in the reserve market without a significant increase in the volatility of interest rates:

Proposition 2 *1. If the control errors are eliminated, then the volatility of overnight interest rates does not increase with the reduction in the frequency of open market operations. It is therefore possible to limit the frequency of central bank's interventions in the reserve market without a significant increase in the volatility of interest rates.*
2. The availability of real-time data on the liquidity conditions throughout the maintenance period is likely to represent an additional factor dampening the excess

volatility of overnight interest rates associated with a reduction in the frequency of open market operations.

Proof. The volatility of overnight interest rates under the multiple operations' strategy $L(m_1^*, m_2^*)$ is given by:

$$L(m_1^*, m_2^*) = \mathrm{E}\left\{[i_1(m_1^*, m_2^*) - i]^2 + [i_1(m_1^*, m_2^*) - i]^2\right\}$$

$$= \frac{\delta_2^2 + \delta_1^2(\alpha_2^2 + 1)}{\delta_1^2 \delta_2^2}\sigma_a^2 + \frac{\delta_2^2 + \alpha_2^2 \delta_1^2}{\delta_1^2 \delta_2^2}\sigma_{s_1}^2 + \frac{1}{\delta_2^2}\sigma_{s_2}^2 + \frac{\delta_2^2 + \delta_1^2}{\delta_1^2 \delta_2^2}\sigma_\varepsilon^2. \qquad (30)$$

The corresponding loss in the case when open market operations are carried out solely on the first day of the reserve maintenance period is given as:

$$L(m_1^{**}) = L(m_1^*, m_2^*) + \frac{1}{\delta_2^2 + \alpha_2^2 \delta_1^2}$$

$$\times \left[(\delta_2 - \alpha_2 \delta_1)i + (\beta_1 \alpha_2 - 1)a_2^f + (\gamma_1 \alpha_2 - \gamma_2)R\right]^2 \qquad (31)$$

whereas the loss incurred when the operations take place on the second day of the reserve maintenance period is given as:

$$L(m_2^{**}) = L(m_1^*, m_2^*) + \frac{1}{\beta_1^2 \delta_2^2 + \delta_1^2}$$

$$\times \left[(\beta_1 \delta_2 - \delta_1)i + (1 - \beta_1 \alpha_2)a_1^f + (\gamma_1 - \beta_1 \gamma_2)R\right]^2. \qquad (32)$$

Therefore, if $R = R(m_1^{**})$ ($R = R(m_2^{**})$), then $L(m_1^{**}) = L(m_1^*, m_2^*)$ ($L(m_2^{**}) = L(m_1^*, m_2^*)$).

The use of real-time information affects the *ex ante* expected volatility loss: $L(\widehat{m}_2^{**})$ is given by:

$$L(\widehat{m}_2^{**}) = L(m_2^{**}) + \frac{\beta_1^2 \delta_2^2}{(\beta_1^2 \delta_2^2 + \delta_1^2)^2}\sigma_\varepsilon^2$$

$$+ \left\{\left[\frac{\beta_1 \delta_2(\beta_1 \alpha_2 - 1)}{\beta_1^2 \delta_2^2 + \delta_1^2}\right]^2 - \frac{\alpha_2^2}{\delta_2^2}\right\}\left(\sigma_a^2 + \sigma_{s_1}^2\right). \qquad (33)$$

Since $\left(\left\{[\beta_1 \delta_2(\beta_1 \alpha_2 - 1)]/(\beta_1^2 \delta_2^2 + \delta_1^2)\right\}^2 - (\alpha_2^2/\delta_2^2)\right) - [\beta_1^2 \delta_2^2/(\beta_1^2 \delta_2^2 + \delta_1^2)^2] = -\alpha_2(2\beta_1^3 \delta_2^4 + 2\alpha_2 \beta_1^2 \delta_2^2 \delta_1^2 + \alpha_2 \delta_1^4)/(\beta_1^2 \delta_2^2 + \delta_1^2)^2 \delta_2^2 \leq 0$, then (unless σ_ε^2 is much larger than $(\sigma_a^2 + \sigma_{s_1}^2)$), $L(\widehat{m}_2^{**}) < L(m_2^{**})$.

The second part of Proposition 2 leads to an immediate result:

Proposition 3 *Foregoing open market operations at the beginning of the reserve maintenance period is likely to yield lower excess overnight volatility than foregoing operations at the end of the maintenance period.*

Proof. The difference between the losses in terms of excess overnight volatility due to limited frequency of open market operations is given as:

$$
L(m_1^{**}) - L(m_2^{**}) = \frac{1}{\delta_2^2 + \alpha_2^2 \delta_1^2} \left[(\delta_2 - \alpha_2 \delta_1)i + (\beta_1 \alpha_2 - 1)a_2^f \right.
$$

$$
\left. + (\gamma_1 \alpha_2 - \gamma_2)R \right]^2
$$

$$
- \frac{1}{\beta_1^2 \delta_2^2 + \delta_1^2} \left[(\beta_1 \delta_2 - \delta_1)i + (1 - \beta_1 \alpha_2)a_1^f \right.
$$

$$
\left. + (\gamma_1 - \beta_1 \gamma_2)R \right]^2 .
$$

If we assume $1/(\delta_2^2 + \alpha_2^2 \delta_1^2) \geq 1/(\beta_1^2 \delta_2^2 + \delta_1^2)$ then for control errors of comparable magnitude, $L(m_1^{**}) \geq L(m_2^{**}) \geq L(\widehat{m}_2^{**})$.

Discussion

The model predicts that average control errors in the US should be smaller than in the euro area since the Federal Reserve intervenes every day. These conclusions are supported by the empirical evidence, reported in Table 9.4. Annual average deviations of the federal funds rate from the target are hardly ever significantly different from zero. The average control errors in the management of the overnight interest rate in the euro area are always significantly different from zero, although their magnitude is very small.

Nevertheless, it is the overnight volatility which we are mostly concerned about. Our results suggest that comparable levels of overnight interest-rate volatility in the euro area and in the United States are due an appropriate use of required reserves. Table 9.5 presents average levels of required reserves in comparison to

Table 9.4 Average interest-rate control errors in the euro zone and the US

	Eonia	*t-statistic*	*FF rate*	*t-statistic*
1999	0.026	2.189	−0.006	−0.568
2000	0.109	11.786	0.018	2.444
2001	0.090	6.375	−0.014	−1.113
2002	0.068	8.588	−0.002	−0.475

Table 9.5 Required reserves and autonomous factors in the euro area and the USA

	Euro area (EUR bln)			USA (USD bln)		
	R	a_t^f	R/a_t^f	R	$E(a_t)^1$	$R/E(a_t)$
1999	101.69	84.34[2]	1.206	41.63	536.75	0.008
2000	111.64	113.26	0.986	38.95	571.62	0.007
2001	123.73	94.86	1.304	38.45	601.49	0.006
2002	129.88	54.30	2.392	38.76	654.36	0.006

Notes:
1. Currency in circulation. In: the United States the net value of other autonomous factors but currency is close to zero; see Board of Governors of the Federal Reserve System (2001).
2. The actual average.

average levels of net autonomous factors in Europe and in the United States over the years 1999–2001.

Comparing this table with the overnight volatility numbers (reported in Table 9.2), we can conclude that a unique ratio of average required reserves and the average of forecasted autonomous factors yielding the best results in terms of reducing the excess overnight volatility seems to exist: R/a_t^f close to 1.25. The results of our analysis indeed confirm that such a ratio should exist. Moreover, the empirical ratio corresponds surprisingly well to average of the model-implied ratios:[22] $(1/2)\left\{\left[\partial R(m_1^{**})/\partial a_2^f\right] + \left[\partial R(m_2^{**})/\partial a_1^f\right]\right\} = 1.3957$.

Although we have to acknowledge that our findings are based on certain simplifications *vis-à-vis* actual practices (e.g. an implicit treatment of averaging provisions) we were still able to address interesting policy-related issues regarding the factors affecting the overnight volatility. We have identified the crucial factor reducing the overnight volatility in the euro area and bringing it in line with the overnight volatility in the United States: the appropriate level of required reserves implemented by the European Central Bank.

Appendix

Inventory-theoretic approach to the demand for reserves

In this section we seek to provide very simple micro-foundations for the error correction mechanism given by (3). Let us assume that a representative commercial bank wants to minimize the discounted cost of holding reserves over the reserve maintenance period of length T, given as the sum of the following components:

1. opportunity cost

$$\sum_{t=1}^{T} \delta^t i_t r_t$$

where δ is the discount factor, i_t is the overnight interest rate and r_t is the level of reserves

2. cost of having excess reserves on the last day of the maintenance period

$$(i_T - i_d)\delta^T \left[\left(\frac{1}{T} \sum_{t=1}^{T} r_t - R \right) + x \right] \Pr \left(\frac{1}{T} \sum_{t=1}^{T} r_t + x > R \right)$$

3. cost of being short of reserve requirements on day T

$$i_f \delta^T \left[x + \left(\frac{1}{T} \sum_{t=1}^{T} r_t - R \right) \right] \Pr \left(\frac{1}{T} \sum_{t=1}^{T} r_t + x < R \right)$$

where x is the liquidity shock on the last day of the maintenance period.

If we assume that this shock is uniformly distributed over $[-M, M]$ (where negative (positive) values correspond to an unexpected outflow (inflow) of liquidity), the bank is facing the following costs:

$$TC = \sum_{t=1}^{T} \delta^t i_t r_t + (i_T - i_d)\delta^T \left[\left(\frac{1}{T} \sum_{t=1}^{T} r_t - R \right) + x \right] \Pr \left(\frac{1}{T} \sum_{t=1}^{T} r_t + x > R \right)$$

$$+ i_f \delta^T \left[x + \left(\frac{1}{T} \sum_{t=1}^{T} r_t - R \right) \right] \Pr \left(\frac{1}{T} \sum_{t=1}^{T} r_t + x < R \right)$$

$$= \sum_{t=1}^{T} \delta^t i_t r_t + \frac{1}{4} (i_T - i_d) \delta^T$$

$$\times \frac{M^2 T^2 - 3 \left(\sum_{t=1}^{T} r_t \right)^2 + 6 \left(\sum_{t=1}^{T} r_t \right) RT - 3R^2 T^2 + 2 \left(\sum_{t=1}^{T} r_t \right) MT - 2RT^2 M}{MT^2}$$

$$- \frac{1}{4} i_f \delta^T \frac{M^2 T^2 - 3 \left(\sum_{t=1}^{T} r_t \right)^2 + 6 \left(\sum_{t=1}^{T} r_t \right) RT - 3R^2 T^2 - 2 \left(\sum_{t=1}^{T} r_t \right) MT + 2RT^2 M}{MT^2}.$$

The First Order Condition with respect to time-t reserve holdings is given as:

$$\frac{\partial f}{\partial r_t} = \delta^t i_t - \frac{1}{4} i_f \delta^T \frac{-6 \left(\sum_{t=1}^{T} r_t \right) + 6RT - 2MT}{MT^2}$$

$$+ \frac{1}{4} (i_T - i_d)\delta^T \frac{-6 \left(\sum_{t=1}^{T} r_t \right) + 6RT + 2MT}{MT^2} = 0$$

which results in the following expression:

$$\frac{1}{T}\left(\sum_{t=1}^{T} r_t\right) = -\frac{2}{3}\frac{MT}{\delta^{T-t}\left(i_f + i_d - i_T\right)}i_t + R - \frac{1}{3}M\frac{i_T + i_f - i_d}{i_f + i_d - i_T}.$$

Therefore

$$r_t + r_{t-1} + r_{t+1} = -\frac{2}{3}\frac{MT^2}{\delta^{T-t}\left(i_f + i_d - i_T\right)}i_t + TR - \frac{1}{3}MT\frac{i_T + i_f - i_d}{i_f + i_d - i_T}$$

$$- \sum_{s\neq\{t,t-1,t+1\},s=1}^{T} r_s.$$

It follows that the relationship between day-t reserves and other variables in the model is:

$$\frac{\partial r_t}{\partial r_{t-1}} < 0,\ \frac{\partial r_t}{\partial r_{t+1}} < 0,\ \frac{\partial r_t}{\partial R} > 0,\ \frac{\partial r_t}{\partial i_t} < 0.$$

Regression results[23]

The regressions were carried out on weekly data on the ECB's operations for 1999–2001. The reserve maintenance period was divided into two 2-week sub-periods. The series used were: the average current accounts during the first two weeks (r_t^1), the average current accounts during the last two weeks (r_t^2), the required reserves (R) and average Eonia rate during the first and the last two weeks of the reserve maintenance period (i_t^1 and i_t^2, respectively).

Series	Mean	StDev	ADF test statistic	Unit Root
r_t^1	11.89604	0.989459	−1.354202	*Yes*
r_t^2	11.79642	1.249543	−1.149758	*Yes*
R	11.74642	1.090253	−1.290094	*Yes*
i_t^1	3.676041	0.777347	−2.353858	*Yes*
i_t^2	3.632088	0.825898	−2.477763	*Yes*

The VAR estimation[24] yields the following coefficients for first sub-period of the maintenance period; (standard errors) and [t-statistics]:

α_1	β_1	γ_1	δ_1
0.381094	0.775794	2.153058	0.223444
(0.17963)	(0.12214)	*NA*	(0.15687)
[2.12150]	[6.35149]	*NA*	[1.42440]

For the second sub-period of the maintenance period the estimated VAR coefficients were:

α_2	β_2	γ_2	δ_2
0.688416	0.177981	1.688416	0.048781
(0.09902)	(0.11218)	*NA*	(0.10721)
[6.95210]	[1.58658]	*NA*	[0.45500]

Both coefficients on interest rate in the first and second sub-periods of the reserve maintenance period in the euro zone are barely statistically significant, although they are of the correct sign.

Notes

* I am very grateful to Jan Marc Berk, Job Swank, Ulrich Bindseil, Martin Schüler and anonymous referees for useful comments on earlier drafts. The author gratefully acknowledges support from the European Community's Phare ACE Programme 1998. The content of the publication is the sole responsibility of the author and it in no way represents the views of the Commission or its services. Views expressed are those of the author and do not necessarily reflect the position of De Nederlandsche Bank.

1 With the exception of Hardy (1997), who examines the consequences of an informational advantage on the side of reserve market participants versus the central bank.

2 Overnight interest rates can be steered through a (tight) corridor between the rates on standing facilities. Creating an interest rate corridor might be a very efficient way of steering overnight interest rates. This approach, however, may practically eliminate the market for short-term liquidity; see also Davies (1998).

3 For a comprehensive discussion, see Borio *et al*. (2001) or Borio (1997).

4 In the case of Japan, since March 2006.

5 The model builds on the work developed in the European Monetary Institute in the preparatory phase for the Stage Three of the Economic and Monetary Union.

6 The regular main refinancing operations in the case of the ECB. We will ignore ad hoc operations (structural and fine-tuning) and the longer-term refinancing operations, which (by construction) are carried out only once per maintenance period.

7 Data on the ECB's balance sheet indicate that reserves held by the banking sector have, on average, constituted around 54.7% and net autonomous factors 45.0% of liabilities. On the assets' side, 73.6% of liquidity was provided via main refinancing operations and 26.1% via longer-term operations. The deposit and lending facilities accounted for around 0.3% of assets and liabilities, respectively (European Central Bank 2002).

8 This assumption seems justifiable, since the annual averages of ECB's forecasts were approximately equal to the averages of actual autonomous factors (for 2001 and 2002).

9 This characteristic seems to be in line with the averaging provision.

10 See e.g. Swank (1995), Bindseil (2000) and Borio *et al*. (2001). In our model $(\partial r_t / \partial i_{t+1}^e) = (\partial r_t / \partial r_{t+1}^e)(\partial r_{t+1}^e / \partial i_{t+1}^e) = -\beta_t(-\delta_{t+1}) > 0$ if $\beta, \delta > 0$.

11 Ideally, we should have estimates for the United States as well. However, for the US, the data regarding the sub-periods within a single maintenance period are not available.

12 The results were obtained by splitting the reserve maintenance period into two 2-week sub-periods. For further details, see Appendix.

13 See e.g. Ayuso and Repullo (2003), Bartolini *et al*. (2001), Bindseil (2000), Perez-Quirós and Rodríguez Mendizábal (2001) and Välimäki (2002).

14 See e.g. Bartolini *et al.* (2002) and Furfine (1998).
15 Averaging is justified in the case of the euro area but problematic in the case of the United States.
16 r_0 is the level of reserves held in the preceding maintenance period and r_3^e is the expected level of reserves on the first day of the following maintenance period.
17 Derived from $[E(r_1) + E(r_2)]/2 = R$, where r_1 and r_2 are given by (3).
18 ρ denotes the ratio of interest rates elasticities: $\rho = \delta_1/\delta_2$. If $\delta_2 \to 0$ then $\rho \to \infty$. $\rho = 4.4$ corresponds to the parameters presented in Table 9.3.
19 Or $(a_1 - s_1)$ in the case of $\hat{m}_2^{**}$.
20 So that the Tinbergen principle of one instrument–one goal (one intervention-stabilizing interest rate in one sub-period) is satisfied.
21 Thereby removing one of the instruments, but leaving two objectives.
22 Calibrated using the values reported in Table 9.3.
23 I am very grateful to my colleagues, Robert Paul Berben, Jan Marc Berk and Philipp Maier, for their invaluable help.
24 The stationary variables used were the excess reserves (i.e. $r_t - R$) and first differences of interest rates.

Comment

Ulrike Neyer

The starting point of the chapter is that a central bank wants to minimize deviations from its interest rate target in the interbank money market. The main question raised is whether the frequency of the central bank's operations play an important role in achieving this goal. The author refers to the Federal Reserve System and the Eurosystem. The former intervenes in the interbank money market daily, the latter only weekly. However, empirical analyses do not show that the deviations of the interbank market rate from the central bank's target are smaller in the US than in the euro area. The author argues that a reason may be the buffer function of minimum reserves, i.e. not only is the frequency of the central bank's operations in the interbank market decisive for having a low volatility in the interbank market rate, but so also is the ratio between minimum reserves and autonomous factors. An adequate ratio can absorb liquidity shocks so that daily interventions by the central bank in the interbank market are not necessary.

Overview of the theoretical model

The author employs a model of a reserve market to present the idea theoretically. The supply side consists of the reserves supplied by the central bank (open market operations m and net standing facilities) minus autonomous factors. The banks' demand for reserves in period t depends on the reserves of the period $t-1$, expected reserves for the next period $t+1$, the interbank market rate and a liquidity shock. The author derives the demand for reserves from an inventory theoretical model, in which the optimal holdings of required reserves of a single bank are analysed. She shows that the bank's optimal holdings of reserves depend on the opportunity costs, captured by the interbank market rate, expected costs of having excess reserves and expected costs of being short of reserves on the last day of a reserve maintenance period. The author considers a maintenance period of two periods, determines optimal reserve holdings for both periods, inserts the results into the supply equation and solves the model for the interbank market rate. Then she models the loss function of the central bank in which the central banks will face a loss if the interbank market rate deviates from the central bank's target. She minimizes the loss function over the open market operations m. The results of

her theoretical model are: with multiple open market operations (the central bank intervenes twice in the interbank market) the central bank is able to keep on average to the target, while with single open market operations (the central bank intervenes only once) the monetary authority is not able to keep to the target on average. The reason is obvious: it cannot react to new information. However, the author argues that the problem can be reduced by an appropriate reserve ratio.

Problems and questions

While I very much liked the idea of the analysis with the emphasis on the buffer function of reserve requirements, I have some major problems with the design of the theoretical model.

The inventory theoretical model is the base for the demand side of the reserve market. In that model, the interbank market rate plays a crucial role for the bank's optimal holdings of reserves. However, in the euro area, which is the area the author refers to, reserves are remunerated at a rate close to the interbank market rate, so that the opportunity costs of holding reserves should be negligible. However, in the whole theoretical part of the chapter these opportunity costs of holding reserves play a crucial role; they imply that aggregate demand for reserves depends on the interbank market rate.

A further ingredient in the inventory theoretical model is the cost of being short of or having excess reserves on the last day of the maintenance period. This is the case if the bank must borrow from the central bank on the last day of the maintenance period (at a high rate) or must put liquidity into the deposit facility (at a low rate) on the last day. However, in the model a single bank is considered. So my question is: Why can't this bank transact in the interbank market on the last day? If this is not possible, there must be some sort of friction, as, for example, in Bartolini *et al*. (2001) or Furfine (2000). However, in the chapter no frictions are mentioned. Another possibility is that there is an aggregate liquidity shock, which is also not mentioned. The demand for reserves is derived from the inventory theoretical model, in which a single bank is considered. Nothing is said about the kind of aggregation used to derive the aggregate demand for reserves in the reserve market model.

A final point concerns the equilibrium interbank market rate. According to the author, the actual interbank market rate i_t can be anywhere between the rate on the deposit facility (i^d) and the credit facility (i^f) if it is not equal to the central bank's target rate i. However, what is the intuition for $i^d < i_t < i^f$ and $i_t \neq i$? If there are no frictions, i.e. if markets are perfect, i_t should equal the target i if there is no liquidity shock, or it should be equal to i^d or i^f if a liquidity shock implies that there is excess liquidity or a liquidity shortage in the market.

Suggestion

I think the theoretical model can be kept much simpler to capture the core ideas. In what follows I will give two numerical examples which may be transformed rather easily into such a simpler theoretical model. A starting point may be the

Table 9.6 Buffer function of minimum reserves works

	Reserve maintenance period			
	1	2	3	4
A^f	300	300	300	300
R	100	100	100	100
2 Interventions				
M	**400**	→	**425**	→
A^r	350	300	300	300
R^r	50	100	125	125
Faci	***0***	***0***	***0***	***0***
i	i^{target}			→
4 Interventions				
M	**400**	**450**	**400**	**400**
A^r	350	300	300	300
R^r	50	150	100	100
Faci	0	0	0	0
i	i^{target}			→

symmetric corridor approach as in Bindseil (2004b, chapter 3.4). The examples are given in Tables 9.6 and 9.7. In the first example, the buffer function of the minimum reserves works, in the second it does not, and we will see which role the frequency of central bank's interventions plays in this context.

We will look at the example in which the buffer function works first (Table 9.6). There is a reserve maintenance period, divided into four subperiods. Aggregate liquidity needs of the banking sector arise from autonomous factors and reserve requirements. The central bank's forecast of autonomous factors A^f are given in the first line, required reserves in the second. It is important that these reserve

Table 9.7 Buffer function of minimum reserves does not work

	Reserve maintenance period			
	1	2	3	4
A^f	300	300	300	300
R	100	100	100	100
2 Interventions				
M	**400**	→	**450**	→
A^r	450	300	300	300
R^r	0	100	150	150
Faci	***50***	***0***	***0***	***0***
i	i^f	i^{target}		→
4 Interventions				
M	**400**	**500**	**400**	**400**
A^r	450	300	300	300
R^r	0	200	100	100
Faci	50	0	0	0
i	i^f	i^{target}		→

requirements can be fulfilled on average over the reserve maintenance period. We distinguish between two cases concerning the frequency of the central bank's interventions. In the first case, it intervenes twice (in period one and in period three), in the second case it intervenes in each period, i.e. four times. The sum of the forecast of the autonomous factors and reserve requirements induces the central bank to supply 400 units liquidity to the banking sector. However, after the central bank's intervention a negative liquidity shock occurs. Actual autonomous factors A^r are not 300, but 350 units. However, in both cases this negative liquidity shock can be absorbed by the minimum reserves. The banking sector does not take recourse to the marginal lending facility, and the interbank market rate remains at the central bank's target throughout the maintenance period, since we assume that the banks know that the central bank will provide the liquidity needed for fulfilling reserves in that maintenance period when it intervenes in the interbank market the next time.

The numerical example given in Table 9.7 shows what will happen if the buffer function of the minimum reserves is not effective. This occurs if the liquidity shock is so large that it cannot be absorbed by the minimum reserves. Then the banking sector must have recourse to the marginal lending facility and the interbank market rate will increase to the rate of the marginal lending facility i^f, independently of the number of interventions. Note that the shock occurs in the first period only.

This means there can only be three values for the equilibrium interbank market rate:

 (i) If there is enough aggregate liquidity, i.e. if a shock occurs it can be absorbed by the minimum reserves, despite the liquidity shock, the equilibrium interbank market rate will be equal to the central bank's target rate.
 (ii) If there is a shock implying that there is too much liquidity so that banks take recourse to the marginal deposit facility the rate will be equal to this deposit rate, and if there is a liquidity shortage, the rate will be equal to the rate on the lending facilities (F denotes the facilities; if $F > 0$, the banks will take recourse to the marginal lending facility, if $F < 0$, they will put liquidity into the marginal deposit facility):

$$i = \begin{cases} i^{target} & if \quad F = 0 \\ i^d & if \quad F < 0 \quad \text{where } F(A^f, R, \text{liquidity shock}). \\ i^f & if \quad F > 0, \end{cases}$$

Thus we can conclude that if the ratio between R and A^f is so high that the buffer function of the minimum reserves works, the frequency of the central bank's operations has no impact on the volatility of the interbank market rate. If the buffer function does not work, a higher frequency will only reduce the volatility of the interbank market rate if (a) the liquidity shock occurs in the third period or (b) if the shock occurs in the first period but lasts into the second period. In these cases, the central bank can react to the new information if it intervenes more often in the interbank market.

10 Money market volatility – A simulation study

Michal Kempa[1]

The view that the central bank (CB) exerts an influence over the economy by using interest rates as a direct tool has now been widely accepted for some time. The exact mechanism of control over the interest rate or the, so-called, operational policy has, however, attracted much less attention and is very often taken for granted. This particular research niche has recently seen some revived interest, resulting in a series of publications; however, many questions still remain open.

Operational policy targets the level and volatility of the interbank market interest rates; the basic instruments at the CB's disposal include: an obligatory reserve requirement, open market operations (OMO) and lending/deposit facilities. So far no golden rule for effective operational policy mix has been found. Indeed, countries around the world have decided in favour of very different setups and none of them can claim perfect control, even though most are successful in setting rates at target levels in the long term. There are several issues to consider, such as the balance between intensity (or willingness) of the central bank intervention and the volatility of interest rates. Still, countries using similar tools experience systematic patterns of interest-rate behaviour, overcoming country-specific features. For example, a system with an averaging reserve requirement, infrequent (i.e. not daily) open market operations and a wide channel of standing facilities (similar to the one present in the Eurozone and the US) apparently experiences fairly low volatility during the maintenance period but risks regular spikes around the end of the periods (see Figure 10.1 that presents the time series of target and market rates). On the other hand, countries such as Canada or Sweden, supplying the liquidity through daily OMO and narrow standing facilities rates (thus running a more active policy) enjoy much less volatility of interest rates at the cost of a less active interbank market and a higher degree of central bank intervention (see Figure 10.1). Somewhere in the middle is the UK with its system of a one-day maintenance period and daily interventions (since changed towards the Eurozone/US approach).

The similarities in patterns of interest-rate behaviour between markets as different as the US and the European raise several research questions. What is the impact of different aspects of operational policies on the behaviour of the money market? How does the volatility of interest rates change when a different mix of
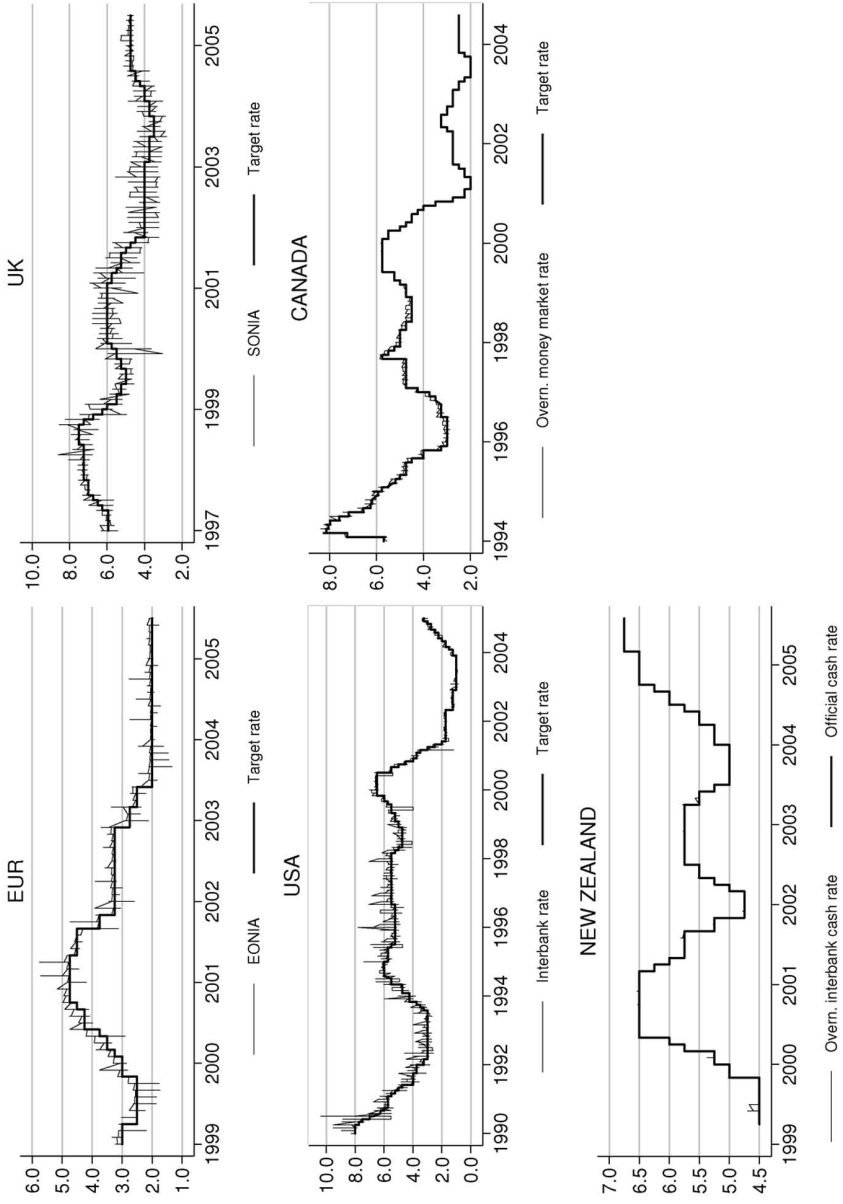
Figure 10.1 Target and money market interest rates.

the operational policy instruments is applied? What is the impact on the central bank standing facilities to be used? Suppose the central bank commits to a specific policy – what is the volume of open market operations that would keep the rates on target? The usual approach is to target aggregate liquidity, without consideration of the individual shock distribution across banks. What if the information about the distribution were actually included in the decision process? The following addresses those questions.

Despite its central position in the central bank policy, the money market has only recently started to attract an appropriate amount of attention. An excellent and extensive introduction to the field is presented by Bindseil (2004b). Hamilton (1996) expressed formally one of the most fundamental hypotheses related to the market: money market funds should be perfect substitutes in all days of the reserve requirement period, which implies the interest rates should satisfy the martingale property. He then analysed the data series for the US and found it did not hold, which sparked a lot of research on that topic. Most of this was based on a single bank's profit-maximizing behaviour in a general equilibrium setup, in the spirit of Poole (1968). For the Eurosystem an interbank model was designed in (Pérez-Quirós and Rodríguez-Mendizábal 2001; Gaspar *et al.* 2004). Analogous references for the USA are Bartolini *et al.* (2001, 2002); both analyses, however, are strictly tailored to country-specific features. They have concentrated on the volatility of the interbank interest rates in different stages of the maintenance period as a phenomenon crucially dependent on the obligatory reserve requirement. In these models the emphasis is on the commercial bank's behaviour, while the role of the central bank as the initial supplier of the liquidity is very often simplified by assuming the starting assets as given.

Models that overcome these limitations were created by Välimäki (2003) and Moschitz (2004), where the supply of the funds by the central bank is included as well. Those papers do not, however, explore the details of the optimal level of liquidity. The model which is closest to mine is Bartolini and Prati (2003), where they investigate market volatility under a spectrum of different policies for liquidity supply, using similar methods. In their model OMOs take place every day, with their volume chosen so to minimize the deviation from the target rate. Without any restrictions that approach leads to full control over the rates, which is not realistic. That result is replicated as one of the sub-cases in this study as well. To bring their study a bit closer to reality then, they constrain the central banks actions by introducing some arbitrary limits on the volume of the interventions. In this chapter a different approach is used where the central bank is restricted by the operational policy details (such as timing or frequency of OMO) rather than its ability to offset liquidity shocks. Bartolini and Prati (2003) do not also analyse the impact of periodic OMO or effects of the policy setting neutral liquidity.

Finally the regime where the banks have different maintenance period dates has been discussed only in Cox and Leach (1964) but without rigorous analysis.

This chapter contributes to the existing research in several ways. First, it simulates the behaviour of money markets under different regimes within one framework. This provides an opportunity for a clear comparison of policy

performance measured in terms of the use of the standing facilities or volatility of interest rates.

Second, active central bank liquidity supply policy provides a benchmark against which neutral market liquidity targeting can be compared.

Third, the regime with overlapping maintenance periods has not been properly examined before in the literature, while it is a potentially very interesting case combining some of the benefits and costs of existing policies.

This study is structured in the following way. It starts with the basic model structure, then adds details on the liquidity demand (commercial banks) and supply (central bank) side of the market. The results for different simulations follow before drawing conclusions.

Model overview

Every day banks are involved in scores of transactions, resulting in changes of their own as well as market liquidity. From the perspective of individual banks some can be predicted in advance with a fairly good accuracy – an example would be maturing securities – but others constitute a stochastic shock. The money market in this world is used to help to manage liquidity and moderate the liquidity shocks. The banking market is governed by standard economic rules, where excess liquidity depresses the interest rate and shortage of free funds drives it up. A policy targeting the level of the interest rates can therefore be implemented through channels that control the market liquidity.

The market liquidity is settled during open market operations before the interbank trade is closed, which is incorporated in the structure of the model by using a simple two-stage framework. In the early stage the central bank sets the value of market liquidity and, in the later one, banks trade excess resources at the market rate. More specifically the timing of events in the market is as follows:

1. A commercial bank starts the day with a balance at the CB account m_t.
2. Open market operations start; as a result, the bank's current-account balance changes by θ_t.
3. An early stochastic shock ε_{1t} occurs
4. The interbank money market opens with banks trading assets b_t at a market clearing interest rate i_t.
5. A late stochastic shock ε_{2t} occurs after no more trading is possible. After that, the final bank balance in the central bank is calculated, and that constitutes the opening balance for the next day. Depending on the sign, the bank automatically refers to either the deposit or the lending facility.

$$\underrightarrow{m_{t,1} \qquad \theta_t \qquad \varepsilon_{1t} \qquad b_t \qquad \varepsilon_{2t} \qquad m_{t+1,1}}$$

Combining the steps 1–5 results in the following difference equation:

$$m_t = m_{t-1} + b_t + \theta_t + \varepsilon_t \tag{1}$$

where m_t denotes the assets in the central bank, b_t denotes net change in interbank lending, θ_t is the balance of open market operations and $\varepsilon_t = \varepsilon_{1t} + \varepsilon_{2t}$ is the sum of stochastic shocks during a day.

The shocks capture the imperfect information that is faced by both central bank and commercial banks and here are assumed to have the same variance σ. One of the shocks, ε_{1t}, apart from shifting the liquidity between banks also has an aggregate impact on the market. In real life this occurs whenever there is a change in balance of so called autonomous liquidity factors[2] such as currency balances or government accounts. The other shock, ε_{1t}, is idiosyncratic and reflects the balance of transactions performed between banks during the day.[3] They satisfy $\sum_{i=1}^{n} \varepsilon_{1ti} \neq 0$ and $\sum_{i=1}^{n} \varepsilon_{2ti} = 0$.

The interbank trade is driven by profit-maximizing banks that cash the profits on lending but are subject to two constraints:

1. The end-of-the-day balance at the central bank account must stay non-negative – otherwise, the bank is automatically forced to use the central bank lending facility
2. An average level of reserve requirement must be satisfied throughout the maintenance period.

More detailed explanation is included in the following section, but it might be useful to look into the one-period commercial bank expected profit function:

$$\Pi_t = i_t b_t - \mathrm{E}_t(c_t) \tag{2}$$

where i_t denotes the interbank interest rate, b_t bank choice of lending value and $\mathrm{E}_t(c_t)$ is the expected cost of using the standing facilities after the final liquidity shock arrives. The profit maximization problem has to be solved in an environment with stochastic liquidity shocks (denoted ε_t before). Note that from the bank's perspective the early shock is less interesting, since it can be offset through interbank trade. However, any mistakes in calculations of the late shock force the bank to use costly standing facilities.

The central bank's goal is to keep the market interest rates as close to the target as possible. To achieve this, it supplies the liquidity both actively, using open market operations (denoted θ), and passively, using standing facilities. Depending on the monetary policy setup, the extent and frequency of open market operations may differ, but their value is set so as to keep the market rates on target. The deposit and lending facilities help the banks to manage the uncertainty. Should an individual bank's current account balance turn negative in the end of the day, the bank resorts to the (marginal) lending facility. If the account value exceeds the amount of reserve requirement, the bank places a deposit. The interest rates for standing facilities are accordingly i^l for lending and i^d for deposit and they are tied to the target by the assumption that the target rate $i^* = (i^l + i^d)/2$, i.e. lies exactly in the middle of the channel system (as is the case for example for the ECB).

In practice, the averaging provision reserve requirement means that the bank has to accumulate a fixed amount of funds on its account during the maintenance period. Denote this amount by R and the time t deficiency by d_t, d_t satisfies:

$$d_1 = R \tag{3}$$

$$d_i = \begin{cases} d_{i-1} & \text{if} \quad m_i < 0 \\ d_{i-1} - m_i & \text{if} \quad 0 < m_i < d_{i-1} \\ 0 & \text{if} \quad m_i > d_{i-1} \end{cases} \tag{4}$$

for any $T \geq i \geq 2$, where T is the end of the maintenance period. If $d_T > m_T + \varepsilon_T$ the bank does not satisfy its reserve requirement at the end of the day T, and it has to refer to the central bank standing facilities without extra penalty. There is no interest capitalization and the time span is only one maintenance period. It is assumed that there is no change in the regime or level of the target interest rate.

Demand side

This section presents the model of the commercial banks' behaviour in the inter-bank market. The section follows quite closely the work of Välimäki (2003) and Pérez-Quirós and Rodríguez-Mendizábal (2001).

No reserve requirement

Without a reserve requirement, there is no significant difference between different days. The situation is similar on the last day of the maintenance period in the regime with a reserve requirement. The expected profit function of the banks takes the one-period form

$$V_t = \max_{b_t} \mathrm{E}_t(\Pi_t) = \mathrm{E}_t(i_t b_t - c_t) \tag{5}$$

where $i_t b_t$ stands for the profit from interbank lending and $\mathrm{E}(c_t)$ denotes expected cost given by

$$\mathrm{E}(c_t) = i^l \left[\int_{-\infty}^{-m_t + b_t - \theta_t - \varepsilon_{1t}} (m_t - b_t + \theta_t + \varepsilon_t) f(\varepsilon_{2t}) \mathrm{d}\varepsilon_{2t} \right]$$

$$- i^d \left[\int_{-m_t + b_t - \theta_t - \varepsilon_{1t}}^{\infty} (m_t - b_t + \theta_t + \varepsilon_t) f(\varepsilon_{2t}) \mathrm{d}\varepsilon_{2t} \right] \tag{6}$$

where $f(\varepsilon_T)$ denotes the density function of the shock. The expected cost for an individual bank is calculated using the fact that whenever the negative liquidity

shock does not exceed the bank's current account balance at the end of the day (given by $m_t + \theta_t - b_t - \varepsilon_{2t}$), the remaining assets are remunerated at the i^d interest rate. Otherwise a bank is forced to use the borrowing facility at the rate i^l.

Using the Leibniz Rule and first-order conditions one arrives at the well-known result (Proof in Appendix A)

$$i_t = i^d + (i^l - i^d)F_{\varepsilon_{2t}}(b_t - m_t - \theta_t - \varepsilon_{1t}) \tag{7}$$

with $F_{\varepsilon_{2t}}(\cdot)$ as the associated distribution function of the ε_{2t} late shock. The inter-bank interest rate is equal to the expected cost of using the CB lending/borrowing facility. Equation (7) holds for all the banks and the inverse of normal distribution function $F_{\varepsilon_{2t}}^{-1}$ exists, so one can aggregate the equation to obtain the following result:

$$i_t = i^d + (i^l - i^d)F(-M_t - \Theta_t - \bar{\varepsilon}_{1t}). \tag{8}$$

Bank loans net to zero, $M_t = \sum_{i=1}^{n} m_t^i$ is the aggregate amount of funds in the account in the central bank in the beginning of a day and $\bar{\varepsilon}_{1t} = \sum_{i=1}^{n} \varepsilon_t^i$ is the aggregate shock value. This result indicates how the central bank, by controlling the aggregates, can influence the level of interest rates, without worrying about the distribution of assets across banks. This is a very strong result, giving support to the policies of several central banks that tend to use only aggregated liquidity information when calculating the allotment.[4] Note, however, that this holds only under fairly strong assumptions (identical distribution, no reserve requirement) that do not necessarily survive extensions into more general settings.

Before moving further, one last remark. The case described in this section has a straightforward extension to a regime with a reserve requirement but *without* an averaging provision (as hitherto in the United Kingdom). It is enough to add a constant term, equal to the required reserves, to the expression in $F(\cdot)$ in (8) in the last day of the maintenance period and leave the equations on other days unchanged.

Reserve requirement

Last day of maintenance period T

In the last day the situation is very similar to the case above, except for the reserve deficiency as an additional term d_T in the cost equation:

$$\mathrm{E}(c_T) = i^l \left[\int_{-\infty}^{-m_T + b_T + d_T - \theta_T - \varepsilon_{1t}} (m_T - b_T + d_T + \theta_T + \varepsilon_T)f(\varepsilon_{2T})\mathrm{d}\varepsilon_{2T} \right]$$
$$- i^d \left[\int_{-m_T + b_T + d_T - \theta_T - \varepsilon_{1t}}^{\infty} (m_T - b_T + d_T + \theta_T + \varepsilon_T)f(\varepsilon_{2T})\mathrm{d}\varepsilon_{2T} \right]. \tag{9}$$

Solving the first-order conditions associated with the optimization problem (5) explicitly gives the value of optimal borrowing at rate i_T:

$$i_T = i^d + (i^l - i^d)F(b_T + d_T - m_T - \theta_T - \varepsilon_{1T}). \tag{10}$$

This expression is essentially the same as (7) with the term d_T being the only difference. Note that since $d_T \geq 0$, the amount the bank is willing to lend at some interest rate level i, with the same asset m and OMO volume θ, will be lower in the regime with a reserve requirement than in that without. This result is quite intuitive but it has a direct implication. Once the equation is aggregated – as in the previous section – one gets

$$i_T = i^d + (i^l - i^d)F(D_T - M_T - \Theta_T - \bar{\varepsilon}_{1T}) \tag{11}$$

with the aggregate borrowing cancelled out. Now the interest rate is a function of large aggregates. Hence the following property holds. *In the last day of the maintenance period, the distribution of the individual shock among banks has no impact on the interest level and neutral market liquidity results in rates in the middle of the channel system.* Neutral liquidity is defined as the level of funds that will be just enough to satisfy the reserve requirement. The last part of the property stems from the normal distribution assumption ($F(0) = 1/2$) and is often used as a basis for the central bank liquidity supply policy. This issue is discussed in more detail later on.

Days before end of maintenance period $t < T$

Moving now to the earlier stages – the value function in Bellman's equation takes the form $V_t = \max_{b_t} E_t(\Pi_t + V_{t+1}) = \max_{b_t} E_t(i_t b_t - c_t + V_{t+1})$.

The interest rate that solves that problem for each individual bank can be shown (see Pérez-Quirós and Rodríguez-Mendizábal (2001) for proofs) to satisfy

$$i_t = \underbrace{i^l F(b_t - m_t - \theta_t - \varepsilon_{1t})}_{1.} + \underbrace{i^d [1 - F(b_t + d_t - m_t - \theta_t - \varepsilon_{1t})]}_{2.}$$

$$-\underbrace{\int_{b_t - m_t - \theta_t - \varepsilon_{1t}}^{b_t + d_t - m_t - \theta_t - \varepsilon_{1t}} \frac{\partial V_{t+1}}{\partial d_{t+1}} f(\varepsilon) d\varepsilon}_{3.} \tag{12}$$

and

$$\frac{\partial V_t}{\partial d_t} = -i^d [1 - F(d_t - m_t - \theta_t - \varepsilon_{1t})] + \int_{-\infty}^{d_t - m_t - \theta_t - \varepsilon_{1t}} \frac{\partial V_{t+1}}{\partial d_{t+1}} f(\varepsilon) d\varepsilon. \tag{13}$$

The intuition behind these results is as follows: marginal benefits (i_t) are equal to the weighted cost of:

(1) referring to the lending facility (when the shock exhaust all the funds at the current account),
(2) the deposit facility (the shock is high enough to exceed the required reserves) and
(3) the impact of decreased deficiency today on the profits in the future (the shock value keeps the balance positive but does not exceed the deficiency).

Contrary to the case without a reserve requirement, the optimal borrowing value cannot be calculated explicitly from (12). This means that the market clearing condition must be derived using numerical methods.

Recall the aggregation procedure used to calculate (8) for the last day of the maintenance period. The single market rate implies that the liquidity value ($b_T + d_T - m_T - \theta_T - \varepsilon_{1T}$) for all banks was the same, so the interbank market's only function (term b_t) was to equalize the liquidity among banks. That also allowed for easy aggregation and, with the assumption of a normal distribution for the shocks, the observation that neutral liquidity leads to the market rate being in the middle of the channel system. An inspection of (12) reveals that this is not the case any more in the periods preceding the end of the maintenance period. The banks will consider not only the current liquidity position, but also future implications. That reflects the phenomenon pointed out by Pérez-Quirós and Rodríguez-Mendizábal (2001): banks care about the *future* probabilities of referring to standing facilities, more specifically the increased probability of being forced to use the deposit facility once the reserve requirement buffer is lost. In some extreme cases (a bank hit by a series of shocks) the last term might be much more important than current liquidity, which might have profound consequences for the value market liquidity that would set the rates on target. These issues must be taken into consideration when designing the optimal policy setup.

Different settlement dates

Finally, I also want to look into the case where banks are required to maintain the reserve requirement during a maintenance period, but the end of the period is different for the groups of banks. That would allow the banking sector to operate as a whole with a lower total amount of funds and cancel the regular spikes currently observed at the end of the maintenance period. In principle, bank policy still follows the same equations (10) and (12), but the difference shows up on the aggregate level now. The periodic spikes in this setup will be smoothed. No predictions, however, can be made about the magnitude of volatility.

A potential weakness of this type of regime has been raised by some policy practitioners: it seems that the banking sector would have the possibility of transferring the liquidity to the banks that end the maintenance period, and ignore the reserve requirement on every other day. At first sight it seems that such a behaviour would vastly reduce the structural deficit of funds, which is supposed to be the

basis of effective operational policy. Taking a closer look at averaging provision, however, helps one to realize that these concerns are misplaced. Aggregate current account holdings hardly ever exceed *the daily* portion of the reserve requirement (in the model they exactly match) of the whole banking sector and hence there is no surplus liquidity on the market.

Another problem may arise whenever there is a change in the target rate. Taking the ECB as an example, the changes of rates have been recently synchronized with the maintenance period, in order to prevent speculative accumulation of liquidity during the period. Letting the end of the maintenance period dates differ will obviously increase the level of such a wasteful activity.

Supply side

The supply side – the amount of liquidity the central bank injects into the market – will be modelled following the approach introduced by Välimäki (2003) and later on by Moschitz (2004).

First of all, the CB, facing a choice *how* to supply the excess liquidity, has to consider the following trade-offs:

1. Daily OMOs allow for great flexibility and swift adjustments but might pose some operational and technical problems.
2. Late-liquidity supplying operations (fine tuning or narrow channel system) essentially set the end of the day rate at a specified target, but take away some incentives for trading on the interbank market (since the penalty for using CB facilities is much lower).
3. The reserve requirement allows a bank more flexibility when faced by the shock, since it works as a buffer. Should the bank run short (or an excess) of funds at the end of the day, instead of referring to the CB standing facilities the banks can ignore it and make up for it later during the maintenance period. The problems, however, occur around the end of the maintenance period, when the volatility and level of rates become much higher.

An interesting alternative – already mentioned above – that has not, however, been implemented in practice, would be to change the averaging provision regime and allow for different settlement dates between banks.

These trade-offs set the frame for the present analysis. By comparing final interest rates and values of CB intervention in different regimes it is possible to evaluate the efficiency of each policy mechanism.

In terms of the model, regardless of the policy applied, I assume the central bank goal is to minimize the deviation from the fixed target rate i^*. More specifically, the CB is assumed to operate with a quadratic objective function

$$\min E \left[\sum_{t=1}^{T} (i_t - i^*)^2 \right].$$

The target rate is linked to the commercial banks' behaviour by setting the middle point of the channel system. Also banks are assumed to expect future rates equal to the target rate. This assumption is justified by ignoring the possibility of changes to the target rates.

To achieve its target the central bank must find (1) the amount of liquidity that would induce the interest rate to remain as close as possible to the target, while (2) using the information about the expected changes in the autonomous liquidity factors and remaining deficiency.

In this study I do not analyse potential additional central bank motives such as supervision of the banking sector or its credit risks. Hence the Central Bank facilities (including OMOs) will always be available no matter what is the value of assets of an individual bank.

Depending on the frequency of OMOs the model time horizon T will take different values. In the case of daily OMOs the CB will be looking one period ahead, while in case of a single OMO T will cover the whole maintenance period. Even though the model assumes the CB carries no cost for OMOs, there are still some other restrictions that render the problem non-trivial. The most important is that the CB cannot simply assign an *individual* allotment value but must assign an *aggregate.* In other words, the central bank cannot decide on how much liquidity each bank receives separately and it must count on the market to distribute it efficiently. There is also another time lag (and shock realization ε_{1t}) before the CB allotment decision and the interbank market close, so that if the individual liquidity distribution matters, there will be some deviation from the target.

The exact allotment policy in this model is simplified to divide the aggregate amount equally among all banking players. Since the money market opens after the allotment, banks are free to trade any excess liquidity among themselves. Hence this assumption is not particularly restrictive.[5]

No reserve requirement

Whenever OMOs are performed on a daily basis, the aggregate value of the shock can be corrected by the CB on a daily basis. Available assets for each bank, $m_t + \theta_t$, are set by the central bank and the problem of finding the right allotment value reduces to solving (8) $i_t = i^d + (i^l - i^d)F(-M_t - \Theta_t)$.

The symmetric corridor with the target rate in the middle and normal distribution implies the solution hinted at already.

$$F(-M_t - \Theta_t) = \frac{1}{2} \tag{14}$$

or using the normal distribution property

$$-M_t - \Theta_t = 0 \tag{15}$$

so the CB should attempt to sweep away any excess liquidity.

The situation is different if the OMO takes place once in a while, say every Tth period. The target would then be to set the *average* rate during that period, i.e.

$$i^* = E_0 \frac{\sum_{t=0}^{T} i_t}{T}.$$

With such a policy, just offsetting predicted liquidity shock might encounter a major problem. Suppose the CB predicts the aggregate value of autonomous liquidity factors during T periods to reach some value (say, negative), and sets the amount of funds allotted in the beginning so as to offset the size of the shock. Clearly, in the first period that would mean that the market is flooded with money and would drive the rates all the way to the deposit facility rate. Only in the last period will the shock be finally balanced (if the predictions prove true) and the rate reach the target. Indeed, the simulation results indicate that the optimal allotment value differs from such a policy.

Reserve requirement

Regardless of the frequency of CB intervention (OMOs), the question of the optimal level of liquidity arises also with the reserve requirement present. On one hand, more liquidity is needed on the market (higher early CB intervention), on the other, the liquidity can be used as a cushion against volatile shocks (less late intervention).

Unfortunately this model offers an analytical solution only for the problem in the last day of the maintenance period, which is a simple modification of (11). In all other cases, the CB will face a simple optimization problem, to be solved for the optimal amount of liquidity allotment. The details are included in the section describing a simulation study.

Before the simulation study results, let us come back to the problem of targeting individual versus aggregate liquidity. The problem is not a trivial issue, since most popular operating procedures usually concentrate on the aggregate market shortage or excess. From the results presented so far it seems, however, that ignoring the information about individual liquidity can only work properly in a few regime types (e.g. without a reserve requirement) but otherwise it does matter. This issue has been also discussed by Bindseil (2004b) in relation to the excess reserves tracking.

First of all, in the last day of the maintenance period, the individual assets history is indirectly included in the *aggregate* deficiency D_T, calculated from the individual deficiencies from earlier dates and might differ even though the market asset value at time T and $T - 1$ and the *aggregate* shock realization are the same. A simple example with two banks and two periods illustrate the argument. Two cases with same aggregate values of assets or shocks but different distributions of starting deficiency result in very different outcomes on the market.

Case 1.

	Day T−1		Shock	Day T	
	Assets	Deficiency		Assets	Deficiency
Bank A	5	1	10	15	0
Bank B	5	19	−10	−5	19
Total	**10**	**20**	**0**	**10**	**19**

Case 2.

	Day T−1		Shock	Day T	
	Assets	Deficiency		Assets	Deficiency
Bank A	5	10	10	15	0
Bank B	5	10	−10	−5	10
Total	**10**	**20**	**0**	**10**	**10**

In the example, the aggregate value of assets (10 units) is just enough to satisfy the reserve requirement (total deficiency of 20 spread over two days), hence the central bank not concerned about individual assets would simply refrain from any intervention (the liquidity shock netting to 0). Sticking to that policy works well in case 2, since the market ends the maintenance period exactly with neutral liquidity. That, according to (11), results in rates on target. A similar policy, however, fails to provide the market with enough liquidity in case 1. That, according to the same formula, will result in a market rate higher than the target.

A real-life situation reflected in the example above could appear in the regime with periodic OMOs, when there is no possibility to alter market liquidity in the last day of the maintenance period. However, a regime that would allow for additional liquidity inflow in the last day of the maintenance period (in a form of fine tuning or additional open market operations) would still be capable of making the necessary correction. This leads to an important observation: not only the frequency but also the timing of the operations matter. This view is apparently shared by the ECB, where late liquidity operations have been recently launched.

To conclude this section, the most important finding is that not only aggregate value but also the distribution of the shock among the market participants might be important. A simple example illustrates the case where the same initial aggregate market liquidity and deficiency might result in very different market clearing rates. This can be managed by appropriate timing, such as the introduction of some form of late interventions.

Simulation study

In order to show the aggregate banking sector behaviour, with each bank's borrowing given by equation (12), I turn to numerical methods. In this section the design and results of the simulation study are presented.

The purpose of the chapter is to analyse the impact of different market designs on the behaviour of the interbank market. In practice it means I am going to keep the interbank money market (demand structure) unchanged, while experimenting with various ways of supplying the liquidity (supply structure). More precisely the profit-maximizing behaviour and the exogenous shocks are going to be kept fixed, while the value and timing of open market operations or the reserve requirement regime will be altered.

The elements of the operational policy analysed are:

1. The averaging provision regime, with three possible cases: (a) Traditional regime with the same maintenance period for all banks; (b) Regime without any reserve requirement at all; (c) Regime with different maintenance periods for groups of banks.
2. The frequency of the open market operations (early liquidity-supplying operation): (a) Daily supply (daily OMO); (b) Periodic supply (once per maintenance period).
3. The volume of the open market operations (a) Supplying an amount equal to the shortage of funds to the market (zero-excess liquidity); (b) Supplying the value of funds using a simple optimization algorithm (optimized liquidity).

The reason these regimes were picked is their resemblance to the actual policies of central banks. For example, the ECB uses the averaging provision reserve requirement, periodic liquidity supply with the value equal to the predicted forthcoming autonomous liquidity factors (aggregate shock in the model) and remaining deficiency.[6] On the other hand, Sveriges Riksbank uses no reserve requirement with daily liquidity operations.

For clarity, the simulation has been divided into three sections corresponding to different reserve requirement policies, and then each of four regimes is analysed:

- I. Daily OMO, zero-excess liquidity;
- II. Periodic OMO, zero-excess liquidity;
- III. Daily OMO, optimized liquidity;
- IV. Periodic OMO, optimized liquidity.

For each analysed variant of the policy, the following parameters are of particular interest:

1. The volatility of the interest rate measured during the simulation runs.
2. The volume of trade on the interbank market, measuring how efficiently the banking sector deals with smoothing out the effects of liquidity shocks. Ideally each individual bank should trade the amount that would leave it with a neutral liquidity position.
3. The recourse to deposit and lending facilities of the central bank, showing the level of late intervention.

4. The average liquidity left on the market after the open market operation (measured as the sum of liquidity shock *and* liquidity allotment).

The results are reported in the following sections.

Method outline

In what follows an outline of the method is presented. The details are included in the Appendix.

Following the approach of other researchers in this field, commercial banks' expectations of the interest rates will be given by the central bank rates. These beliefs are confirmed by the data, where indeed the hypothesis of significant difference between mean interest rates in any day of the maintenance period is rejected; see e.g. Moschitz (2004) for EMU data.

There are no frictions on the market that in the real life are likely to occur, for example due to cross-border cost of information. Hence, the markets always clear.

The simulation follows the model outline, meaning it is divided into demand and supply parts. The algorithm takes the following form (details can be found in the Appendix):

Step 1.   The central bank sets a level of aggregate liquidity (supply of funds).
Step 2.   The market clearing rate is calculated (where the aggregate borrowing ends close to zero).[7]
Step 3.   Should the market rate end up away from the target, the initial allotment decision is updated.

When the central bank calculates the expected market rate in Step 2, it has some initial idea about the distribution of liquidity, but it may change by the time the market opens. This reflects the fact that in reality central banks have developed very accurate techniques for predicting the *aggregate* liquidity shocks, but do not try to guess *individual* values. This distinction is reflected in the simulation design as well, by allowing two shock realizations. One of them has an aggregate value different from zero (like changes in autonomous liquidity factors), but known by the central bank. The second part of the shock is purely idiosyncratic,[8] and is excluded from the central bank optimization algorithm.

The presentation of the simulation results will be divided into groups, following the scheme introduced early in this paragraph. For the simulations the commercial bank assets value $m_t = 200$ units is used, with the liquidity shock variance (ε_{1t} and ε_{2t}) equal to 60. There are $N = 10$ banks on the market, and the reserve maintenance period is 3 days. During that period each bank is obliged to accumulate $R = 3m_t = 600$ units of money, so that there is enough liquidity on the market. The choice of the parameters has been arbitrary and roughly follows the values used in the existing research.

Averaging reserve requirement

I start the presentation of the results with the case when the commercial banks must satisfy the reserve requirement with an averaging provision. Within that framework, there are several interesting extensions, namely the impact of daily or periodic OMOs and which algorithm for funds allotment works better. Note that one of the cases (no. II in Table 10.1), i.e. periodic, zero-excess liquidity OMO quite closely reflects the policy run by the ECB, hence its relative importance compared to the other cases.

The volume of trade on the market differs slightly between allotment regimes, but is not influenced by the frequency of OMOs. This result is quite intuitive – the value of trade depends on the variance of assets among banks (all have to satisfy the reserve requirement of the same value) that are trading in the money market to adjust for liquidity shocks. The OMO in this setup does not influence that variance (the target is the aggregate liquidity), hence its neutral impact on trade volume.

The increase in volume can still be observed as time passes. This is related to the same issues brought up before: all banks in the model start the day with the same assets, but as the shock realizations build up, the variance of assets among the banking sector increases. In general, the volume of trade in that case will be

Table 10.1 Averaging provision reserve requirement

| | Regime type | | | |
Day	I	II	III	IV
Trade volume on day:				
1	718.2	728.2	613.4	719.1
2	1052.8	1033.4	905.4	1041.0
3	1414.2	1394.5	1245.1	1397.6
Recourse to CB deposit facilities on day:				
1	0.2	0.0	0.0	0.0
2	25.5	12.6	0.0	0.0
3	457.9	286.4	12.8	97.8
Recourse to CB lending facilities on day:				
1	4.8	0.6	0.0	1.1
2	21.1	2.6	0.0	2.7
3	411.1	216.3	40.4	50.4
Standard deviation on day:				
1	0.020	0.105	0.01	0.07
2	0.050	0.147	0.01	0.06
3	0.217	0.258	0.02	0.08
Average excess liquidity left after intervention on day:				
1	0.0	0.0	−224.8	10.4
2	0.0	0.0	217.9	−7.1
3	0.0	0.0	204.0	−16.0

used later on as a benchmark for measuring the efficiency of the interbank market, with different policy setups.

Let us move on to the use of standing facilities. The use of both facilities – at least whenever the optimization algorithm is used – seems limited, with a jump on the last day of the maintenance period. This is plausible; early on it is still possible to use the funds to satisfy the reserve requirement, so there is no need to make a deposit. At the same time positive balances serve as a buffer from negative shocks, preventing the lending facility from being used. All these advantages vanish at the end of the maintenance period and result in an increased spike that is also observed, for example, in Eurozone data (the average recursion to lending facilities in the period 1999–2005 was roughly 5 times higher on the last day of the maintenance period than in other periods; for the borrowing facility that ratio was around 9). Note that whenever the optimization algorithm is used to determine the allotment value, the recursion to standing facilities is much lower.

The next entry in Table 10.1 refers to the volatility of the interest rates on different days of the maintenance period. First of all there is a vast difference between the daily and periodic OMO cases. This is not surprising: the payoff between frequent intervention and rates volatility has been widely acknowledged in the literature.

The model predicts that volatility is increasing toward the end of the period, especially in the last day. That again is in line with the data (in Eurozone, the variance of the EONIA rate is on average 5 times larger compared to the other days) and all previous research. This result becomes even more intuitive once one looks back at plotted demand functions (Figure 10.2). In the last day of the maintenance period the price elasticities are significantly larger than in other periods, which means that the interest rates are going to respond much more to the same shock value compared to earlier days. Intuitively, this result has to do with the fact that: (1) at least some banks in the market have already satisfied the reserve requirement and hence lost the buffer; and (2) the others banks' balance, to avoid using an expensive lending facility, must not only remain positive (as in previous days) but also exceed the deficiency value.

Note that the volatility of the rates differs significantly between different allotment regimes, which brings me to the last figures in the table, i.e. the volume of liquidity required for the interest rates to stay on target. Remember that in the first two regimes analysed (namely I and II), the amount of liquidity was just enough to offset the liquidity shock, while in the other cases (III and IV) it was recalculated based on an optimization algorithm for each iteration separately. From the simulation run it seems that even such a simple algorithm performs better comparing to a simple zero-excess-liquidity policy. Particularly interesting are the values of intervention in the case of a daily OMO. It seems that different days of the period require different *signs* for the intervention, i.e. the early stage requires liquidity shortage, then neutral liquidity in middle stage, finally moving to liquidity surplus in the late stage.

This result is related to the phenomenon pointed out by Pérez-Quirós and Rodríguez-Mendizábal (2001) where they analysed the German money market
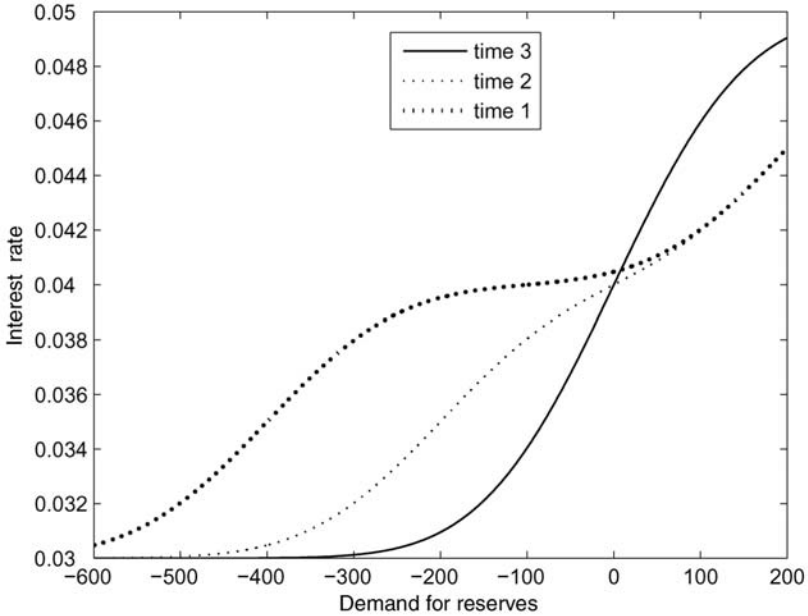
Figure 10.2 Demand for reserves.

before 1999 and noticed that the rates tended to be higher in the late days of the maintenance period, hence the liquidity at the end of the period must be more valuable. Their explanation is that early in the maintenance period, in order to enjoy a buffer of required funds, banks deliberately maintain lower liquidity (pushing the interest rates down), a trend that is reversed toward the end of the period.

There is also another explanation for that. Suppose the market *as a whole* has enough liquidity to satisfy the reserve requirement. Suppose further that one commercial bank is hit by a series of positive liquidity shocks which results in that bank fulfilling its obligations for that maintenance period. Now, any positive balance it will happen to hold until the end of the period will be deposited in the Central Bank and *will not* contribute toward satisfying global (market) deficiency. That, however, means that the rest of the market will be faced with a shortage of liquidity, driving the rates above the target level. In other words, the use of the deposit facility depletes the pool of funds that banks use to satisfy the reserve requirement. Obviously the problem will be more severe toward the end of the period. An active CB policy (such as the one using the optimization algorithm) would incorporate that fact in calculating the optimal value of liquidity allotment which contributes to its overall better performance. This, again, also provides additional support for the ECB policy of late interventions (called end-of-the-period fine-tuning operations).

To summarize the findings of this section, the most important result is that the neutral liquidity provision policy, just offsetting the liquidity shock, can be improved even by a relatively simple optimization algorithm. Also, daily OMOs

tend to protect interest rates from excess volatility but require a higher level of central bank intervention. Daily OMOs also require changing the market liquidity in different stages of the maintenance period.

No reserve requirement

This section contains the results of the simulations for regimes without reserve requirement (Table 10.2). In practice, countries that applied this type of regime have also committed to frequent liquidity-supplying injections to counter the liquidity shocks. Since there is no deficiency that needs to be covered, the only purpose the funds serve is to secure commercial banks from incoming late liquidity shocks that cannot be offset by the interbank market. In the previous section, the asset value of the commercial bank sector was set just to satisfy the reserve requirement. To keep the results comparable, this time it is just set to zero.

Before moving on, note that with daily OMO the optimal policy coincides with zero-excess liquidity, hence the results from regimes I and III are identical.

The volume of trade is in general lower than in the corresponding cases with the reserve requirement regime, but this just reflects the fact that without a maintenance period this becomes a one-period model, hence the assets variance decreases. The market still works efficiently, with the end-of-trade bank liquidity (sum of initial assets, shock realization and interbank borrowing) close to zero.

Table 10.2 No reserve requirement

	Regime type			
Day	*I*	*II*	*III*	*IV*
Trade volume on day:				
1	496.0	449.6	524.6	507.7
2	NA	684.7	NA	724.8
3	NA	903.9	NA	879.8
Recourse to CB deposit facilities on day:				
1	383.5	275.4	386.0	149.9
2	NA	239.7	NA	122.3
3	NA	193.7	NA	135.7
Recourse to CB lending facilities on day:				
1	383.5	281.2	383.9	53.8
2	NA	242.9	NA	35.7
3	NA	193.7	NA	43.7
Standard deviation on day:				
1	0.000	0.284	0.00	0.15
2	NA	0.213	NA	0.11
3	NA	0.000	NA	0.12
Average excess liquidity left after intervention on day:				
1	0.0	0.0	0.0	96.3
2	0.0	0.0	0.0	86.9
3	0.0	0.0	0.0	92.4

Limited liquidity in the market is transferred to the extent the standing facilities are used. Now that there is no cushion from funds kept for the reserve requirement and most banks end trade in the money market with a zero balance, they must rely on the central bank to offset their late liquidity shock. Periodic OMOs do not change that outcome significantly.

Without a reserve requirement the rate responds very strongly to any changes in aggregate liquidity, but once it is exactly balanced the volatility vanishes completely (the result already derived analytically). Increased sensitivity is due to the shape of demand curves (such as the ones in Figure 10.2), which are very inelastic in the last day of the maintenance period. After aggregation, it transforms even a relatively small liquidity shortage into a large deviation from the target, a result that was observed by all researchers in the field. Zero variance with no excess funds follows just the logic of the base model, and property (14), hence the results for the daily OMO and last day of the periodic regime.

Finally a last look at the value of liquidity if the OMOs are performed on a periodic basis. It seems that, in that case, the most effective policy would be to supply at least some liquidity on average, which reduces the use of lending facilities. It does not, however, improve the volatility of the rates, which remains at a high level.

To conclude, the most important finding is that the zero-excess liquidity drives the variance in rates to zero, but any excess (or shortage) of funds results in much higher volatility and use of standing facilities, compared to the reserve requirement regime. It also leads to a higher level of late intervention (in the form of standing facilities or alternatively fine-tuning operations) with the market left without any liquidity buffer to offset late shocks.

Different maintenance period dates

This section contain the analysis of a regime where the banks are still obliged to satisfy a reserve requirement, but the maintenance period for different banks (or group of banks) ends on different days (Table 10.3). In our model, there are three maintenance period dates with three different groups of banks. The total size of the market remained unchanged, hence the size of each group is 1/3 of the total number of banks. The value of assets (hence market liquidity) is kept at the same level as in the simulation with regular maintenance period, so that it is just enough to satisfy individual bank deficiency.

The results of the simulation seem to indicate that the banking sector is no more eager to trade than in the setups analysed so far. In fact in the case of daily OMOs the volume is even smaller. At the same time, the optimal OMO value stays close to zero, indicating no excess liquidity. This gives support to the idea that it is not optimal for the banks to ignore the reserve requirement completely, and count on being able to satisfy it in the last period of their own maintenance period. Hence there is no ground for worries about banks overcoming reserve requirements whenever they are allowed different maintenance period dates.

Table 10.3 Different maintenance periods

Day	Regime type			
	I	*II*	*III*	*IV*
Trade volume on day:				
1	479.5	770.9	401.9	760.9
2	NA	907.1	NA	899.8
3	NA	953.7	NA	946.4
Recourse to CB deposit facilities on day:				
1	117.2	157.5	93.7	126.4
2	NA	266.9	NA	214.5
3	NA	319.9	NA	268.3
Recourse to CB lending facilities on day:				
1	97.6	127.8	101.6	125.3
2	NA	245.4	NA	243.6
3	NA	305.8	NA	302.5
Standard deviation on day:				
1	0.134	0.192	0.009	0.092
2	NA	0.206	NA	0.086
3	NA	0.201	NA	0.114
Average excess liquidity left after intervention on day:				
1	0.0	0.0	−1.5	−34.4
2	0.0	0.0	0.0	−48.3
3	0.0	0.0	0.0	−40.0

So what is the effectiveness of this operational policy as measured by the use of standing facilities and volatility of interest rates?

The first observation is that the spikes or regular patterns in the interest-rate behaviour are gone. Small fluctuations in the standing facilities usage, present only in the regime with periodic open market operations, are due to increased variance of assets between allotment dates.

The second observation is that how effective this regime is (compared to traditional reserve requirement) depends heavily on the frequency of the open market operations. In the case of daily OMOs the variance of the interest rates drops almost to the lowest level usually observed in the maintenance period. It is not so clear with periodic OMO regimes (especially for the case where the optimization algorithm is used) but the same general trend exists. It can therefore be concluded that introduction of different maintenance periods for banks leads to a significant reduction of the periodic spikes in volatility, at the same time keeping the average level relatively low.

The analysis of the usage of standing facilities leads to a similar conclusion. First of all, remember that only 1/3 of the number of banks used in previous simulations now ends the maintenance period on the same day. Comparing to the situation where most of the facilities were used in the last period, it is no wonder

that significant improvement can be made. Once again using the optimization algorithm helps to improve the results even further.

To summarize the results of this section, first the concerns about banks using the different maintenance dates system as a tool to trade liquidity between themselves seem to be misplaced. No increase in trade volume or permanently changed aggregate liquidity is needed. When analysing the volatility in rates, the system works efficiently in the case of daily OMO and, although results for the periodic OMOs are not so clear, they point in the same direction.

Summary of results

The above sections contain the results for market volatility resulting from different policy setups. It is not the goal of the study to decide in favour of any of them, yet a short comparison might be interesting.

The trade-off between frequency of liquidity-supply operations and stability of interest rates has been acknowledged in the literature. The results from the simulations seem to confirm that intuition. Indeed, the lowest volatility (actually no volatility) is enjoyed by the regime without reserve requirements or other market frictions, with perfect forecasts of incoming liquidity shock and the central bank eager to supply massive amounts of liquidity in both the early (OMO) and the late (standing facilities) stages.

A slightly more realistic scenario, also with very good results, involves an averaging provision and daily OMO. Apart from the obvious technical difficulties from daily operations, it also involves shifting huge amounts of liquidity between different days.

Allowing banks different maintenance period dates succeeds in removing the spikes or periodic patterns from the data, but requires more late intervention on all days instead of the last one only.

There is one common point in all the regimes, a very important result of the study: even a relatively simple optimization algorithm indicates that even though the aggregate liquidity matters, the distribution of liquidity among the banks is at least as important. The same banking sector asset value might require different policies in order to set the rates on target.

Conclusions

This chapter uses simulation studies to compare the behaviour of the interbank market and CB interventions in different structural setups. The starting point is the model for demand for funds, based on the construction of Pérez-Quirós and Rodríguez-Mendizábal (2001). They analyse the regular patterns of the interest rate that can be observed in countries using an averaging provision reserve requirement and a channel system of standing facilities. The supply side of the market is given by the central bank open market operations, aiming at setting the interbank rates at some target.

The most important findings of the chapter are that targeting the aggregate instead of individual bank liquidity is not enough to maintain a low level of market volatility. Indeed the optimization algorithm, which calculates the optimal allotment taking into account individual information, performs much better than a simple policy of keeping the market with no excess (or shortage) of liquidity.

Apart from that, the popular view that frequent liquidity-supplying operations result in lower variance also finds support here. Zero variance is possible only under the unrealistic scenario where the central bank can predict the autonomous liquidity factors with 100% probability and there is no reserve requirement. In that case, however, the burden of offsetting the late liquidity shock is totally on the standing facilities, with the interbank market left with no liquidity. Some specific features of the money markets, such as the increasing volatility towards the end of the maintenance with the averaging provision regime, are replicated here as well. Introducing different maintenance period dates as a new type of regime helps to reduce the periodic spikes, but results in higher use of standing facilities.

Analysing different setups offers an interesting comparison of costs and benefits of the policies applied by different central banks, but does not help to evaluate what the optimal policy is for a given country. Answering that question requires an estimate of how costly the liquidity-supplying operations are for central authorities in different countries and what are the determinants of that cost.

Appendix

A proof of the results

The expected profit maximization-problem of a bank can be written as

$$\max_{b_t} \mathrm{E}_t(\Pi_t) = \max_{b_t} \mathrm{E}_t(i_t b_t - c_t) \tag{16}$$

where

$$
\begin{aligned}
\mathrm{E}(c_t) = i^l &\left[\int_{-\infty}^{-m_t+b_t-\theta_t-\varepsilon_{1t}} (m_t - b_t + \theta_t + \varepsilon_t) f(\varepsilon_{2t}) \mathrm{d}\varepsilon_{2t} \right] \\
- i^d &\left[\int_{-m_t+b_t-\theta_t-\varepsilon_{1t}}^{\infty} (m_t - b_t + \theta_t + \varepsilon_t) f(\varepsilon_{2t}) \mathrm{d}\varepsilon_{2t} \right].
\end{aligned}
\tag{17}
$$

The expected profit function can then be rewritten as

$$E_t(\Pi_t) = i_t b_t - i^l(m_t - b_t + \theta_t + \varepsilon_{1t})F(-m_t + b_t - \theta_t - \varepsilon_{1t})$$

$$+ i^d(m_t - b_t + \theta_t + \varepsilon_{1t})[1 - F(-m_t + b_t - \theta_t - \varepsilon_{1t})]$$

$$- i^l \left[\int_{-\infty}^{-m_t + b_t - \theta_t - \varepsilon_{1t}} \varepsilon_{2t} f(\varepsilon_{2t}) d\varepsilon_{2t} \right]$$

$$+ i^d \left[\int_{-m_t + b_t - \theta_t - \varepsilon_{1t}}^{\infty} \varepsilon_{2t} f(\varepsilon_{2t}) d\varepsilon_{2t} \right]. \tag{18}$$

The first-order conditions for that problem with respect to b_t are:

$$-i_t = i^l F(-m_t + b_t - \theta_t - \varepsilon_{1t}) - i^l(m_t - b_t + \theta_t + \varepsilon_{1t})f(-m_t + b_t - \theta_t - \varepsilon_{1t})$$

$$- i^d[1 - F(-m_t + b_t - \theta_t - \varepsilon_{1t})] - i^d(m_t - b_t + \theta_t + \varepsilon_{1t})$$

$$\times f(-m_t + b_t - \theta_t - \varepsilon_{1t}) + i^l(m_t - b_t + \theta_t + \varepsilon_{1t})f(-m_t + b_t - \theta_t - \varepsilon_{1t})$$

$$+ i^d(m_t - b_t + \theta_t + \varepsilon_{1t})f(-m_t + b_t - \theta_t - \varepsilon_{1t}) \tag{19}$$

where the last line follows from the Leibniz rule. Rearranging yields:

$$i_t = i^l F(-m_t + b_t - \theta_t - \varepsilon_{1t}) + i^d(1 - F(-m_t + b_t - \theta_t - \varepsilon_{1t})). \tag{20}$$

Simulation method

The demand side

I start with the basic case with reserve requirement and 3-day maintenance period (T). In the first period each bank decides about the value of optimal borrowing level based on (*a*) current interest rate, (*b*) its own liquidity and (*c*) expectations about future rates.

The last element is necessary to calculate the derivatives of the value function and I will assume they will be equal to the CB target rate. Using the traditional grid method it is possible to calculate the value functions in all possible states in period T (last day). By substituting these values into (13) one can compute analogous derivatives in period $T - 1$ and finally use them to calculate the optimal borrowing for some initial guess of the interest rates at $T - 2$. The same procedure is repeated for all N banks to come up with the aggregate borrowing until the market clearing condition is satisfied, or no further improvement can be made.

Once the interest rate and optimal borrowing for each bank participant in $T - 2$ are known, I can move to the following periods $T - 1$ and T. Each time shock realizations move the system to new states (i.e. assets and deficiency) for which the above procedure is repeated.

The behaviour of the interbank system without reserve requirements simply replicates the last stage of the procedure above, using different parameters of the monetary policy (such as narrow borders of the channel system).

Finally, in the last regime, banks have different maintenance periods. To capture that I have created three groups of banks, *n* banks in each, that share a common end-of-maintenance-period date. The *n* is set in a way so that the total number of banks is similar in all setups. Then, given the market rate one can compute the individual demands for each group member, using the procedure already described above. The resulting rate satisfies market clearing conditions. After the rate and the lending have been calculated, I use them to come up with next-day deficiencies (except of course for the group that starts a new maintenance period, in which case they are reset to the initial values) and assets. To ensure that these results are comparable with other setups (where I had only three periods) I reset the asset value of all banks every third iteration (otherwise asset values following a random walk become more volatile with each round of the simulation).

The supply side

The value of the central bank allotment is determined in two different ways. One – called here zero-excess liquidity – just supplied the value of funds equal to the sum of autonomous liquidity factors, so that the market is left with neutral liquidity. A second way is to use a simple optimization algorithm, that takes some value of allotment, and checks what are the predicted interest rates and whether any improvement can be made by changing the liquidity value. Once the decision has been made about the optimal allotment value, it is distributed evenly among market participants.

Analysing the supply policy, note that between the OMO and the opening of the interbank market, another shock realization occurs (denoted ε_{1t}), meaning that the rate that is calculated in the optimization algorithm and the final end-of-the-day rate are going to be different only if the distribution of shocks matters (which is the finding of the chapter).

The parameters of the simulation are set so that the model is comparable with earlier research. Increasing the shock variance or decreasing market assets results in higher rate volatility, but the results are generally robust.

Notes

1 I thank Hugo Rodríguez-Mendizábal for Gauss code, Tuomas Välimäki, Alain Durré and participants of the seminars in the Bank of Finland and FDPE for comments and OP Bank Group Foundation for financial support. Errors and omissions are my own responsibility.
2 Bindseil (2004) provides the following definition of autonomous liquidity factors: 'All items in the balance sheet of the central bank that do not reflect monetary policy operations, or the reserve holdings (that is, the "deposits" or "current accounts") of banks with the central bank'.

3 In the Eurozone, the late liquidity shock usually results from smaller transactions, hence its relatively lower significance compared to the early shock. In the simulation, however, for computational reasons these two have been assumed identically and independently distributed.

4 In the case of the ECB, a so-called benchmark allotment value is calculated by adding up the realized and expected figures for aggregate deficiency and autonomous liquidity factors (past and predicted) from one OMO to another.

5 Actual tender bidding policies of individual banks have been analysed by Välimäki (2003) and are beyond the scope of this chapter.

6 The ECB, however, performs four liquidity supply operations every maintenance period.

7 I thank Hugo Rodríguez-Mendizábal for providing the code used in the paper 'The Daily Market for Funds in Europe', which is the basis for this part of the simulation.

8 This shock reflects the balance of payments of transactions taking place inside the banking sector.

Discussion of Kempa – Complexity and challenges of modelling the central bank operational policies

Alain Durré*

As underlined in the chapters by David Laidler and Daniel Thornton, many text-books in economics, if not all, usually mention that the central bank affects the money market interest rates through its monetary policy decisions, which set the pattern of rates in the medium term. In many books, there is the conventional view that the central bank alters the supply of liquidity according to a pre-defined policy rate, which acts as a reference in the money market. But rarely are the mechanisms through which the central bank can impact the money market interest rates in prac-tice through its liquidity policy described explicitly, even in specialized textbooks (see e.g. Mishkin, 1995).

From this perspective, Michal Kempa's chapter contributes to filling this gap in the monetary policy analysis. It is also in line with the recent growing literature in finance, which tries to improve our understanding of monetary policy implemen-tation. Based on a pure theoretical model, his chapter discusses various options for implementing the liquidity policy of the central bank and provides interesting stylized facts. Although the results contained in this chapter could be intuitively expected, the main advantage of Kempa's analysis is to make formal the mecha-nisms that can increase or reduce the volatility of the overnight interest rate. As the operational framework of the monetary policy is usually the trade-off between good sense and theoretical considerations, the issue treated in Kempa's chapter is interesting not only for policymakers but also for practitioners and academics. Given this, this chapter should be considered as a meaningful and educational step.

Focusing my discussion on the benefits and the limits of Kempa's approach, I will structure the remainder of my discussion around two key issues related to the design of the central bank operational framework.[1] In fact, I will first raise the controversial question of the need to limit the volatility of the overnight interest rate. Based on a short comparative analysis between the US and the Euro area, I will then show how difficult the application of theoretical results could be in practice. Although important when discussing open market operations (OMOs), both issues are imperfectly, if at all, addressed in Kempa's analysis. Nevertheless, that analysis offers an opportunity for thinking about the mechanical implications of the different allotment frameworks on the volatility of the overnight interest rate.

Is the volatility of the overnight interest rate really an issue from the operational viewpoint?

In this book an interesting debate emerges among participants on the need to limit the overnight interest-rate volatility from the central bank point of view. In a simplified setting, there are two opposing views. On one side, there is the view that does not consider that some volatility of rates is needed to let the market operate properly. This view, supported by Bindseil and Würtz (ch. 4) among others, considers that by nature noise in prices cannot be considered as desirable since it can disturb the arbitrage of market participants between markets. On the other side, participants such as Allen (ch. 3) argued that there is a significant risk of resource misallocation if interest rates are too tightly controlled. Addressing the issue of monetary policy signalling, this latter view points out the risk of sending the wrong signals to market participants.

From the policymaker's viewpoint, this is a key issue, as one should look not only at the levels of the interest rates in the money market but also at their second moment. Since volatility of interest rates is a proxy of market participant uncertainty it should indeed reflect how confident market participants could be when collecting liquidity in the overnight market.

In the particular context of the Euro-area overnight money market, volatility of the overnight rate is directly conditioned by the minimum reserve requirements over a certain period, called the reserve maintenance period (RMP). Given the averaging provision, overnight interest rates are stable most of the time but they tend to increase at the end of the RMP when reserve requirements have to be fulfilled. Additional shocks are also observed at the end of the month, of the quarter, the semester or the year, i.e. the so-called 'calendar effects' (Moschitz 2004). Beyond these 'foreseeable' shocks, it is of particular interest to analyse the evolution of the volatility in the overnight market and to address the issue of its potential implications on other markets if volatility displays irregular patterns too frequently. It could be argued for instance that very high and unexpected increases in volatility may decrease the trading volume on the derivatives markets.

As underlined in Kempa's study, the volatility of the overnight interest rate can be increased or reduced by the design of the liquidity policy of the central bank. This theoretical result from Kempa's study is supported by recent experiences in the Euro-area operational framework.

Before March 2004, the ECB experienced regular underbidding during periods where market participants expected key ECB interest rates to be cut. In this context, banks delayed their accumulation of reserve holdings to meet required reserves in anticipation of being obliged to accumulate holdings later in the maintenance period at a lower interest rate. One reason for this development was the overlapping between the last (OMO) of the RMP and the Governing Council meeting during which a monetary policy decision was taken. By creating unbalanced liquidity conditions, underbidding led to greater volatility of the overnight interest rate.

On 10 March 2004, the ECB therefore decided to introduce a number of changes to the operational framework for limiting such developments. First, the timing of

the RMP was changed so that a maintenance period always starts on the settlement day of the main refinancing operation following the Governing Council meeting at which the monthly assessment of the monetary policy stance is pre-scheduled. Second, changes to the standing facility rates were implemented at the start of the new RMP. Finally, the maturity of the main refinancing operations was shortened from two weeks to one week. The changes lead to a situation where expectations of key ECB interest rates are flat over the entire maintenance period, and there are thus no incentives for underbidding (ECB 2004).

The early experience after these changes were implemented to the operational framework was quite promising. In fact, as shown by Figure 10.3, the volatility of the overnight interest rate, based on the realized volatility measure,[2] exhibited a downward trend after the launch of the new operational framework. This result remains true when comparing the mean of the (log-realized) volatility of the overnight interest rate during the last week of RMP, i.e. the days between the last allotment and the end of the period. However, from August 2004 the volatility of the overnight interest rate increased again, albeit from a low level, to reach a peak in March 2005. Recently the ECB launched end-of-period fine-tuning operations more frequently, which helped to loosen the pressure on volatility somewhat. As suggested by Figure 10.3, the volatility indeed declined after the launch of the first fine-tuning operations to reach a historical low level in May 2005. However, for obscure reasons, the volatility of the overnight interest rate has increased since then.
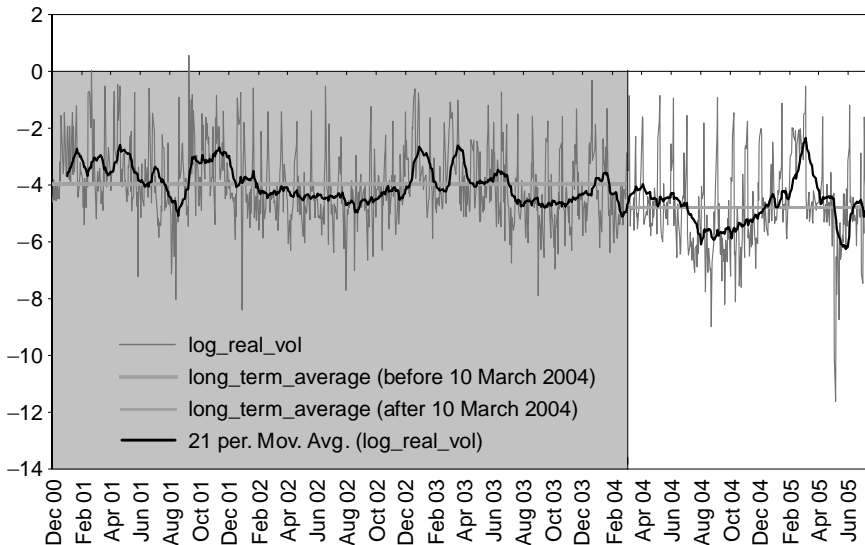
Figure 10.3 (Log-realised) volatility of the overnight interest rate (December 2000 to July 2005). *Source*: Durré and Nardelli (2005).

Table 10.4 Test for equality of means for the volatility of the overnight interest rate before and after March 2004 during the last week of RMP

	Old framework	*New framework*
Mean	−2.84	−3.65
St. dev.	1.36	1.80
No. obs.	158	91
t-statistics		3.72
(diff. in means)		(*degrees of freedom* = 150)

Source: Durré and Nardelli (2005).

Note:
t-test for the hypothesis according to which the (log-realized) volatility of the overnight interest rate during the days between last allotment and end of the maintenance period (i.e. last week of RMP) is the same in both periods, i.e. before and after 10 March 2004. Critical value of the test (two-tail) is 1.98.

Nevertheless, as reported in Table 10.4, the level of the volatility during the last week of the maintenance period has been significantly lower on average since the introduction of the changes to the operational framework than before March 2004.

The developments described above for the Euro area illustrate the difficulty of addressing the volatility issue in a pure mechanical way. The underlying problem is related to the fact that the liquidity policy of the central bank is constrained by the behaviour of market participants. Moreover, their perception of the liquidity policy also matters. If, for any reason, market participants have strong preferences for a long position or have a tight perception when the central bank announces its target of neutral liquidity conditions at the end of the RMP, the outcome of the allotment policy may differ considerably from the (optimal) situation described in Kempa's chapter. In fact, such strong preferences or perceptions, which may be related to strategic behaviour, will impact the volatility in the overnight market[3] while they will be difficult to anticipate. Compared to Kempa's model, this type of shock, also affecting the aggregated level of liquidity, is different from the idiosyncratic shock described in the chapter. For example, in the case of strong preferences by market participants for a long position, the outcome of the allotment will not be symmetric between liquidity-providing and liquidity-absorbing operations. In summary, it is correct that, as nicely emphasized by Kempa's chapter, factors such as the frequency and the volume of OMOs directly impact the volatility of the overnight interest rate. However, bidding behaviour and banks' strategic preferences also matter and are able to shift the final outcome of the allotment from the *ex ante* optimal equilibrium derived from Kempa's model.

These elements that can be observed in practice are far from the ideal situation described by Kempa's model. They also show the limits of measures which try to contain the volatility of the overnight interest rate. Against this background, there is thus a risk that the central bank spends considerable energy for marginal outcomes in terms of volatility. Furthermore, following Allen's idea, this may raise a potential conflict between liquidity policy and monetary policy signalling. Such a conflict is more pronounced in a framework such as the Euro area where

liquidity policy is conditional on monetary policy and thus neutral regarding the monetary policy rate decided by the Governing Council. If one takes the specific case of the Euro area, any pro-active liquidity policy, which de facto puts growing attention on the realized rate at each allotment, might eventually be confusing regarding the role that the policy rate, i.e. the minimum bid rate, should have as an anchor. In this spirit, the 'risk of misallocation of resources' underlined by Allen could be true not only for market participants but also for the central bank.

From theoretical exercise to implementation in practice

As nicely described in many studies, e.g. Rudebusch (1998), Meulendyke (1998) and Poole (2000), innovations, technological progress and deregulation affected the functioning of financial markets significantly in the past and hence the behaviour of market participants. The operational framework of monetary policy was not insulated from these developments and still continues to be affected. As a result, designing the operational framework should be viewed as an evolving process over time. It is therefore important to analyse the evolution of the market carefully to capture any new development or behaviour that might require further adjustments in the operational framework.

As already mentioned, an exercise such as in Kempa's chapter, even if purely theoretical, is thus useful and necessary for thinking about potential developments in the future. However, such an exercise has its own limits, which is basically the risk of over-simplification that a theoretical exercise may have. In particular, the weakness of such an exercise is probably the inability to be generalizable, as country-specific features may reduce the discussion to a case-by-case study.

In this context, it is worth noting that some of the optimal rules or operational design discussed in Kempa's study cannot be applied everywhere, as the general discussion might suggest. In fact, the feasibility of any proposal is strongly dependent on the size and the integration of the market considered, among the technical characteristics.

Among others, let me raise potential problems that can emerge with three options for the allotment procedure described in the chapter: the so-called optimization algorithm (called optimal rule hereafter), the daily frequency for OMOs and the different settlement periods. Whilst the last two options are obvious, the optimal rule boils down to advice to the central bank to look not only at the aggregate liquidity but also at the individual situation of banks, which can be affected by idiosyncratic shocks. In a nutshell, the central bank should provide a large amount of liquidity in the market to eliminate tensions in the overnight interest rate, especially at the end of the RMP, and not simply target neutral conditions, i.e. zero excess/shortage liquidity, based on aggregate information.

The main and quite new finding in Kempa's work is that the optimal allotment, focusing on specific current-account information of each counterparty, out-performs the simple targeting of neutral aggregate liquidity conditions in terms of lower volatility of the overnight interest rate. Furthermore, as expected, Kempa

also finds that more frequent OMOs also contribute to reducing the volatility of the overnight interest rate. As a kind of trade-off between the neutral and the optimal liquidity target, the central bank may instead opt for a system with different RMP dates which could also help to contain the volatility of the interest rate.

Clearly the implementation of such options in practice is strongly dependent of the market size and/or the number of counterparties taking part in OMOs. In this respect, reality may differ from one system to another. As suggested by Table 10.5, the situation in the US is for instance quite different from the situation in the Euro area.

For example, having daily frequency of OMOs in the US is an option, which seems to work, probably because of the limited amount of OMOs and counterparties. By contrast, this would be a more difficult task in the Euro area, which has to deal with more than 250 counterparties on average in each OMO, i.e. more than ten times the number in the US.

In the same vein, considering different RMP dates among market participants also seems to be unrealistic. This option involves huge technical complexity for the central bank, and would also complicate the job of liquidity managers in banks significantly if they really want to benefit from its full scope. Finally, the optimal rule might be the most realistic option at this stage, even if it could be constrained in the long run by the availability of good-quality collateral, which is another issue. However, over and above the technical reasons that can impede the implementation of the optimal rule, the central bank may have strong preferences given its history

Table 10.5 Number of credit institutions and eligible counterparties in the US and Euro area operational framework

	US[a]	Euro area[b]
Credit institutions	1024[c]	6776
Eligible counterparties for regular OMOs	22	2243
Eligible counterparties for marginal lending	Very few[d]	2749
Eligible counterparties for deposit facility	–	3188
Counterparties participating at regular OMO	22	252
Counterparties participating at long-term OMO	–	136
Indicative amount of regular OMO	USD 30–40 billion (daily)	EUR 240 billion (weekly)

Notes:
a   Indicative figure published in Federal Reserve Bank of New York (2005).
b   Figures in June 2003 published in ECB (2004).
c   For the US, this is the number of institutions which operated at least one transaction in the federal funds market on a quarterly basis (Furfine 1999).
d   In the US, banks seem relatively reluctant to participate in this kind of operation given the 'bad signal' such an operation may contain (Furfine 2001). For a comprehensive description of the US operational framework, see Furfine (1999).

and own experience. As explained by Thornton (ch. 8), a central bank, such as the Federal Reserve, is reluctant to be engaged in a large OMO, which could be explained by its indirect structure of refinancing. Of course, the larger the OMO, the bigger the influence of the central bank in the money market will be.

Concluding remarks

One can directly understand the complexity of the issue from the previous discussion, which probably explains the reluctance of some academics to be involved in such research. One also understands the position of Michal Kempa better when he says that his study '…does not help to evaluate what the optimal policy is for a given country. Answering that question requires an estimate of how costly the liquidity-supplying operations are for central authorities in different countries and what are the determinants of that cost'. This is precisely the key issue in the debate of the optimal operational framework. In fact, the general discussion on potential operational schemes is strongly constrained by the issue of feasibility, which is in turn connected to cost-benefit analysis. The theoretical exercise provided by Kempa is useful in keeping us aware that there are many options for designing an operational framework. But reality and specific country characteristics often oblige policymarkers to choose more pragmatic solutions. Although challenging, the implementation of the central bank liquidity policy has also its element of frustration.

Notes

* The views expressed in this comment are those of the author and do not necessarily reflect the views of the European Central Bank.
1 For the purpose of the discussion, I will reduce the money market solely to the overnight segment, which is usually defined as the very short end of the money market that normally includes maturities from the overnight to 12 months.
2 This measure of daily realized volatility is constructed by summing the squared change in the overnight interest rate for the period 4 December 2000–12 July 2005, where the change is calculated for each 5-minute interval between 9 a.m. and 6 p.m. See Durré and Nardelli (2005) for further details.
3 The interested reader will note that the nature of the volatility will differ according to the tender procedure of the OMOs. In the case of allotment with fixed-rate tender, the volatility in the overnight rate will bear upon the quantity of liquidity bid by market participants at each allotment. By contrast, in the case of allotment with variable-rate tender, the volatility will be included in the overnight interest rate.

11 Monetary policy by signal

Sheila Dow, Matthias Klaes and
Alberto Montagnoli

The way in which monetary policy is understood, both in practice and in the theoretical literature, has evolved in significant ways over the last few decades. Most significant, arguably, is an increasing awareness of the importance of the presentation of monetary policy. Central bankers have long been aware of the importance of the signalling effect of interest-rate decisions on the one hand (Dow and Saville 1988), and the care with which official pronouncements should be worded on the other. But it is only recently that there has been public discussion by central banks of the means by which monetary policy decisions are reached (e.g. Bank of England 1999). At the same time, the theoretical literature has increased its focus on information, and information asymmetries between the monetary authorities and markets, as a critical element determining the outcome of monetary policy decisions. In particular there has been an increased focus on the transparency of monetary policy decision-making; see Geraats (2002) for a review. But analysis of signals in relation to uncertainty qualifies the case for transparency. The purpose of this chapter is to reflect on the signalling aspect of monetary policy in terms of an analysis of uncertainty. In particular, we consider how the central bank signals its own uncertainty.

The concept of uncertainty itself is problematic, being subject to a range of different understandings. It is not our purpose here to make the case for any particular meaning(s), being concerned primarily with identifying what is being signalled. Where agents are uncertain, then the signals provided by the monetary authorities take on a critical role; any actual repo rate change is known with certainty, but its effects in general are not. We distinguish uncertainty in the economic system in a global sense, from model uncertainty on the one hand, and signal uncertainty on the other. Given that in the particular institutional framework of UK monetary policy-making a suite of models is consulted rather than a single most trusted model, model uncertainty, in a sense to be further specified, is a matter of fact of actual policy decisions. Likewise, given that the signals emanating from the decision-making process of monetary policy are both quantitative and discursive, signal uncertainty finds expression in both quantitative and non-quantitative ways. We are interested here in how model and signal uncertainty are related, and how to analyse non-quantitative signal uncertainty.

We start by tracing thought about the role of information in relation to monetary policy, and then consider specifically the uncertainty attached to the information content of monetary policy signals. Different conceptions of model uncertainty are then explored. To the extent that monetary policy is not based on forecasts derived from a single stochastic model, the authorities are experiencing a form of model uncertainty that extends beyond the parametric uncertainty usually considered in the model uncertainty literature. In such a context, signalling assumes added importance since, in addition to offering a mechanism for transparency, it adds a further dimension of information with respect to analysis and decision-making under uncertainty. The possibility is discussed of incommensurate models, not only as an input to decision-making, but also as an input to the public's understanding of monetary policy. Such incommensurability is resolved, by policy-maker and public alike, by the exercise of judgement, which we discuss in the fourth section. The foregoing analysis provides the basis for a discussion of how the central bank actually signals its uncertainty. In particular we discuss the scope for measurement of uncertainty by means of quantitative indicators and by means of discourse analysis. We then suggest an application of our approach to the monetary policy process of the Bank of England.

The role of information in monetary policy

Monetary policy operates in conditions of uncertainty, in terms of both a potential asymmetry between the knowledge of the monetary authority and market participants, and the uncertainty with which that knowledge is held. There is further an interdependence between the monetary authorities' knowledge, and uncertainty, and those of the market, since each enter into the expectations of the other. We will proceed on the assumption that it is sufficient to consider two types of economic agent: those who take the relevant decision on behalf of the monetary authority of an economy, and those who populate the markets of that economy, whom we will refer to as the 'economic public'.

Both types of agent will base their decisions on an understanding of the causal mechanisms at work in the economy, and the likely effects of monetary policy action. Formal economic models provide a mechanism for articulating these causal mechanisms, and are explicitly used by the monetary authorities and key market players. These models, and the data inputs, play a key role in conveying signals about the thinking of each type of agent. There is scope for asymmetry, in terms of differences in model employed, different data inputs, and different levels of awareness of each others' models. Issues of information asymmetry and transparency have been central to much of the development of the theory of monetary policy over the past three decades. We discuss these developments to consider how they have been qualified in the course of the growing focus on issues of uncertainty. We argue that this has involved a changing sense of the role of formal models relative to more discursive understandings of causal mechanisms.

Rational expectations hypothesis (REH)

The advent of rational expectations in economic modelling brought a new role for monetary policy. Based on the insight of Lucas (1972) that the general public cannot be systematically fooled by the policymakers, REH economists found that business cycles and movements in unemployment are compatible with dynamic stochastic general equilibrium models where agents' decisions are the result of optimizing behaviour. According to the REH, the Central Bank (CB) and economic agents act on the same model: economic agents form their expectations on the basis of the CB model. That model is public (whether made public, or due to the general public being able to impute the CB model according to the best available economic model provided by economists).

The REH revolution brought two influential results: the policy ineffectiveness theorem (Sargent and Wallace 1975) and the time-consistency policy (Kydland and Prescott 1977; Barro and Gordon 1983). According to the first, active monetary policy is impossible if private sector expectations are rational and are formed using the same model as the authorities. Temporary deviations from long-term equilibrium can only be achieved if the authorities are able to shock the private sector with unanticipated policy actions, thus confusing expectations. Time consistency on the other hand requires that, to attain a low and stable inflation level, monetary policy should be chosen such that, if it is chosen as optimal at time t, it should remain so at time $t + 1$. As a result academics and the central bank started to look for predictable economic rules which could be applied to the day-to-day operation of a monetary policy.

New Keynesian economics (NKE)

The REH in effect removes uncertainty from the monetary policy process in that it assumes a close alignment between the monetary authority and the economic public, with both forming their expectations according to a single transparent model. In the last twenty years modern macroeconomics has taken a different perspective on the monetary policy context. Instead of simply assuming close alignment, attention has now focussed on how such alignment could be brought about in practice through CB efforts. In other words, the focus has shifted to the provision of microeconomic foundations to macroeconomic questions. Deviations from long-run equilibrium are located in market imperfections, particularly price stickiness and information asymmetries. Reducing such imperfections will facilitate long-run equilibrium. Clear central bank signals about monetary policy are an important element in eliminating asymmetries.

One of the main insights here has been the so-called New Keynesian Phillips curve, which results from the decisions taken by rational agents when bargaining their wages. Prices are shown to be sticky and to exhibit persistence over time, resulting in a forward-looking dimension to inflation (Taylor 1979; Calvo 1983; Fuhrer and Moore 1995; see also Clarida *et al*. 1999). Using a model *à la* Calvo, Ball (1994) shows for example how monetary policy could reduce inflation and

produce a boom at the same time. Provided that price setters are forward looking, the announcement of a lower level of money supply by the CB will prompt firms to lower their expectations of the future money stock level. This leads to a lower price level today, and at the same time boosts today's real money supply, and consequently output. In essence inflation can be costlessly reduced. The key here is the forward-looking nature of price setters, which in turn rests on a certain level of transparency between monetary authority and the economic public.

New macroeconomic consensus

Following Arestis and Sawyer (2004), a certain convergence on key issues can currently be identified in macroeconomics, which forms the basis of what may best be described as a new monetary economics consensus. It is based on three propositions: nominal neutrality, inflation neutrality, and supply-side thinking. According to nominal neutrality, long-run equilibrium is not affected by the price level. According to inflation neutrality, real equilibrium is independent of the growth rate of nominal variables. The supply-side perspective, finally, implies that long-run unemployment is entirely determined by the supply side, so that there is no scope for a long-run trade-off between unemployment and inflation and between inflation and output.

Dynamic stochastic general equilibrium models based on these principles, put together with the aim of investigating optimal monetary policy, suggest that monetary policy can be regarded more as a science than an art, with applied modelling being in a position to steer monetary policy (Zimmermann 2003). These models are usually based on the assumption that central bankers, before implementing their policies, solve a dynamic optimization problem under the restriction of given resources, institutions, and information, in order to maximize the utility of a given representative household. A feedback rule is then derived assuming that the CB has a target function which is defined as a quadratic loss function with respect to negative as well as positive deviations of inflation and output from the respective targets or reference values.

This framework suggests, contrary to REH for example, that inflation as such is harmful for economic growth and efficiency, so that achieving low and stable inflation is the main step towards a sound macroeconomic environment. Moreover, there is a clear and direct link between the interest rate as a CB instrument and the level of inflation. Probably the biggest conceptual result of this literature is the inflation-targeting framework: monetary policy should explicitly declare an optimal level of inflation and act so that this target is met at every point in time. The advantage of such an approach, apart from the reduction in inflationary bias, would be its positive ramifications in terms of credibility problems. In particular, inflation targetting encourages increased transparency regarding inflation objectives via improved communication with the economic public (Mishkin 2004b).

The question here is how far the information provided by the CB is rather part of a circular exercise in ensuring that CB expectations and those of the private sector converge on particular levels of the interest rate, which in turn are understood

to conform to the achievement of the inflation target. It would then primarily be CB credibility in achieving the inflation target which would bring about wage and price settlements in the light of that target. But since changes in the repo rate do also have short-run real effects, the possibility remains for expectations not to be self-fulfilling, and for credibility to be damaged. Further, the recent attention to model uncertainty suggests that central banks are not fully confident in any one model, and consequent interest-rate rule implied, to determine the policy decision. Although many mathematically sophisticated micro-founded DSGE models propose policy rules that CBs should apply under different macroeconomic scenarios, no monetary institution has so far decided to adopt them. The reason is that the models cannot fully replicate the global uncertainty which governs the daily economic environment. The issue then is whether, and if so how, CBs communicate this uncertainty and its role in monetary policy and its transmission. We explore the meaning and significance of model uncertainty in the next section.

Model uncertainty: 'strong' versus 'weak' epistemic hypotheses

One implicit presumption behind the theoretical developments considered in the previous section was that each agent has one preferred model, and there is confidence in that preference. Let us refer to this presumption as the 'strong epistemic hypothesis'. Model uncertainty captures the fact that central bankers are not necessarily confident enough to rely on a single model as the basis for policy decisions. In other words, they doubt the strong hypothesis. To date, most efforts to take account of model uncertainty have relaxed the strong hypothesis while maintaining that one best model does exist, by allowing for the fact that there may be problems in identifying the best model correctly. Let us refer to this relaxation as the 'weak epistemic hypothesis'.

Following Walsh (2004), let us consider a simple way of taking account of model uncertainty along the lines of the weak epistemic hypothesis by taking a look at the following macroeconomic model:

$$y_{t+1} = Z_1 y_t + Z_2 \hat{y}_{t/t} + K i_t + u_{t+1} \tag{1}$$

where

y_{t+1} is the state vector of macroeconomic variables;
$\hat{y}_{t/t}$ is the current estimate (best guess) of $y_{t/t}$;
i_t is the policy instrument;
u_{t+1} is a vector of error terms (i.e. stochastic exogenous shocks) assumed equal to $T h_{t+1}$;
$Z_{1,2}$, K_{t+1} and T are matrices of the model parameters.

Uncertainty arises because estimates of $Z_{1,2}$, K_{t+1} and T by the policy-makers are different from the true values. Define these estimates as $\hat{Z}_{1,2}$, $\hat{K}_{t+1}$ and $\hat{T}$; while $\hat{y}_{t/t}$ denotes the policy-maker's estimate of the current state $y_{t/t}$.

With $Z = Z_1 + Z_2$ and $\hat{Z} = \hat{Z}_1 + \hat{Z}_2$ we can rewrite the policy makers' perceived model as

$$y_{t+1} = \hat{Z}\hat{y}_{t/t} + \hat{K}i_t + \hat{T}(h_{t+1} + w_{t+1})$$

where

$$w_{t+1} = \hat{T}^{-1}\big[(Z - \hat{Z})\hat{y}_{t/t} + (K - \hat{K})i_t + (T - \hat{T})h_{t+1}\big]$$

$$+ \hat{T}^{-1}Z_1(y_t - y_{t/t}) + \hat{T}^{-1}\hat{Z}(y_{t/t} - \hat{y}_{t/t}).$$

There are three separate sources of model error in the above representation (Walsh 2004):

- **Model-misspecification**
  This is given by $\big[(Z - \hat{Z})\hat{y}_{t/t} + (K - \hat{K})i_t + (T - \hat{T})h_{t+1}\big]$; these are the errors which arise when the policymakers' estimates differ from the their true value. Moreover this term captures the errors made in modelling the structural impacts of exogenous disturbances, $(T - \hat{T})h$.

- **Imperfect information**
  $Z_1(y_t - y_{t/t})$: errors arising from the estimate of the true state. Orphanides (2003) argues that these types of error were the main cause of important policy errors in the 1970s.

- **Asymmetric and/or inefficient forecasting**
  $\hat{Z}(y_{t/t} - \hat{y}_{t/t})$; this term reflects both inefficiencies in the policy-maker's estimate of the current state vector (y_{t+1}) and informational asymmetries between the economic agents and the authorities.

We should add that model uncertainty can take various other forms. In the context of the above specification, uncertainty may also arise from missing variables in the vector y_{t+1} or from misspecification of an equation, or from misspecification in the functional form of the system.

To check how robust a specific policy is to model uncertainty that accords to the weak epistemic hypothesis researchers usually follow three steps: (1) choose a reference model of the economy; (2) define a set of shocks/perturbations around this model, where the set is structured so that the uncertainty is focused on potentially important weaknesses of the reference model; (3) choose policy so that it works best for the worst model from the set. Hansen and Sargent (2004) suggest using a robust control method. Robust control amounts to acknowledgement and incorporation of model uncertainty of the above kind in optimal control models, allowing selection of the best policy for the best outcome for the possible worst model. It is always assumed, though, that the economic model is the same for the policy-maker and for the market participants.

Recently, more radical departures from the traditional line of model uncertainty have begun to emerge. Eusepi (2005) for example proposes a model in

which the central bank and the economic actors are uncertain about the model environment. He distinguishes between uncertainty about the evolution of output and inflation on the one hand, and uncertainty about the central bank monetary policy strategy on the other hand. The main conclusion is that CB transparency renders 'the optimal policy rule robust to expectational mistakes, even in the plausible case where the economic agents face other sources of uncertainty about the economic environment. On the other end, lack of transparency can lead to a welfare-reducing outcome where self-fulfilling expectations destabilize the economic system' (Eusepi 2005: 22).

The problem in trying to solve the model uncertainty issue lies in the inability of the researcher to work with the *true* economic model. In other words, the strong epistemic hypothesis assumes an omniscience on the part of economists which is, at best, an instrumental methodological assumption. This is borne out by the fact that all the various scenarios generated in the literature are always model-specific; the competing reference models have marked differences in how expectations are formed, and on the persistence of output and inflation.

Dow (2004) has drawn out the inevitable conclusion of these further relaxations of the strong epistemic hypothesis, by tackling head-on the thorny issue of model uncertainty in terms of the question as to which is the best model among a set of incommensurable candidate models, none of which provides a complete account of causal mechanisms. The issue here is the possibility that no one model can conceivably provide an adequate base for monetary policy. Without a reference model, model uncertainty cannot be expressed formally in terms of that model. Further there is no formal focal point around which all actors' expectations can converge.

The monetary policy decision and the basis on which it is arrived at then involve elements beyond any one model. In the context of policy signals, this means that what is being signalled goes beyond formal properties of models or datasets. The simple fact that monetary policy decisions are communicated via several channels at once, some quantitative and some discursive, lends credence to such an alternative hypothesis. So does commentary that finds that interest-rate decisions are made by a committee where 'each member holds to a particular view of the behaviour of the economy, represented by a macro model' (Levin and Williams 2003: 946).

Signals, uncertainty and ambiguity

In the previous section, we discussed a policy scenario that took account not just of the possibility that the economic public may be imperfectly informed about the model on which the monetary authority acts, but also of the possibility that decision-making within the monetary authority is subject to imperfect knowledge. The monetary authority may not have access to a single model of the economy which is regarded as encompassing all available knowledge, but instead is forced to rely on a suite of models that, if evaluated individually

within a committee decision-making structure, may give rise to competing policy recommendations. We will now explore this scenario more systematically by distinguishing between three different kinds of uncertainty as they arise in a policy context.

Consider the following, not too uncommon, context of monetary policy decision-making with an independent CB, whereby at regular intervals interest-rate decisions (the repo rate) are taken by an independent Policy Committee (PC) whose meeting minutes are subsequently made public in one form or another. The PC takes account of the current state of the economy and its likely development in the future, evaluates this state according to a set of models, and communicates the outcomes of its deliberations via several communication channels (minutes, press conferences and speeches, hearings with parliamentary committees, various CB reports, etc.) We call the information on the current state of the economy the PC's input data, the outcome of the set of procedures to which it has access to extrapolate from this data its empirical models, and the intellectual frameworks on the basis of which it evaluates the combination of input data and empirical models its theoretical models.

The first form of uncertainty, which we take for granted here by simply referring to it as global uncertainty, refers to the subject matter of the monetary policy decision: the economy. In the medium and longer term, knowledge derived on the basis of extrapolation from past data is subject to considerable uncertainty, in the sense that any given prediction is typically confounded by subsequent events. The various *ceteris paribus* clauses of the models informing PC decision-making will rarely if at all be sufficiently satisfied for the models to act as a precise and unambiguous guide to policy decisions. In other words, the economy is subject to unpredictable shocks, including structural shocks.

By contrast, on the level of models we encounter model uncertainty, in particular in the form of the multi-model interpretation of model uncertainty discussed above. The assumption here is that, even if the economy were to develop deterministically, our knowledge of it would be such that we are still unable to arrive at a single trusted model of it, be it an empirical or a theoretical model. The reasoning is either that we would lack access to crucial data, or that our conceptual understanding of economic phenomena would be bounded either in principle (due to limitations on human cognitive capacity, global uncertainty, etc.) or as a matter of fact.

Signal uncertainty, finally, is associated with the outputs of the PC decision-making process, rather than its inputs or models. These outputs as we have seen can take various forms, henceforth called 'channels'. The first channel on which we will focus consists of the interest-rate decision itself. The announced value of the repo rate is of course transparently known with certainty by the economic public. But we are concerned here with the uncertainty surrounding the analysis behind the setting of the value, and about its likely consequences. This analysis is important for the formation of the public's expectations about the future path of the repo rate. In particular, correctly anticipating changes in the repo rate is critical to the operations of financial institutions.

But monetary policy may also be transmitted through other channels, in addition to the behaviour of financial institutions. The effect of a repo rate change itself is felt by the company and household sectors indirectly through the financial institutions from which they borrow, or with whom they invest. But the expectations generated by the signals accompanying the rate change can also have a direct effect on expenditure plans. A fall in the repo rate accompanied by signals that the PC is uncertain about the prospects for economic growth may have conflicting effects on company investment plans: the rate fall encourages investment, while the accompanying signal discourages it. The PC's analysis is thus also important for the non-bank public's interpretation of the significance of any repo rate change. If the PC is uncertain about the effect of its monetary policy on expenditure and on inflation, and/or if the public are uncertain about the PC's expectations, then this will impact on the uncertainty with which the public interpret monetary policy.

The Bank's thinking about economic relations, including market uncertainty, and the PC's own uncertainty, are signalled through several channels which operate alongside the primary channel of the interest-rate decision itself. Traditionally, effects of changes in policy variables have been discussed in the literature in terms of the 'transmission mechanism' of monetary policy. We are here concerned with the discursive dimensions of any such mechanism, however its precise shape and details. The second channel of PC decision-making by which signal uncertainty is transmitted is a communication of the PC's evaluation of economic uncertainty as it can be extracted from official CB publications. A third channel which may be considered, finally, consists of the explicit or implicit communication of subjective views and evaluations of PC members.

If the output information arising from the PC decision-making process via these two additional channels, alongside the interest-rate decision itself, is regarded as a signal to the economic public, then the presence of signal uncertainty will mean that the economic public are only imperfectly informed about this decision-making process. This may either be intended by the monetary authority as a strategic reflection of the PC's own uncertainty, or instead it may be an inadvertent, possibly even inescapable, consequence of signalling processes of this kind.

It is important to be clear about the source of signal uncertainty. We assume that signal uncertainty, like model uncertainty as discussed above, would prevail even if the economy were to develop in a deterministic way, so that global uncertainty would not be an issue. Likewise, signal uncertainty does not depend on the presence of model uncertainty. This is due to the fact that the success of any act of communication relies not just on the intentions of the sender but on how the signal is interpreted by the recipient, and that economic communication takes place in a strategic context. However, even if the monetary authority could commit itself in a way that would allow it to send credible signals, the very fact that these signals go beyond numerical expressions and include discursive material of the other two channels that we consider here makes them subject to the ambiguities any discursive attempt at communication is bound to exhibit (see further Winkler 2000; Klaes 2006).

To recap, global uncertainty relates to the state of the economy, model uncertainty relates to the state of our knowledge of the economy, and signal uncertainty relates to our ability to communicate about economic matters. These concepts are nested: global uncertainty precludes the identification of a single model to capture economic relations (even stochastically) and thus requires the exercise of judgement. Global uncertainty therefore implies model and signal uncertainty. Even without global uncertainty, model uncertainty of the multi-model scenario kind means that judgement is required for policy decisions and, given the discursive nature of the expression of judgement, it also implies signal uncertainty. Signal uncertainty finally can stand alone, even without global or model uncertainty, if a policy decision involves explicit or implicit channels of communication via verbal expressions over and above monetary policy measures such as the repo rate announcement as such.

Judgement and the signalling of uncertainty

Uncertainty and the role of judgement

Model uncertainty of the kind considered above has a noteworthy implication. In the absence of a single trusted model or of the possibility of expressing rationally a degree of confidence in a suite of models and a mechanism for coordinating them, decision-making requires the exercise of judgement (Dow 2004). This judgement is required with respect to the interpretation of information, and to the choice, and use made, of models, both empirical and theoretical. Judgement, by definition, is not the rational derivation of a single solution to a model. In the context of true model uncertainty, candidate models are incommensurate with each other; were they commensurate they could all be incorporated in one large model, potentially obviating the need for judgement. Even more open to judgement are model selection criteria, issues of interpretation of terms and of new data with respect to models, and the formulation of a coherent set of forecasts.

It is conventional at this point to discuss the relative merits of the basis for decision-making as an art rather than a science. But our analysis of uncertainty does not allow such a bifurcation. Rather, evidence and modelling are used as far as they can be justified. But selecting the evidence and the models, combining the insights from each into an understanding of the forces at work in the economy and the likely effects of monetary policy actions, and formulating a policy decision require judgement, or art. Under conditions of uncertainty science requires art.

Further, any monetary-policy decision-making process will need to consist of a set of institutionalized procedures that rely on expert input and follow a consensus mechanism that ensures that policy decisions, e.g. interest-rate decisions, are arrived at. While such institutionalized procedures ultimately result in unambiguous repo rate decisions, they are nevertheless open to different interpretations by market participants, and may in fact be considered as a fourth communication channel, alongside the three considered above.

In the conventional literature on the theory of monetary policy, the challenge for policy is to ensure adequate transparency of the form and content of decision procedures for revealing the collective judgement of the PC. This would make it more likely that behaviour would be conditioned by the same expectations as the PC, helping to ensure that the PC's predicted outcome does transpire. But also it would facilitate a closer anticipation of future decisions (thus avoiding policy shocks) if past PC thinking is well understood. Hence the central role of signals in monetary policy. The channels which send these signals are thus of central significance.

We have referred to signal uncertainty, meaning a lack of clarity in the signals implicitly or explicitly sent by the PC. But if that thinking is conditioned by uncertainty, then an analysis of signals needs to include an indication of uncertainty and how it is being handled as part of the content being signalled. The transparency literature itself is not unambiguously in favour of signalling uncertainty. There has been some analysis of the uncertainty effects of transparency (reviewed by Geraats 2002: F534-6) which suggests that transparency with respect to monetary authority uncertainty may actually be welfare-reducing by increasing the variance of target variables: knowledge of the authority's uncertainty increases the public's forecast errors.

But in any case, if judgement extends beyond knowledge or otherwise of white noise surrounding inputs to the policy model, then making sure that policy action is fully anticipated is more complex than being transparent about 'the' model and 'the' information set. Runde (1990) considers the implications of greater awareness of uncertainty of this kind. He shows how additional evidence, rather than reducing uncertainty, can actually increase awareness of the limitations of the preferred set of causal explanations, and thus reduce confidence in the explanations. How far increasing awareness of our ignorance is welfare-enhancing and how far welfare-reducing is a moot point (Dow 1995). It may be possible to agree on the merits of reducing signal uncertainty itself; but, if what is being signalled is a matter of judgement, where uncertainty is an inevitable element, then the issue remains as to whether that uncertainty should be signalled. Being transparent about uncertainty may reduce the effectiveness of monetary policy.

Here we confine ourselves to the empirical question of considering more generally how, and how far, a PC signals its uncertainty. We are interested in considering how a PC may explicitly express its own uncertainty, and what can be gleaned from more implicit forms of expression which may be intended or unintended. In the next section we consider two approaches to signalling uncertainty: a quantitative approach of 'uncertainty indicators', and a non-quantitative approach of 'discursive signals' in the form of published minutes, reports, etc.

Conventional indicators of market uncertainty

The empirical literature has a long tradition in attempting to measure macroeconomic uncertainty. There are two broad classes of technique available to quantify uncertainty: *ex post* versus *ex ante* approaches. The former traces uncertainty in

the historical data of the process that generates the variable of concern. This group of methods includes:

(i) traditional statistical variance or similar, such as a moving standard deviation;
(ii) variance of the irregular component of a given stochastic process;
(iii) the conditional variance estimated via a General Autoregressive Conditional Heteroskedastic (GARCH) model where the mean equation is a first-order autoregression, allowing for ARMA errors. This is arguably the most popular methodology currently used to proxy uncertainty in whatever market or indicator the researcher is interested in. This approach is justified by Huizinga (1993: 528) as follows: 'The use of an ARCH model reflects a decision that the particular measure of uncertainty to be evaluated is the conditional variance of a series. This measure seems to best account for the idea that for series whose deviations from the unconditional mean can be reliably predicted, it is not fluctuations around an average value that are of concern (that is the unconditional variance) but rather fluctuations about a predicted future path'.
(iv) Recently, unobserved components models have been used to extract a long- and a short-run uncertainty from historic time series (see Harvey 1993; Kim 1993).

The *ex ante* method makes use of survey data to derive some statistical measure of the variance. The main advantage of using survey data is that uncertainty measures are able to represent individual perceptions of risks based on the information available to individual agents. The drawback is that it requires a large amount of respondents to obtain meaningful data. Moreover, the assumption underlining this approach is that the subjective probability distributions of events reflect objective probability distributions. In practice, the majority of the studies apply *ex post* methods in quantifying uncertainty.

PC minutes and other discursive data

Uncertainty indicators that are designed to reflect market uncertainty are only one of several kinds of contextualizing data available alongside formal PC decisions such as the repo rate. There is scope for deriving some indicators of uncertainty from the various other channels through which the PC communicates, implicitly or explicitly: minutes of PC meetings, to the extent that they are made public, any additional CB reports, etc. Additional indicators may thus be obtained, furnishing a potential proxy for the uncertainty as faced by the PC in their considerations. On the most basic level, for example, a simple count of uses of the terms 'uncertain' and 'uncertainty' may be taken as an ordinal indicator of how much uncertainty the PC was experiencing. Further analysis may involve relating the incidence of the 'uncertainty' terms with economic fundamentals, and also with indicators of uncertainty in financial markets and in the corporate sector. Thus, if a prior theory is formulated about how decision-making responds to particular developments (such as a financial crisis), how PC deliberations draw on a range of inputs,

how uncertainty is understood by the PC, and how it affects policy decisions, then quantitative indicators can be used for an empirical test of such a theory.

The Bank of England and monetary policy signals

Having outlined our general approach, we will now take a first step of applying the framework to the analysis of a particular case. Our general framework of analysis proceeds from a policy scenario that takes account not just of the possibility that the economic public may be imperfectly informed about the model on which the monetary authority acts, but also of the possibility that decision-making within the monetary authority is subject to imperfect knowledge. The monetary authority may not have access to a single model of the economy which is regarded as encompassing all available knowledge, but instead is forced to rely on a suite of models that, if evaluated individually within a committee decision-making structure, may give rise to competing policy recommendations. This is the scenario expressed in the Bank of England's (1999) discussion of its modelling approach, which in our interpretation explicitly acknowledges the challenges posed by model uncertainty.

We will in the following restrict our attention to interest-rate decisions as they are taken by the Monetary Policy Committee (MPC) of the Bank of England. The MPC meets monthly to consider changes in the interest rate under its control (the repo rate). In doing so, it takes account of the current state of the economy and its likely development in the future, evaluates this state according to a set of models, and communicates the outcomes of its deliberations via several communication channels (minutes of MPC meetings, press conferences and speeches, hearings with parliamentary committees, and the quarterly *Inflation Report*; see further Bell 2005).[1] The MPC has no expectation of their central projection being precisely met (Bell 2005: 7). In other words, the MPC accepts an overall context of global uncertainty as defined above.

The first channel for communicating the MPC's monetary policy is of course the interest-rate decision itself. Its output is a numerical value (so far) on a 'quarter-percent scale' that indicates by which amount, if any, the rate is adjusted up or down. The second channel of MPC decision-making is a communication of the MPC's evaluation of economic uncertainty as it can be extracted from the notation of the fan charts of the *Inflation Report*s. The third channel we will consider, finally, consists of the published minutes of the MPC meetings, which, since discursive in nature, must be regarded as a source of potentially significant signal uncertainty. If the output information arising from the MPC decision-making process is regarded as a signal to the economic public, then the presence of signal uncertainty will mean that the economic public are only imperfectly informed about this decision-making process. If the Bank of England is concerned with increasing transparency, it should therefore be concerned with signal uncertainty of this kind.

We argued above that once the strong epistemic hypothesis relating to models informing monetary policy is relaxed to the point where model uncertainty

is explicitly acknowledged, monetary policy will have to rely on the exercise of judgement, even though it may be informed by a suite of trusted models. The models employed by the Bank of England in its suite-of-models approach are themselves incommensurate; were they commensurate they could all be incorporated in one large model, potentially obviating the need for judgement. Were judgement not such a central aspect of the MPC's deliberations, there would be little scope for the kind of disagreement which arises between members in the exercise of judgement.

The MPC are quite explicit that their decision-making involves the exercise of judgement with respect to knowledge which is held with uncertainty (Bank of England 1999; Lomax 2005). This openness about uncertainty is a relatively recent feature of central bank pronouncements, following the disappointment in the 1980s with relying on single large models for monetary policy-making. We are interested in considering how the MPC explicitly expresses its own uncertainty, and what can be gleaned from more implicit forms of expression.

We consider two approaches to signalling uncertainty: the quantitative approach of 'uncertainty indicators', and the non-quantitative approach of 'discursive signals' in the form of published minutes, reports, etc. What we wish to stress here though is the complementary nature of discursive and quantitative channels, rather than discursive sources merely adding a secondary gloss on quantitative indicators. For example, while the fan charts express the uncertainty surrounding the two-year point forecast, the minutes express the uncertainty surrounding specific aspects of the analysis which led up to that forecast, and thus provide additional signals to the public. While summary statistics can thus tell us something further than the fan charts, a detailed study of the texts of minutes, as is done by market watchers and market participants, is an additional channel of communication.

We now turn to a more detailed consideration of the main signalling channels of MPC decision making.

The Bank of England fan charts

Since 1996, even before the current institutional arrangements for monetary-policy decision-making were established, the Bank of England has published its inflation and GDP projections in the form of fan charts. Rather than focusing on one central forecast, the fan shows a range of bands around the central forecast, in order to express its own model uncertainty. There are ten bands, and there is a 10% probability of the actual inflation rate falling within each band (at the end of the two-year forecast horizon – the intervening period's bands are simply interpolated).

As an expression of uncertainty, the fan chart is clearly quantified (indeed the Bank publishes the precise data on which it is based). But how are we to understand what is being measured? The Bank's explanatory notes shed some light on this, explaining that 'the fan chart portrays a probability distribution that approximates to the MPC's subjective assessment of inflationary pressures evolving through time, based on a central view and the risks surrounding it' (Britton *et al.* 1998: 31).

Further, 'the uncertainty in the subjective assessment of inflation relates to how likely it is that the future events will differ from the central view. It is therefore a forward-looking view of the risks to the forecast, not a mechanical extrapolation of past uncertainty' (Britton *et al*. 1998: 32).

The language quoted above is that of the Subjective Expected Utility (SEU) approach whereby, even if there is no concrete objective basis for probability estimates, these can be assigned subjectively. Here the requirement is stronger, that the MPC arrive at a collective subjective assignation of *ex ante* probabilities to the risks attached to the central forecast. But there is no formal basis for doing this, given the derivation of the central forecast from a suite of models to which judgment is applied following lengthy deliberations. Rather, the fan charts apply a forward-looking modelling approach to calculating the risks attached to the central forecast on the basis of past errors; it is only the degree of skewness which is the outcome of subjective judgment (Nikolov 2002).[2]

An interesting characteristic of the Bank of England forecasts is that they are computed assuming both an unchanged repo rate and an interest rate based on market's interest-rate expectations. This second case introduces the hypothesis that there may be a *reverse channel*, where the Central Bank acquires information from the market rather than vice versa. But since the market agents form their expectations on the signals given by policy-makers, we are therefore faced with the potential of a circular policy environment with no economic leader.[3]

MPC minutes and other discursive data

But the fan charts are only one channel for communicating the MPC's thinking on uncertainty. There is scope for deriving some indicators of uncertainty from the other channels: the MPC Minutes, the *Inflation Report*, etc. The resulting indicators furnish a proxy for the uncertainty as faced by the MPC in their considerations. On the most basic level, for example, a simple count of uses of the terms 'uncertain' and 'uncertainty' can be taken as an ordinal indicator of how much uncertainty the MPC was experiencing.

Such an approach can be taken further in order to glean more information about the MPC's thinking in relation to uncertainty. Comparing the relative uses of the terms 'uncertain' and 'uncertainty' on the one hand with 'risk' and 'risky' on the other provides information on the relative importance of the two, as well as how far they are correlated, thereby opening up the possibility of an assessment of uncertainty along more than one conceptual dimension. Comparing the relative incidence of both sets of terms in the MPC minutes and in the *Inflation Report* provides some indication on such matters as how far the two documents are consistent (the latter bearing the imprint more of Bank staff), and/or how much additional uncertainty is expressed in the context of the policy decision. Further analysis involves relating the incidence of the 'uncertainty' terms with economic fundamentals, and also with indicators of uncertainty in financial markets and in the corporate sector. Thus, if a prior theory is formulated about how decision-making responds to particular developments (such as a financial crisis), how the

MPC deliberations draw on inputs such as the *Inflation Report*, how uncertainty is understood by the MPC, and how it affects policy decisions, then quantitative indicators can be used for an empirical test of such a theory.

We are therefore suggesting going further than quantitative indicators, drawing on the discourse approach to studying texts which is already well-established in economics (see further Klaes and Sent 2005). This requires a careful, contextual, analysis of the use of terms phrase by phrase in order to glean the intended meaning. This in turn requires that the analysis be embedded in a prior theory as to channels of information and the decision-making process, incorporating feedback between information and decision-making among all the relevant parties. This is particularly apposite for an analysis of uncertainty, where reflexivities abound. The uncertainty faced by the Bank of England arises partly as a result of uncertainty faced by the general public, which in turn is influenced by the Bank's uncertainty.

In arguing for a discursive approach to analysing MPC decision-making, we are not alone. Cobham (2003) provides an example of the form an explorative approach of this kind may take. In an analysis of the factors responsible for interest-rate smoothing, he finds in an analysis of the UK monetary policy context that focuses on the decisions and minutes of the MPC that only limited influence, if at all, can be attributed to perceived uncertainty by the MPC. This perceived uncertainty is identified by considering the importance given in the MPC minutes to economics fundamentals (demand, output, etc.) relative to other factors, which, in Cobham's terminology, include 'uncertainty'. Out of the minutes of 62 MPC meetings considered, uncertainty was regarded as a decisive factor at 23 meetings. The forms of uncertainty considered were data uncertainty, parameter uncertainty, and 'wider uncertainty' associated for example with trends in the world economy. The outcome of 17 of those 23 meetings (74%) was no change in rates, comparing to a 'no decision rate' in all meetings of only 63%.

Rosa and Verga (2005a,b) adopt a more sophisticated methodological framework, albeit in a study of European Central Bank (ECB) monetary policy. Based on the monthly ECB press conferences, they construct a discourse-based uncertainty index. They find that this index provides a complementary explanatory factor, alongside more conventional market-based measures of monetary policy expectations, when it comes to ECB interest-rate policy. We argue for an extension of discourse analytic approaches of this kind. Quantitative indicators based on texts are subject to obvious limitations which need to be considered in any such approach. What is required is a more thorough discursive approach, starting out from close systematic study of CB communications such as minutes, press conferences and other sources.

Conclusion

Central bank documents are worded extremely carefully; there is a good understanding of the signalling value of texts and of the seriousness with which they are therefore pored over by the public. They therefore provide excellent case material for discourse analysis.

We have seen the conventional theoretical rationale for the authorities to adopt the stance that transparency is desirable, on the grounds that their projections are more likely to be met if they are understood and shared by the public. Monetary policy then no longer shocks the economy into a change of course. Rather policy documents, and the announced reasoning behind policy decisions, nudge the economy in the direction the monetary authority wants it to take; ideally the decisions themselves are fully anticipated (Friedman 2004b).

But full certainty is impossible given the possibility of developments unanticipated by the authorities, as well as uncertainty surrounding the interpretation not only of data but more seriously of causal mechanisms, and thus of forecasts. The uncertainty experienced by the authorities is then an input to the uncertainty of the public, and vice versa, and full transparency is open to question. This uncertainty is signalled through a range of channels. While there is some scope for quantitative analysis of texts as a way of identifying the MPC's signalling of its own uncertainty, along the lines described above, ultimately a more deeply probing semantic analysis may be required fully to grasp the wider dimensions of the signal.

Notes

1 In principle the MPC's thinking is communicated in a letter to the Chancellor of the Exchequer if the actual inflation rate deviates unduly from the target, but this has not so far been required.
2 It is still difficult to understand exactly how this collective subjective judgement is in practice quantified in order to be applied to the detailed fan chart's detailed numerical parameters.
3 Bernanke and Woodford (1997) show that it is not optimal for a Central Bank to target private forecasts, since it leads to indeterminacy of the rational expectations equilibria.

12 The impact of the Reserve Bank's open market operations on Australian financial futures markets

Xinsheng Lu and Francis In

The Reserve Bank of Australia (RBA) influences financial markets by manipulating the short-term interest rate or the overnight cash rate in the Australian money market. The Reserve Bank derives its influence over short interest rates in the wholesale money markets from its monopoly of the supply of central bank money, through its daily open market operations (OMOs).

The Reserve Bank has the ability to influence the availability and the 'price' of the short-term cash fund supply in the money market, and hence has the power to maintain or change the cash rate whenever necessary. The primary aim of the Bank's operations in the money market is to implement the interest-rate decisions while meeting the liquidity needs, and so contributing to the stability, of the banking system as a whole. The Reserve Bank Board sets an appropriate target for the official interest-rate level and the Domestic Markets Department of the RBA has the daily task of maintaining conditions in the money market in order to keep the cash rate at or near the operating target decided by the Board.

The primary target of the central bank's open market operations, by its original policy design, is the official interest-rate level. This target is reached through the RBA's two types of market operation, cash-fund-add and cash-fund-drain transactions. The former operation involves the RBA's daily purchase of government securities issued by either the commonwealth government or state governments so as to add cash liquidity in the banking system. The latter operation involves the RBA's selling off government securities so as to drain cash from the banking system. On days when monetary policy is being changed, market operations are aimed at bringing the cash rate to the new target level, while between changes in policy the focus of market operations is on keeping the cash rate close to the target, by managing the supply of funds available to banks in the money market (RBA 2002). The objective of these OMO transactions is therefore to balance supply and demand in the cash market *at the desired cash rate*.

This chapter examines the impact of Open Market Operations conducted by the Reserve Bank of Australia on interest rate and foreign exchange rate spot and futures markets. We examine the influence of the Reserve Bank's domestic market operations on asset return volatilities through an extended EGARCH model. The effects of the Reserve Bank's open market operations are examined in a model

that incorporates announcement-day effects of the official interest rate target. The investigation deals with three markets: 90-day Bank Acceptable Bill (BAB) futures, 3-year Treasury bond futures, and the AUD/USD futures contracts.

There is only a small amount of literature on the impact of central banks' open market operations on financial markets. Harvey and Huang (2002) examined the impact of the US Federal Reserve's open market operations on return volatility and trading patterns of the U.S. interest rate and foreign exchange rate futures markets. They tested a particular period between 1982 and 1988, and provided some insights into the impact of the Fed's market operations on US fixed income instruments and foreign exchange markets. They documented a dramatic increase in volatility during the Fed's market operation time, suggesting that the markets try to infer the Fed's policy implications from its market behaviour and announcements. However, their results also provide some evidence of higher volatilities on days when there are no open market operations, indicating that the higher volatilities are not necessarily dependent on whether the Fed actually trades in the markets, and that the conduct of OMOs might act so as to smooth market expectations. Harvey and Huang (2002) also indicated that, when the central bank keeps its policy intention highly secret, the effects of the central bank's OMOs are limited, since they cause confusion among market participants as a result of their inability to identify the policy intentions and the implications of open market operations. This calls for further examination of the impacts of OMOs, using new data that relate to more transparent monetary policy change. Here we examine the impact of the Australian Reserve Bank's open market operations, with a first-time released data set that covers a period from 17 February 2000 to 21 June 2004.[1]

A number of studies have examined the impact of the Fed's interest-rate stance and changes on financial markets in the U.S. (Cook and Hahn 1989; Bonser-Neal *et al*. 2000; Kuttner 2001). After the increased transparency of the US Fed's monetary policy, Demiralp and Jorda (2002), and Taylor (2001) investigated the Federal Reserve Bank's ability and efficiency in manipulating official cash rates, and they found that monetary policy was more efficient when the central bank communicates with financial market participants more effectively. Kim *et al.* (2000) examined the effectiveness of foreign exchange intervention by the Reserve Bank of Australia on the conditional mean and volatility of USD/AUD exchange rate. Coppel and Connolly (2003) have examined the impact of overnight target cash rate changes and monetary policy transparency on Australian financial markets. However, none of these studies looked at the impact of the central bank's open market operations on the *volatility* of financial markets.

This chapter is motivated by the following questions. Firstly, OMOs are a key monetary policy tool. The Reserve Bank's monopoly role in influencing the settlement fund rate and other interest rates in the broader financial market stems from its control of cash fund availability through the daily OMOs. After decades of monetary policy and financial market deregulation, central banks in major economies now announce their monetary policy target of interest rates immediately after the decisions are made. Do OMOs still influence money market rates, and do OMOs thereby impact on other financial rates in the broader financial market, given

the current conditions of the money market transparency and market efficiency? If they do, how and to what extent do short- and long-term interest rates, as well as the currency market exchange rates, react to the Bank's market operations of buying and selling on the government security market?

These questions are essential for estimating the efficiency and accountability of monetary policy transmission mechanisms and for exploring the linkage between financial markets, with special references to the Australian monetary policy. The relationship between the Bank's monetary market operations, the cash rate and rates in the broader financial market are still an untouched area in Australia, according to current available literature in monetary economics.

The objective of this chapter is thus to reveal the impact of open market operations on Australian interest rate and foreign exchange futures markets. We proceed as follows. We begin by specifying our empirical modelling of the EGARCH framework, and also describe our data set used in this research. We then present the major empirical results from the application of the EGARCH method before concluding.

Data and model specification

Data description and preliminary statistical analysis

Daily Open Market Operations data are obtained from the Reserve Bank of Australia. The OMO data we used here are the sum of outright transactions, repurchase agreements and foreign exchange swaps in terms of Australian dollars. Outright transactions are purchases and sales of Commonwealth Government Securities (CGS) and securities issued by state central borrowing authorities with remaining terms to maturity of up to 18 months. A positive value of this transaction shows that the Bank has added cash settlement funds to the banking system by purchasing securities, while a negative value of this transaction indicates that the Bank has withdrawn cash funds from the banking system by selling securities. Repurchase agreements (RPs) are the aggregate amount of all securities purchased or sold by the Bank under repurchase agreements. The positive and negative signs for RPs have the same meaning as for outright transactions. We have obtained 1108 observations for the OMOs variable from 17 February 2000 to 21 June 2004. Daily data for 90-day bank accepted bill futures, AUD/USD foreign exchange rate futures and 3-year Treasury bond futures contracts are obtained from the Sydney Futures Exchange (SFE). The most frequently traded futures contracts are selected in all three futures markets data. The daily percentage change is used as return for 90-day BAB futures, 3-year bond futures and AUD/USD exchange rate futures, while the OMO series is calculated as first-order differences of daily market operation value.

Panel A of Table 12.1 summarizes statistics on daily returns of Australian interest rate and foreign exchange rate futures markets and OMO series. Daily mean returns from the three futures markets are positive and close to zero. The variances for the three return series of futures contracts range from 0.006 for the 90-day BAB

Table 12.1 (a) Summary statistics on daily returns of Australian interest rate and foreign exchange rate futures markets and OMO series

	BABF	TBF3Y	AUDF	OMO
μ	2.94E-06	1.32E-05	0.0001	1.4285
Max	0.0051	0.0038	0.0293	4518.0
Min	−0.0043	−0.0027	−0.0318	−4853.0
σ	0.0006	0.0008	0.0076	1113.6
Skewness	0.5151	−0.0670	−0.2267	−0.0885
Kurtosis	22.0435	4.2217	4.1702	5.5573
LB(10)	10.83(0.371)	4.64(0.914)	12.82(0.234)	309.93(0.00)***
Observations	1107	1107	1107	1107

(b) Correlation coefficients between variables

	BABF	TBF3Y	AUDF	OMO
BABF	1.0000			
TBF3Y	0.6236	1.0000		
AUDF	−0.0513	−0.0799	1.0000	
OMO	0.0180	−0.0069	0.0304	1.0000

Note:
***, **, * denote significance at the 1%, 5% and 10% level, respectively.
The table reports descriptive summary statistics and correlation matrix for two interest rate markets and Australian dollar exchange rate market: 90-day Bank Acceptable Bill spot futures (*BABF*), 3-year Treasury bond futures (*TBF3Y*), AUD/USD futures (*AUDF*) markets, as well as for the RBA's daily open market operations (*OMO*). μ is the mean and σ is the standard deviation. Max and Min are the maximum and minimum value of observations, respectively. LB(10) is the value of the Ljung-Box test of randomness for the 1st to 10th order autocorrelation, asymptotically distributed as $\chi^2[10]$ under the null hypothesis that the series is a white-noise process in which all autocorrelations are zero. Note that rejecting the null H_0 means accepting an alternative H_1 that at least one autocorrelation is not zero.

futures market to 0.008 for return series of 3-year bond futures market. The sign of skewness for 90-day BAB futures is positive, indicating that distributions of those series have long right tails, while the signs of skewness for 3-year bond futures and AUD/USD foreign exchange futures, as well as for the OMO series, are negative. The distributions of those series are thus negative-skewed with long left tails. The distributions of all four series are thus not symmetric. Kurtosis of all series exceeds 3, and the distribution for the four series is leptokurtic and more peaked than a normal distribution. The reported probability for the Jarque-Bera test is zero for all four series, suggesting (at 1% significance level) that they are not normally distributed. We also reported Augmented Dickey-Fuller (ADF) Test t-statistics for all series. The ADF test critical value at the 1% level is –3.4362, the calculated t-statistics of all the variables for ADF tests are less than the test critical values at the 1% significance level. Hence, the null hypothesis that any one series in this group has a unit root is rejected. Thus all daily time series data (daily percentage changes) are of I (0), and they are stationary.

As reported in panel B of Table 12.1, correlation coefficients between 90-day BAB futures markets and the long-term interest rate futures markets are quite large. The daily percentage changes of the AUD/USD foreign exchange rate futures contract are, as generally expected, negatively correlated with the returns from both 90-day BAB futures and 3-year bond futures markets. The relationship between Australian currency futures markets and short- and long-term interest rate markets is generally weak, as reflected in those simple correlation coefficients. Interestingly, the stronger correlation is observed between exchange rate futures market and long-term interest rate futures market, which can be interpreted as indicating that news that drives the movements of currency markets impacts mainly on long-term interest rate markets, and vice versa.

The last row of the correlation matrix shows correlation coefficients between the OMO variable and the other three markets. The correlation coefficients between the OMO variable and 90-day BAB futures and AUD/USD futures markets are positive while the correlation between OMO and 3-year bond futures market is negative. The correlation coefficient between the OMO variable and the long-term interest rate futures market is relatively weaker, compared with correlations between OMO and the return series from short-term interest rate futures market and the currency futures market. Nevertheless, the interpretability of these simple correlation coefficients is quite limited. Generally speaking, the weak correlation between OMO and the three futures markets might suggest that the RBA's open market operations may not significantly impact directly on the means of the Australian foreign exchange rate and interest rate futures markets. The Reserve Bank's monetary policy operations may impact mainly on the return volatility rather than the mean returns of the three financial futures markets under investigation.[2]

Model specification

In order to estimate the impact of the RBA's open market operations on Australian dollar exchange-rate markets and interest-rate markets, we need to choose an appropriate model that can cater for the key characteristics of daily returns from the three futures markets under investigation. We employ Nelson's (1991) Exponential GARCH modelling procedure, as it is a more general estimation model when compared with the standard GARCH (1,1) model, in the sense that, by modelling the logarithm of the conditional variance, it is no longer necessary for us to artificially impose non-negative conditions for the parameters to be estimated. Also, the EGARCH model allows innovations of different signs to have a different impact on volatility and allows bigger shocks to have a larger impact on volatility than does the standard GARCH model – it allows us to address the volatility asymmetry issue.[3] The EGARCH (1,1) model for this study is specified as following:

$$R_t = b_0 + b_1 R_{t-1} + b_2 \Delta OMO_t + \varepsilon_t$$

where

$$\varepsilon_t = z_t \sqrt{h_t}; \; \varepsilon_t \sim t(0, h, d), \; z_t \sim \text{iid}(0, 1) \tag{1}$$

$$\ln h_t = \alpha_0 + \alpha_1 \ln h_{t-1} + \alpha_2 \left(\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{\pi}{2}} \right) + \alpha_3 \left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right) + d_1 NAD_t$$

$$+ d_2 SID_t + d_3 FRI_t + d_4 MON_t + d_5 ANN_t + d_6 SWD + \phi_0 \Delta OMO_t \tag{2}$$

where R_t is the daily percentage change of 90-day BAB, and 3-year bond and AUD/USD futures prices from day $t - 1$ to day t. ΔOMO_t is the daily change of RBA's open market operations, from day $t - 1$ to day t. The conditional variance is $\ln h_t$, which is an EGARCH process of Nelson (1991) that allows for time-varying heteroskedasticity in the errors and volatility clustering. Parameter ϕ_0 captures the OMO effect. Parameter α_1 captures the persistence in volatility while α_2 captures the ARCH effect. The presence of leverage effects is tested by the hypothesis that the parameter $\alpha_3 < 0$. The impact is asymmetric if $\alpha_3 \neq 0.$[4]

In equation (2), *NAD* is a dummy variable for the day during which the RBA did not take action for the domestic market operations. *SID* is OMO's size dummy that equals to 1 if the absolute value of *OMO* in day t is greater than the sample daily average amount, and 0 otherwise. *MON* and *FRI* are dummy variables that take a value of 1 for Monday and Friday, respectively. *ANN* is an announcement dummy that takes 1 for the first Wednesday of each month when the RBA announces its cash rate stance decided on the previous day, and 0 otherwise. *SWD* is dummy variable for the days on which the Reserve Bank uses foreign exchange swaps for liquidity operations. An important adjustment of OMO operations made by the RBA in recent years has been the increased use of foreign exchange swaps for domestic liquidity management. The use of foreign exchange swaps can be seen as an extension of the collateral pool to include foreign currency government securities. The foreign currency delivered against the Australian dollars represents collateral in the same way that securities do in a domestic repo.

The role of the OMOs as a key monetary policy instrument in the policy transmission process may depend on a number of features. First, we need to consider the OMO effect together with the interest rate target announcement effect. If the OMO day is also on or close to the cash interest rate target announcement day, then the role of open market operations needs to be examined simultaneously with the cash interest rate target announcement effect. Second, the size of RBA's market operation matters. Similar to Kim *et al.*'s (2000) method for the Reserve Bank's interventions in Australian foreign exchange market, we suppose that the size of OMO transactions has to be substantial enough in order to influence the overnight cash interest rate and other short-term rates in the Australian money market and hence impact on the broader financial markets. We then test the significance of the dummy variable for the OMO size. Third, in the days when no market operation is conducted by the Reserve Bank, the role of OMO may still work through its signalling effect. 'No action' itself is also a policy stance of the central bank.

We test this by using a 'no-action dummy' which enables us to distinguish the difference between a normal day's open market operations and those 'zero transaction' anomalies. Fourth, we also incorporate Monday and Friday dummies to catch the day-of-the-week effect and weekend effect.

Empirical results

Table 12.2 reports maximum likelihood estimation results of the EGARCH model for the 90-day BAB futures market. In the mean equation, the autocorrelation coefficient b_1 is statistically significant, while the OMO effect in the mean equation is statistically insignificant. In the variance equation, the ARCH effect (captured by α_2) and volatility persistence, captured by α_1, are all significant at the 1% level. The leverage effect or asymmetric impact of past innovations on current volatility, captured by parameter α_3, is negative and significant at the 1% level, indicating the existence of a leverage effect in the short-term interest rate futures market.[5] The contemporaneous impact of OMOs on volatility, captured by parameter ϕ_0,

Table 12.2 (a) Estimated coefficients of maximum likelihood estimates for 90-day BAB futures market

Variable	Coefficient	S. E.
b_0	−0.0008	0.0015
b_1	−0.0546	0.0295*
b_2	−0.0018	0.1167
α_0	−11.3093	0.4891***
α_1	−0.8084	0.0752***
α_2	0.1925	0.0401***
α_3	−0.0859	0.0256***
ϕ_0	0.0134	0.0043***
d_1	0.0003	0.0006
d_2	−0.0001	0.0001
d_3	0.0032	0.0002***
d_4	0.0022	0.0001***
d_5	0.0013	0.0003***
d_6	−0.0010	0.0002***

(b) Model diagnostics for standardized residuals, 90-day BAB futures market

Mean	−0.0203
S. D.	0.9554
Skewness	1.4364
Kurtosis	24.1326
LB(10) for $Z_{i,t}$	19.704(0.032)
LB(10) for $Z_{i,t}^2$	7.6233(0.666)

Note:
***, **, * denote significance at 1%, 5% and 10% level, respectively.

is positive at the 1% significance level, indicating that the open market operations generate strong shocks on the short-term interest rate futures market and significantly increase conditional volatility in the 90-day BAB interest rate futures market.

Among six dummy variables, d_1 for no action dummy and d_2 for OMO's size dummy are statistically insignificant for the short-term interest rate futures market.

Parameter d_3 is significantly positively correlated with the return volatility in the futures market, suggesting that market volatility on Fridays tends to be larger than average in the short-term futures market. The parameter d_4 for Monday dummy is also significantly positively correlated with the return volatility in the 90-day BAB futures market, suggesting that OMOs tend to increase market volatility on Mondays for the 90-day BAB interest rate futures market.

The significant positive coefficient of d_5 in the variance demonstrates that market volatility is significantly higher on the days when the central bank regularly announces its monetary policy stance each month. Together with the findings of significant positive OMO effect in the 90-day BAB futures market, we have documented a significant positive contemporaneous OMO effect coexisting with the significant positive effect of cash rate target announcements. This result suggests that the impact of OMOs found here is probably independent of the interest rate target announcement effect. We are then in a good position to reject the hypothesis that the impact of OMOs on broader financial markets is a transitory effect resulting from shifting of beliefs among market participants due to monetary policy (the cash rate) announcements made by the Reserve Bank. Parameter d_6 captures the significance of the dummy variable where the Reserve Bank uses foreign exchange swap for liquidity management. The use of foreign exchange swaps can be seen as an extension of the collateral pool to include foreign currency government securities. The foreign currency delivered against the Australian dollars represents collateral in the same way that securities do in a domestic repo.

Coefficient d_6 is significantly negatively correlated with the return volatility in 90-day BAB futures market, suggesting that the Bank's using of foreign exchange swaps for liquidity management plays a role in explaining the significant effect of OMOs found in the short-term interest rate futures market. The Bank's use of foreign exchange swaps itself tends to reduce market volatility in the short-term interest rate futures contract.

Table 12.3 reports our estimation results for the AUD/USD exchange rate futures market. Both the autocorrelation coefficient b_1 and the OMO effect measured by b_2 in the mean equation are statistically insignificant. The ARCH effect captured by α_2 in the variance equation is insignificant, while the coefficient for volatility persistence α_1 is significant at the 1% level. The leverage effect captured by parameter α_3 is negative and significance at the 1% level, indicating that the impact of past innovations on current volatility is asymmetric in the AUD/USD exchange futures market. The contemporaneous impact of OMOs captured by parameter ϕ_0 is negative at the 1% significance level, indicating that the Bank's open market operations significantly reduce shocks on the currency futures market and thus smooth market conditional volatility for the currency futures contract.

Table 12.3 (a) Estimated coefficients of maximum likelihood estimates for AUD/USD futures market

Variable	Coefficient	S. E.
b_0	0.0078	0.0233
b_1	−0.0334	0.0319
b_2	0.0026	0.0022
α_0	−0.3715	0.0911***
α_1	0.3320	0.1427**
α_2	0.0481	0.0572
α_3	−0.1753	0.0420***
ϕ_0	−0.0050	0.0019***
d_1	−0.0814	0.0929
d_2	0.0428	0.0371
d_3	−0.1358	0.0476***
d_4	0.0333	0.0600
d_5	−0.1083	0.1166*
d_6	−0.1633	0.1238

(b) Model diagnostics for standardized residuals, AUD/USD futures market

Mean	−0.0105
S. D.	1.0029
Skewness	−0.2108
Kurtosis	3.9706
LB(10) for $Z_{i,t}$	8.4320(0.587)
LB(10) for $Z_{i,t}^2$	4.6355(0.914)

Note:
***, **, * denote significance at 1%, 5% and 10% level, respectively.

Dummy variable d_1 for no-OMO-transaction day is again insignificant, and d_2 for OMO's size dummy is also statistically insignificant for the currency exchange rate futures market. The Friday dummy d_3 is observed to be significantly negatively correlated with the return volatility in the AUD/USD currency futures market, suggesting that market volatility in weekends tends to be smaller than average. The Monday dummy d_4 is significantly not correlated with the return volatility in the currency futures market, suggesting that OMO transactions on Mondays tend to have no different impact compared to any other day of a week. The parameter d_5 for interest rate target announcement day dummy is significantly negatively related with the return volatility on the currency futures market, which suggests that the volatility during the Bank's cash interest rate target announcement day is lowered by the cash rate target announcement. The policy target announcement therefore calms the currency futures market by reducing the potential uncertainty of market perception regarding the Reserve Bank's monetary policy stance. Parameter d_6 for the Bank's use of foreign exchange swap is insignificant here in the currency futures market, suggesting that the Bank's using of foreign exchange swaps for liquidity management does not significantly impact on market volatility in the currency exchange rate futures market.

Table 12.4 (a) Estimated coefficients of maximum likelihood estimates for 3-year bond futures market

Variable	Coefficient	S. E.
b_0	0.0007	0.0025
b_1	−0.0189	0.0299
b_2	0.0733	0.1563
α_0	−9.2563	0.3813***
α_1	−0.7666	0.0711***
α_2	−0.0403	0.0495
α_3	−0.0676	0.0347*
ϕ_0	0.0121	0.0116
d_1	0.00380	0.0027
d_2	0.0016	0.0004***
d_3	−0.0013	0.0005***
d_4	0.0004	0.0007
d_5	−0.0014	0.0006**
d_6	−0.0020	0.0022

(b) Model diagnostics for standardized residuals, 3-year bond futures market

Mean	−0.0079
S. D.	0.9997
Skewness	−0.2648
Kurtosis	3.7334
LB(10) for $Z_{i,t}$	4.4999(0.922)
LB(10) for $Z_{i,t}^2$	31.956(0.000)

Note:
***, **, * denote significance at 1%, 5% and 10% level, respectively.

Table 12.4 reports estimation results of the EGARCH model for the 3-year bond futures market. The autocorrelation coefficient b_1 and the OMO effect b_2 in the mean equation are all statistically insignificant. In the variance equation, the ARCH effect measured by α_2 is insignificant, while the coefficient of volatility persistence, α_1, is significant at the 1% level. The leverage effect captured by parameter α_3, is again negative and statistically significant, indicating the existence of a leverage effect in the long-term interest rate futures market. However, our empirical results show that the Reserve Bank's open market operations do not have significant contemporaneous impacts on the long-term interest rate futures market. This result is consistent with the conventional notion that the central bank's monetary policy actions are mainly targeted on short-term money market interest rates. The effects of monetary policy may pass through to other financial rates via interactions between those short-term money market interest rates.

The coefficient d_1 for no-OMO-transaction day is again insignificant. The parameter d_2 for OMO's size dummy is statistically significant for the 3-year bond interest rate futures market. However, since an overall impact of OMOs on the 3-year bond futures market is not found, the significance of size dummy appears to be not very interpretable. Parameter d_3 for Friday dummy is significantly

negatively correlated with the return volatility, suggesting that market volatility in weekends tends to be smaller than average in the long-term interest rate futures market. Parameter d_4 for Monday dummy is insignificant; we fail to document any significant Monday effect of OMOs in the long-term interest rate futures market. Parameter d_6 for the Bank's use of foreign exchange swap is insignificant here in the long-term interest rate futures market, suggesting that the Bank's using of foreign exchange swaps for liquidity management does not significantly impact on market volatility in the 3-year bond futures market.

Similarly to the 90-day BAB short-term interest rate futures contract, parameter d_5 for interest rate target announcement day dummy is significantly correlated with the return volatility long-term interest rate futures market, which suggests that the monetary policy target announcement calms the 3-year bond futures market by reducing the market volatility. In fact, the positive sign of parameter d_5 found in the 90-day BAB futures market and the negative signs of parameter d_5 found in AUD/USD futures and 3-year bond futures markets may show that the monetary policy target rate announcement impacts financial markets differently. It increases volatility in the short-term interest rate futures market while smoothening market volatility in the long-term interest rate market and the currency futures market.

To sum up, empirical results from maximum likelihood estimation of the EGARCH model show that the impact of the Reserve Bank's open market operations does not disappear on 90-day BAB spot and futures markets when a strong interest rate target announcement effect exists, which implies that the Bank's domestic market operations affect the volatility of the short-end interest rate futures markets independently. A strong OMO effect coexisting with a strong cash interest rate target announcement effect is also found for the AUD/USD exchange rate futures market.

Conclusions

In this chapter, we examine the impacts of the Reserve Bank's OMOs on Australian interest rate and foreign exchange rate futures markets, using domestic market operation data obtained from the Reserve Bank and disclosed for the first time. We find that the Reserve Bank's open market operations have significant contemporaneous impacts on the short-term interest rate futures market. The OMO variable is found significantly positively correlated with the conditional volatility of the 90-day BAB futures market, suggesting that the Bank's OMOs actually increase market volatility in the short-term interest rate futures market.

A significant negative OMO effect is found for the AUD/USD exchange rate futures market, suggesting that the OMO transactions significantly reduce shocks on the currency futures market and thus smooth market conditional volatility for the currency futures contract. This result shows that the Reserve Bank's OMO transactions as well as monetary policy announcements calm the currency futures market by reducing the potential uncertainty of market perception regarding the Reserve Bank's monetary policy stance.

Those findings suggest that, as a key part of monetary policy, the OMOs conducted by the Reserve Bank convey important information that shapes financial market expectations and hence impact on the return volatility of financial assets. The empirical results from the maximum likelihood estimation of the EGARCH model also suggest that the OMO effect coexists with the interest rate target announcement effect. The impact of OMOs does not disappear on 90-day BAB futures and AUD/USD exchange rate futures markets when a strong interest rate target announcement effect exists, which implies that the Bank's domestic market operations affect the volatility of the short-term interest rate futures market and AUD/USD futures market independently.

Notes

1 The RBA's interest rate targets were first announced in 1990 and open market operations data have been published on the RBA website since January 2003.
2 We also test potential asymmetry of the volatility response to past innovations using a sign test model suggested by Engle and Ng (1993). For the sake of simplicity, we do not report here, but our results show significant sign-bias for 90-day BAB futures and considerable positive-sign bias for the three-year Treasury bond futures market. Overall, we reject the null hypothesis that the three parameters for sign-bias, negative size bias and positive size bias are all equal to zero for two out of three markets, which suggests that weak asymmetric effects on volatility exist for most of the markets under investigation.
3 The multivariate EGARCH specification can be adopted for this analysis (for example, see In *et al.* 2001, 2003). Unlike univariate GARCH models, EGARCH models permit volatility interactions to be *fully* investigated and analysed in a one-step estimation procedure. The possibility that innovation within and across three different financial markets influences volatility *asymmetrically* can be explicitly tested. However, as our research focus is the impact of the Reserve Bank's OMO on Australian financial markets rather than the investigation of volatility transmission mechanisms of the three different financial markets, we have adopted an EGARCH (1, 1) specification rather than the multivariate EGARCH approach.
4 A conditional standardized t distribution with variance h_t and degree of freedom d is used for the residual ε_t to account for possible conditional leptokurtosis (Bollerslev 1987). The log likelihood function is specified as:

$$\ln L = T\left[\ln \Gamma\left(\frac{d+1}{2}\right) - \ln \Gamma\left(\frac{d}{2}\right) - \frac{1}{2}\ln(d-2)\right]$$

$$- \frac{1}{2}\sum_{t=1}^{T}\left\{\ln h_t + (d+1)\ln\left[1 + \frac{\varepsilon_t^2}{h_t(d-2)}\right]\right\}$$

where $\Gamma(\cdot)$ is the gamma function, T is the number of observations, ε_t is the innovation at time t, and as d approaches infinity, the t distribution converges to standardized normal distribution (Kim and Sheen 2000).
5 Although parameter α_3 is highly significant and thus the strong asymmetric effect of 'bad news' is documented in our modelling results, we are not able to tell what caused that leverage effect. What we do know here is that the bad news, no matter what it is, generates larger shocks on return volatility from different financial markets.

13 Sustainability, inflation and public debt policy in Japan*

Takero Doi, Toshihiro Ihori and Kiyoshi Mitsui

Currently it is crucial for the Japanese government to implement tight public debt policy, because it has issued a huge amount of government debts. Japan's fiscal situation deteriorated rapidly with the collapse of the 'bubble economy' in the early 1990s and the deep and prolonged period of economic recession which ensued. The subsequent recovery has been slow and modest despite the implementation of Keynesian counter-cyclical policy. Since nominal national income did not grow much, tax revenue did not increase either. By contrast, government spending has been gradually raised due to the political pressure of interest groups, resulting in large budget deficits.

In 1997, the Japanese government tried to implement the Fiscal Structural Attempt so as to reduce budget deficits. However, in 1998, it stopped the attempt and reduced taxes and increased public investment based on the traditional Keynesian policy, because of the severe economic and financial situation, and the defeat of the governing party (the Liberal Democratic Party) in the Upper House election at that time.

The concern for sustainability of fiscal deficits is a background for the fiscal reconstruction and structural reform movement by the current Koizumi Administration. The 'Structural Reform of the Japanese Economy: Basic Policies for Macroeconomic Development' was decided upon after acceptance of the report compiled by the Council on Economic and Fiscal Policy, an advisory council to the Prime Minister. In this report core policies for the structural reform of the economy were made clear. As part of these policies, a goal to limit the amount of government bond issues to less than 30 trillion yen in the fiscal 2002 budget, and afterwards to achieve a primary surplus, was set, to show that it is necessary to take full-scale measures towards fiscal consolidation or fiscal reconstruction. However, in order to cope with the bad macroeconomic situation, 1.8 trillion yen of the advance tax cuts were employed with a view to strengthening the competitiveness of industry, facilitating a smooth transference of assets to the next generation, promoting a shift from 'saving to investment', advancing effective land use, and so on. The goal of limiting the amount of government bond issues to less than 30 trillion yen in the fiscal 2002 budget was finally abandoned. In fiscal 2005, new government

bond issues are 34.4 trillion yen and the bond dependency ratio has risen to 41.8% in the general account of central government.

The first sustained rise of the long-term interest rate may reflect an enhanced credit risk, if creditors fear that the government is going to be in debt trap. It is noted that although the issue of Japanese Government Bonds (JGBs) has been excessive, their yields are the lowest among the bonds of G7 countries. In this regard, despite its weakening credit ratings, the 10-year JGB nominal yield of about 1.5% in 2005 remains lower than the U.S. bond yield of about 1.8% registered during the Great Depression. However, we have to pay attention to deep deflation: the real rate of interest is not so low. Also, the market yield of the JGBs may not accurately reflect their credit risk. The Japanese banking sector continues to purchase the JGBs simply because short-term capital gains from the JGBs have been an easy option to offset the existing stock losses.

The purpose of this chapter is to analyse sustainability issues of Japan's fiscal policy and open market operations and then to discuss the optimal inflation and debt management policy based on the given maturity structure of government bonds using theoretical models and numerical studies. We also investigate the desirable coordination of fiscal and monetary policy in the process of fiscal reconstruction.

This chapter consists of four sections. In the first section we investigate sustainability issues using a simple overlapping generations model. Namely, we offer a theoretical study of the dynamic effects of inflationary taxes through expansionary open market operations in a debt-financed economy with indexed bonds and nominal bonds. In the next section, we evaluate Japan's inflation and debt management policy by developing a theoretical model for analysing the maturity structure of government bonds. We then implement a simple numerical analysis based on the smoothing rule derived from the theoretical model. Next, we discuss the desirable coordination of monetary and fiscal policy in the process of fiscal reconstruction. The problem in Japan is that the fiscal authority is too weak to cope with political pressures from various interest groups. We explain this aspect using a simple fiscal reconstruction model. Finally, concluding remarks close our discussion.

Sustainability issues and fiscal crisis

Concerns about sustainability

The purpose of this section is to study theoretically the dynamic implications of sustainability issues confronting a potential debt crisis. In this section we also study the dynamic behaviour of the model, where public debt and money holding are explicitly incorporated.

The events of the 1980s and 1990s in Japan suggest that when a government becomes strapped for funds, it will tend to borrow from the world credit market rather than raise taxes to finance additional public spending. Indeed, many governments either did not raise broadly based taxes, e.g. the Thatcher government in Great Britain or the Reagan and Bush Administrations in the United States, or simply could not raise taxes for fear of causing riots, e.g. countries in Latin American

and Eastern Europe, and, arguably, France in the reign of Louis XVI. There are long-term concerns about the accumulated fiscal deficit. An important one is whether such a large deficit can be sustained. The system will be paralysed if public finance collapses under the weight of a massive deficit. As a result, the financial system and the economy as a whole will be seriously affected. An extreme case of hyperinflation or default could develop.

The so-called chain-letter mechanism (or a Ponzi debt game) involves a situation where the future time-path of taxes is fixed and debt finance is used to pay for any additional public spending; debt issuance is thus endogenously determined by the government's budget constraint. If the mechanism is sustainable, increased taxation need not necessarily be required in order to finance increased government spending as the economy converges to the steady-state equilibrium. If the mechanism is unsustainable, the government will eventually go bankrupt in the sense that it will be unable to raise enough revenue to finance public spending and debt repayment. As debt crowds out private capital formation, the economy will also eventually go bankrupt if the mechanism fails. This suggests that studying the chain-letter mechanism and associated sustainability issues is quite important in terms of understanding the effects of government austerity (fiscal reconstruction) measures on the macroeconomy.

Burbidge (1983) contrasted the results of Samuelson (1958) and Gale (1973) with those of Diamond (1965) on debt policy and argued that the stock of debt is endogenous in the Samuelson-Gale model but exogenous in Diamond's model. McCallum (1984) investigated the chain-letter mechanism in a maximizing model that incorporates the crucial components of the Ricardian view, namely, infinite-lived agents who correctly take account of the government budget constraint. Ihori (1988) examined the chain-letter mechanism in a finite-horizon setting.

A simple way to evaluate the fiscal sustainability problem is to focus on the government bond market. In this regard for Japan, despite its weakening credit ratings, the 10-year Japanese Government Bond (JGB) nominal yield of about 1.5% remains in 2005. So far the myth that the JGBs are risk-free has been somehow propagated. This episode may imply that Japan's government solvency is not a serious issue right now. However, Japan has experienced deep deflation, so the real rate of interest is about 2%, which is not so low. We also have to pay attention to the possibility that the market yield of JGB's may not accurately reflect their credit risk.

Ihori *et al.* (2002) attempted a standard approach to test the fiscal sustainability condition, using the methodology of Hamilton and Flavin (1986). They examined Japanese fiscal data from 1957 to 1999. To conduct the test, the values for the nominal growth rate, n, and the nominal interest rate, r, must be specified. Their strategy was to set various values for $r - n$ and to check whether the results are sensitive to the values chosen. The estimated results imply that the null hypothesis cannot be rejected at a 5% significance level, suggesting that government solvency was not a serious problem until the 1996 fiscal year. In contrast, the result for the period 1957–1997 rejects the null hypothesis when $r - n$ is above 0.05, and the results for the period 1957–1998 and the period 1957–1999 also reject the null

hypothesis when $r - n$ is above 0.04. The longer the sample period, the more likely is fiscal crisis.

Bohn (1998) proposed a new method different from existing tests for sustainability of government debt. According to Bohn (1998), the test has better properties than the tests based on estimating a transversality condition and on cointegration tests. The condition that fiscal policy satisfies the intertemporal budget constraint, i.e. the condition on sustainability of government debt, is that the primary surplus to GDP (s_t) increases with the ratio of (start-of-period) debt to GDP (d_t). Strictly speaking, when we can express a relation between the two as

$$s_t = f(d_t) + \mu_t.$$

Suppose other determinants, μ_t, are bounded and the present value of future GDP is finite. Then, government debt satisfies a transversality condition if there is a debt-GDP ratio d^* such that $f'(d_t) \geq \beta > 0$ for all $d_t \geq d^*$, where β is a positive constant. We draw a scatter plot of s_t against d_t in Figure 13.1. Until the early 1990s, Japanese fiscal policy showed a quadratic relation between the two. Recently, Japanese fiscal policy has deviated from the relation substantially. Doi and Ihori (2003) showed that Japanese government debt does not satisfy a transversality condition for the fiscal years from 1965 to 2000 by estimating β.

These observations indicate that fiscal sustainability may become a serious issue. It follows that the chain-letter mechanism will cause a public debt crisis to occur in the near future. Japan has two serious difficulties in terms of sustainability. First, the Japanese primary surplus has apparently been a decreasing function of the debt-GDP ratio since 1990 and hence it does not satisfy Bohn's test. Second, the rate of interest was greater than the growth rate in Japan in the 1990s. Hence, it is important to reduce the government deficit in the near future.
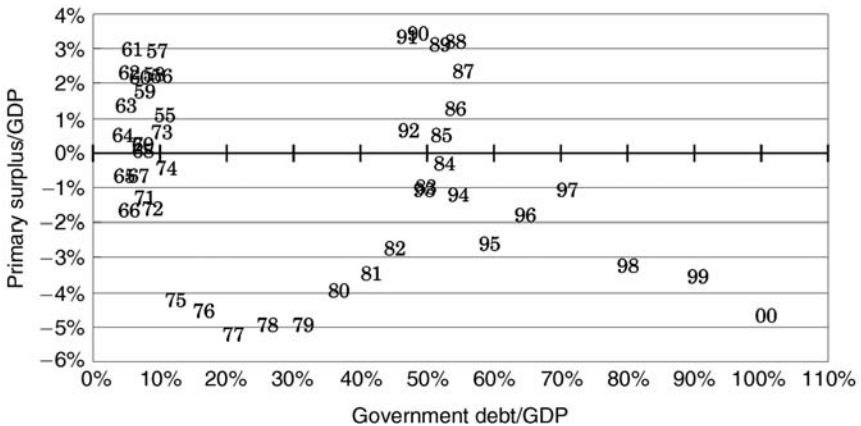
Figure 13.1 Primary surplus and government debt.

Theoretical framework

The young hold government debt to provide for consumption in old age. This requires confidence and trust. Valuation of an intrinsically useless and unbacked asset performing intergenerational transfers from the young to the old requires enough confidence that this asset will not be worthless in the future. But in facing the fiscal crisis no one can guarantee to the young that the rate of return on debt is the same as that of real capital. Put another way, the extent to which the debt burden will be transferred to the next generation is uncertain. This depends on the subjective possibility of future debt default. We then theoretically study the dynamic effects of inflationary taxes through open market operations as an emergency policy. Namely, from now on we investigate the dynamic implications of inflationary taxes in a debt-financed economy with indexed debt and nominal debt. We thus consider how subjective expectations of the future emergency attempt affect the sustainability of debt finance.

Although we have to impose the long-run solvency constraint, the economy can be off the stable manifold in the short run. People believe that sooner or later the policy will be changed so as to satisfy the solvency constraint. At the same time, they do not necessarily think that such a change will happen before they die. The purpose of this section is to investigate what kind of policy changes will be effective to satisfy the solvency condition in the long run. Thus, even if the economy is off the stable manifold initially, people would not expect the government to go bankrupt, because the government is assumed to be going to change the policy sooner or later. It seems that this sort of story is plausible in the real economy. In some countries, such as Japan, the government does not clearly satisfy the solvency condition if the present policy remains unchanged. People still hold the government bonds, which means that they anticipate a future change in fiscal policy so as to satisfy the solvency condition. We think that it is important to have a theoretical framework where it appears that the government will eventually go bankrupt but people still hold the debt.

An agent of generation t is born at time t, considers itself 'young' in period t, 'old' in period $t + 1$, and dies at time $t + 2$. When young an agent of generation t supplies one unit of labour inelastically and receives wages w_t out of which the agent consumes c_t^1, and saves a_t in period t. An agent who saves a_t receives $(1 + r_{t+1})a_t$ when old, which the agent then spends entirely on consumption, c_{t+1}^2 in period $t + 1$. Parameter r_t is the rate of interest in period t. Saving a is invested partly in real capital s which does not depreciate and is a perfect substitute for the consumption good, and partly in government (indexed) bonds b purchased from the older generation. We also incorporate money holdings m. In the second period, the agent, leaving no bequests, consumes all of his accumulated wealth.

Consider the maximizing problem facing a consumer representative of generation t. He chooses c_t^1, c_{t+1}^2, s_t, b_t, and m_t to maximize $u(c_t^1, c_{t+1}^2, m_t)$ subject to $c_t^1 = w_t - T - s_t - b_t - m_t$ and $c_{t+1}^2 = (1 + r_{t+1})(s_t + b_t) + m_t/(1 + \pi_{t+1})$, where T is an exogenously given lump sum tax levied in the first period of his life and π is the rate of inflation. We now include m_t in the utility function explicitly,

since we consider the effect of a change in inflationary taxes in this section. Note that $m_t (= M_t/p_t)$ is real money balances and $\pi_{t+1} (= 1 - p_{t+1}/p_t)$ is the rate of inflation from period t to period $t + 1$, where M_t is nominal money balances and p_t is the price level in period t.

Since government (indexed) debt and real capital are both safe assets and perfect substitutes, the agent's portfolio composition is indeterminate. Then, the total amount of asset accumulation $a (= s + b)$ will be a function of w, r, T, and π. Thus,

$$a = a(w, r, T, \pi). \tag{1}$$

We know $1 > a_w = \partial a/\partial w > 0$, $a_r = \partial a/\partial r \geq 0$ and $-1 < a_T = -a_w = \partial a/\partial T < 0$. What is the effect of π on a? This depends on the effect of π on the marginal utility of consumption in each period. It is easy to show that $a_\pi = \partial a/\partial \pi$ is positive since the negative income effect of an increase in π would reduce the first-period consumption.

A chain-letter mechanism (or a Ponzi debt game) of debt finance means that taxes are predetermined and government debt issuance is endogenously determined by the government budget constraint. Then the rate of inflation π is set by the monetary authority. At first from now on, for simplicity we assume that the central bank commits to the zero-inflation policy at the benchmark case; $\pi = 0$. Thus, the government budget constraint in period $t + 1$ reduces to;

$$b_{t+1} = \frac{(1 + r_{t+1})b_t}{1 + n} + cg - T \tag{2}$$

where c is the marginal cost of the (per-capita) public good g assumed constant for simplicity and n is the population growth rate. We will assume that the primary balance is in surplus $(T > cg)$ and the interest rate is greater than the growth rate $(r > n)$ in a steady state in this subsection.

The bond and capital markets clear:

$$a(w_t, r_{t+1}, T, \pi) = -(1 + n)w'(r_{t+1}) + b_t \tag{3}$$

where $w = w(r)$ is the factor price frontier; $w'(r_t) = -k_t < 0$, $w' > 0$, and k is the capital-labour ratio.

A government is solvent if it does not pursue policies that force the private sector into bankruptcy when an alternative policy exists that would not do so. The private sector is bankrupt when the non-negativity constraints on consumption by the young, consumption by the old, or the capital stock become binding. The stock of public debt is limited by the condition that the total amount of resources taken by the government from the young, whether through borrowing or through taxes, cannot exceed the wage income of the young. As shown by Buiter and Kletzer (1992), if the government can make net transfer payments to a generation when it is young and impose net taxes on that generation when it is old, and if these transfer payments

and taxes can grow at least at the rate of interest, Ponzi finance is possible. This is true regardless of the relationship between the interest rate and the growth rate, and regardless of whether or not the economy is dynamically inefficient or Pareto efficient. If either of these assumptions is violated, the solvency constraint implies that the sequence of public debt discounted at the rate of interest converges to zero.

The dynamic system can be summarized by (2) and (3). Let us investigate the dynamic properties of this economy using a phase diagram in Figure 13.2. From (3) we have

$$r_{t+1} = R(r_t, b_t; T, \pi) \tag{4}$$

where

$$R_r = \frac{\partial r_{t+1}}{\partial r_t} = -\frac{a_w w'}{a_r + (1+n)w''} \tag{5a}$$

$$R_b = \frac{\partial r_{t+1}}{\partial b_t} = \frac{1}{a_r + (1+n)w''}. \tag{5b}$$

To analyse the behaviour of r_t, we first find the locus of (b, r) where $r_{t+1} = r_t$. We call this locus the *rr* curve. From (4) this locus is given as

$$r = R(r, b; T, \pi). \tag{6}$$
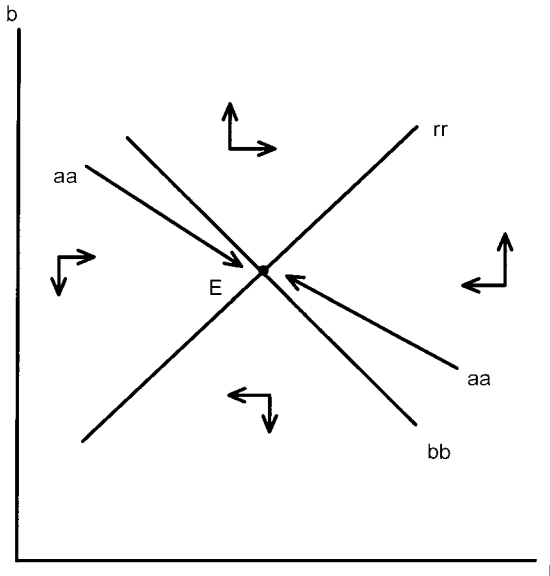
Figure 13.2 Phase diagram of government debt policy.

Totally differentiating (6), we have the slope of the *rr* curve as

$$\frac{db}{dr} = \frac{1 - R_r}{R_b} = (1+n)w'' + a_w w' + a_r. \tag{7}$$

Equation (7) is likely to be positive when the elasticity of substitution between capital and labour is large. Inequality $(1+n)w' + a_w w' + a_r > 0$ is a local stability condition in the basic economy of Diamond (1965). We will assume this condition holds.

Hence, the *rr* curve is upward sloping. From (5*b*), $\partial r_{t+1}/\partial b_t$ is positive. Hence, above the *rr* curve $r_{t+1} > r_t$, and below this locus, $r_{t+1} < r_t$. If *b* were unchanged, above (below) this locus *r* would increase (decrease).

Next, consider the behaviour of b_t. From (2) we have

$$b_{t+1} = \hat{B}(r_{t+1}, b_t; T, \pi).$$

Substituting (4) into the above equation, we have

$$b_{t+1} = \hat{B}[R(r_t, b_t; T, g), b_t; T, \pi] = B(r_t, b_t; T, \pi) \tag{8}$$

where

$$B_r = \frac{\partial b_{t+1}}{\partial r_t} = \frac{R_r b}{1+n} \tag{9a}$$

$$B_b = \frac{\partial b_{t+1}}{\partial b_t} = \frac{R_b b + 1 + r}{1+n}. \tag{9b}$$

Totally differentiating (8) in the steady state, we have the slope of the *bb* curve as

$$\frac{db}{dr} = -\frac{R_r b}{r - n + R_b b} = \frac{a_w w' b}{(r-n)[a_r + (1+n)w''] + b} \tag{10}$$

which is negative at the neighbourhood of an equilibrium. The *bb* curve is downward sloping. From (9*a*) we know that if $b > 0$ on the right-hand side of the *bb* curve, $b_{t+1} > b_t$, and on the left-hand side of the *bb* curve, $b_{t+1} < b_t$. If *r* were unchanged, on the right (left) hand side of the *bb* curve *b* would increase (decrease).

The dynamic properties of the system are depicted in the phase diagram in Figure 13.2. For given tastes, technology and policy, there is a unique steady-state equilibrium point *E*. From a stability point of view, point *E* is a saddle-point and hence unstable except along one convergent path *aa*.

There are three possibilities for the government's public debt policy.

(i) Eventual bankruptcy

Above the convergent path, b and r will eventually approach infinity. As b increases, savings of real capital will decrease. The economy ends up in a vicious circle where the government borrows to finance the interest payments on its continually increasing stock of public debt. As soon as public borrowing completely absorbs private saving, the stock of capital is exhausted, and all economic activities stop. It seems reasonable to call such a situation bankruptcy of the economy. The paths above the convergent path will not be equilibrium paths and hence will be unsustainable. The government cannot roll its debt over forever in dynamically efficient economies. If the future austerity programmes are expected, however, it is possible for the economy to be above the convergent path for a while.

(ii) Saddle-point equilibrium

If the economy is initially on the *aa* path, the economy eventually approaches point E; the chain-letter mechanism will be sustainable in the long run. In the steady state, $T = cg + (r - n)b$, or $b = (T - cg)/(r - n)$, which means that debt is balanced with the discounted present value of primary surpluses. In such a case the government is able to issue new debt to finance the interest and redemption of its inherited stock of debt as the economy converges to the steady-state equilibrium.

(iii) Balanced budget policy

If the economy is initially below the *aa* curve, it will eventually approach the point where $b = 0$. In that case, the government can attain the (primary) balanced budget of $T = cg$ by reducing taxes or raising spending, both of which are most likely to be politically acceptable policies and such policies would in general be Pareto-improving. Thus, the convergent path *aa* determines the maximum sustainable public debt at the given level of capital stock.

Future emergency attempts

Many governments prefer to rely on the issuance of debt rather than explicit taxation in financing expenditures. Recent experience suggests that a number of countries are facing potential bankruptcy as a result of issuing too much debt. As we have shown, the chain-letter mechanism is more likely to be unsustainable when the initial interest rate and stock of government debt are larger or when the propensity to save and the growth rate are lower above the convergent path *aa*. Such a situation might be relevant for the recent Japanese economy.

When the government eventually goes bankrupt, austerity measures such as fiscal reconstruction will be required. The consequences will depend critically on the response of the private sector to the specific austerity policy and more

specifically on the response of capital accumulation. Serious mistakes, which will possibly exacerbate the bankruptcy problem, may occur if the wrong action is taken. The conventional wisdom suggests that the government must either raise taxes or dramatically reduce spending. This is contingent on an increase in capital accumulation taking place in response to the change in policy. However, whether these contractions will be effected through cuts in spending or increases in explicit tax collections, and when these actions will be taken, is in general unknown. Expectations of future policy changes are crucial in understanding seemingly counterintuitive macroeconomic dynamics. Bertola and Drazen (1993) argued that expectations about the discrete character of future fiscal adjustments could help explain the effects of current fiscal policy. They showed that if government spending follows an upward-trending stochastic process which the public believes may fall sharply when it reaches specific 'trigger' points, then optimizing consumption behaviour and simple budget-constraint arithmetic imply a nonlinear relationship between private consumption and government spending. This theoretical relation is consistent with the experience of several countries.

A recent line of economic research suggests that private agents realize that current bond-financed deficits carry with them future tax obligations. Anticipating higher future taxes, private agents change current spending behaviour to smooth consumption intertemporally. Although the econometric study of this issue is still in its infancy, some recent research indicates that private Japanese behaviour has partially offset recent changes in fiscal policy; see Ihori and Sato (2002) among others.

In reality, it may be difficult to employ the standard austerity measures at the proper time. For example, Japan's fiscal policy in 1990s showed a tendency to postpone fiscal reconstruction attempts. The consensus at the time was that there was no immediate need for such painful measures as long as government policy prevented the economy from slipping into recession. There was, indeed, a widespread feeling in the private sector that the government would come to its aid if the economic situation worsened. That feeling fostered complacency in the business world, making many corporate managers liable to 'moral hazard' – risks stemming from lack of self-discipline. The continuation of the short-term stimulus policy, at a time when the economy needed long-term structural changes, discouraged self-help efforts in the private sector. Lobbying activities of local interest groups were exaggerated in the 1990s, as shown in empirical evidence in Ihori *et al.* (2001) and Doi and Ihori (2002). This is also one of the main reasons why Japan's fiscal reconstruction did not perform very well in the 1990s.

It is thus argued that if the current deficits seem unsustainable and the fiscal authority cannot take any action, the monetary authority in such countries will be forced in effect to repudiate their debt. One option is inflation depreciation (inflationary taxes) through expansionary open market operations. We may call such a policy change the emergency monetary attempt at debt repudiation. It should be stressed that if the private sector recognizes such possibilities of future emergency monetary attempts, government bonds and real capital may no longer be regarded as perfect substitutes. The more likely it is that the current deficits seem

not sustainable, the higher is the private sector's subjective probability of the future emergency monetary attempt.

Several important papers investigated debt Ponzi games under uncertainty. The average riskless rate may be a poor guide as to whether permanent rollover of debt is feasible when economies are stochastic. Blanchard and Weil (1992) showed that whether or not governments can rollover debt in dynamically efficient economies depends on whether the issuance of public debt can partially substitute missing markets. Bohn (1991) showed that the sustainability, even of simple policy rules such as balanced budgets or tax rate smoothing, should not be taken for granted in a stochastic economy and that sustainability is often sensitive to assumptions about debt management. The sustainability question in stochastic models is an aspect of fiscal policy that deserves more attention in future research and in policy-making.

Bearing these aspects in mind, we formalize one such psychological phenomenon: subjective probability. Put another way, it is not certain to what extent the debt burden will be transferred to the next generation. That depends on the private sector's subjective evaluation of the possibility of a future emergency monetary attempt. Holding government debt to provide for old-age consumption requires confidence and trust since no one can guarantee the young that the rate of return on debt is the same as that on real capital.

Inflationary taxes with indexed debt

We consider inflationary taxes through expansionary open market operations, which are conducted by the central bank as the emergency monetary attempt of the last resort. The fiscal authority does not (or cannot) take any actions for fiscal reconstruction. In this subsection we only consider indexed bonds. The private sector does not necessarily know if the central bank really will take this action. Let us denote by θ the subjective probability of the future emergency attempt of inflationary taxes. In other words, $1 - \theta$ is a subjective probability that all of the debt burden will be transferred to the next generation.

We assume that utility is time-separable and that consumers are Von Neumann-Morgenstern expected utility maximizers. A young person born at t chooses

$$c_t^1, c_{t+1}^1, s_t, b_t, m_t$$

to maximize

$$\mathrm{E}_t\left[u\left(c_t^1\right) + v(m_t) + \sigma u\left(c_{t+1}^2\right)\right]$$

subject to

$$c_t^1 = w_t - s_t - b_t - T_t - m_t \tag{11}$$

$$c_{t+1}^{2+} = (1 + r_{t+1})s_t + (1 + i_{t+1})b_t + m_t \quad for \ pb. = 1 - \theta \tag{12a}$$

$$c_{t+1}^{2-} = (1 + r_{t+1})s_t + (1 + i_{t+1})b_t + m_t - \tau_{t+1} \quad for \ pb. = \theta \tag{12b}$$

where σ is the subjective discount factor. E( ) denotes the expected value conditional on information available to the young, i is the rate of return on government debt, and τ is an inflationary tax levied in the second period of his life; $\tau_{t+1} = \dfrac{m_t \pi_{t+1}}{1 + \pi_{t+1}}$.

For simplicity, $cg = T_t$: the primary balance is assumed without the emergency attempt. The (expected) government budget constraint in period $t + 1$ is now given as

$$b_{t+1} = \frac{1 + i_{t+1}}{1 + n} b_t - \frac{q\tau_{t+1}}{1 + n}. \tag{13}$$

Here the central bank introduces an inflationary tax τ with probability q. If $q = 0$, the central bank does not actually introduce expansionary open market operations. If $q = 1$, the central bank certainly introduces inflationary taxes through expansionary open market operations. If $q = \theta$, the expectation of the private sector is fulfilled.

Even if the emergency attempt is uncertain, there is no uncertainty about the net rate of return on (indexed) government debt. Government debt and real capital are both safe assets and perfect substitutes. Portfolio composition would be irrelevant.

Then, the first-order condition is simply

$$E_t u'(c_t^1) = (1 + r_{t+1})\sigma E_t u'(c_{t+1}^2). \tag{14}$$

The total saving $a \ (= s + b)$ will be a function of w, r, θ and τ. An increase in θ will reduce the expected disposable lifetime income and hence the first-period consumption. It follows that the total savings will increase with θ.

An increase in θ has two stabilizing effects. First, the real saving of the private sector increases because the expected lifetime income and the desired first-period consumption decrease. Second, the rate of interest on government debt falls due to capital accumulation. The *rr* curve shifts upward in Figure 13.2 by an increase in θ. The greater the value of $\partial a/\partial \theta$, the more likely it is that the chain-letter mechanism becomes sustainable in the long run. The government budget may avoid bankruptcy if θ is raised enough. An increase in the subjective probability of the future emergency attempt has a desirable effect on the sustainability of the system and long-run welfare.

An increase in q or τ will have a similar stabilizing effect. Note that an increase in τ will directly improve the fiscal balance and have an indirect stabilizing effect by stimulating real saving. Both the *rr* curve and *bb* curve shift upward by an increase in q. These results are intuitively plausible.

Inflationary taxes with nominal debt

We now consider the opposite extreme case where the government only issues nominal bonds. When inflation occurs, we have as the inflationary taxes

$$\tau_{t+1} = \frac{m_t \pi_{t+1}}{1 + \pi_{t+1}} + \frac{b_t \pi_{t+1}}{1 + \pi_{t+1}} \tag{15}$$

which now includes taxes on holding nominal bonds.

Now consumers believe that the net rate of return $\hat{i} \left(= i - \dfrac{\pi}{1 + \pi} \right)$ is a random variable, depending on the subjective probability of inflationary taxes, θ. The first-order conditions for an interior maximum are given as

$$\mathrm{E}\big[u'(c_t^1) - \sigma(1 + r_{t+1})u'(c_{t+1}^2)\big] = 0 \tag{16}$$

$$\mathrm{E}\big[u'(c_t^1) - \sigma(1 + \hat{i}_{t+1})u'(c_{t+1}^2)\big] = 0. \tag{17}$$

As for the comparative static results, all income effects are positive. An increase in w will raise both s and b. It is possible to increase both present consumption and future consumption from the levels enjoyed before the change in yield. As for substitution effects, direct substitution effects are positive, while the signs of the cross-substitution effects are indeterminate. If the debt burden is more likely to be transferred to the next generation (i.e. the subjective probability of the introduction of the emergency attempt is lowered), the demand for debt, the risky asset, increases.

An increase in the subjective probability of an introduction of inflationary taxes θ has two real effects. The first effect is that the gross rate of return on government debt increases because debt is now perceived as more risky by the private sector. The *bb* curve shifts downward. The second effect is that the real savings of the private sector may or may not increase because capital is more attractive than debt to the private sector, while the gross rate of return on government debt is raised. The first effect is destabilizing, while the second effect may or may not be stabilizing. In the special case of the Cobb-Douglas utility function the second effect is assumed away because the total savings are dependent only on the lifetime labour income. It follows that the higher the subjective probability of default, the more likely it is that the economy eventually goes bankrupt. In this sense, the subjective expectation becomes self-fulfilling.

We then consider the extreme case of $q = \theta = 1$. After the introduction of inflationary taxes there is no uncertainty about the net rate of return on government debt. We have $i - \dfrac{\pi}{1 + \pi} = r$, and real capital and government debt become perfect substitutes as in the indexed debt case.

Although the inflationary tax by expansionary open market operations is always effective to alleviate fiscal crisis, an increase in the subjective probability of inflationary tax is not necessarily effective in the case of nominal bonds. This is because debt is then perceived as more risky by the private sector and hence the gross rate

of return on government debt increases. Thus, the issuance of indexed bonds may be better than the issuance of nominal bonds when the private sector is concerned with the future fiscal crisis.

Remarks

In the overlapping generations framework Tirole (1985) and Weil (1989) examined deterministic and speculative bubbles, which are, like government debt, inter-generational schemes based on trust. Weil considered a two-state model with real capital and a bubble. The bubble has probability θ of bursting every period. The main result in Weil is that the highest sustainable bubble (the equivalent of the highest sustainable debt in the present chapter) decreases with the probability of bursting (debt repudiation).

Economic theory has begun to catch up with political reality. It has done this not only by studying the optimality of inflation and debt policy in a context where explicit account is taken of the government's budget constraint, but it has gone a step further by examining the time consistency of optimal policy. Here, it is the issue of whether it is optimal to keep promises that were optimal to make in the past. The latter lies at the heart of the credibility dilemma faced by any serious politician. Calvo (1988) studied models in which debt repudiation is possible and showed that expectations may play a crucial role in the determination of equilibrium. See also Chari and Kehoe (1993) and Bulow and Rogoff (1989).

The fiscal and monetary regime prevailing in an economy, as well as the type of fiscal relationships expected to arise from a such a regime, is an important factor in determining the response of private agents to fiscal signals. Fiscal and monetary regimes differ across countries and change over time. At each point in time there is uncertainty about the regime that will prevail from then on. A high government deficit financed by debt can be regarded as unsustainable and therefore may be taken to signal future contractions in the deficits. Alesina *et al*. (1989) showed that the maturity structure of public debt might influence the likelihood of a confidence crisis on the debt. The shorter and more concentrated the maturity, the more likely is a confidence crisis. See also Giavazzi and Pagano (1989). We will investigate inflation and debt management policy in the following section.

Debt management policy of the Japanese government

Japan's government bonds

The Japanese government currently issues government bonds, which can be classified into six categories: short-term (6-month and 1-year Treasury bills); medium-term (2-year and 5-year bonds); long-term (10-year bonds); super-long-term (15-year, 20-year and 30-year bonds); government bonds for individual investors; and inflation-indexed bonds. The short-term government bonds are all discount bonds. On the other hand, all medium, long and super-long-term government bonds, except for the 15-year floating-rate bonds, are bonds with

fixed-rate coupons. The 15-year floating-rate bonds and the government bonds for individual investors feature a coupon rate that varies according to certain rules. The inflation-indexed bonds are issued as the 10-years bonds to finance funds for the Fiscal Investment and Loan Programme.[1]

The planned issue amount of each JGB for fiscal 2004 is shown in Table 13.1. In the past, there used to be some other types of government bond. But after the August 1988 3-year fixed-rate bonds, the September 2000 5-year discount bonds, the February 2001 4-year fixed-rate bonds, the March 2001 6-year fixed-rate bonds and the November 2002 3-year discount bonds, these bonds have never been issued. The current maturity structure of the government bonds (outstanding basis) is shown in Figure 13.3.

Theoretical framework of debt management policy

In this section we develop a theoretical model based on Beetsma and Bovenberg (1997a,b). We also include the maturity structure of the government bonds in the model. There are households, firms, the fiscal authority (government) and the monetary authority (central bank). The households live for three periods. The firms produce a private good by using labour, at given price level, P_t ($t = 1, 2, 3$). Their production function is $Y_t = L_t^{\eta}$ ($0 < \eta < 1$), where Y_t denotes output, L_t denotes input of labour. Their profit is described as $(1 - \tau_t)P_t L_t^{\eta} - W_t L_t$, where W_t denotes nominal wage rate. The firms' output is taxed at a rate τ_t.

The households organize labour unions, the objective of which is to obtain a target real wage rate. They are assumed to expect inflation rationally. We also assume that the unions have monopoly power in the labour market. By normalizing the logarithm of the real wage rate to zero, the (log) of the nominal wage rate is set equal to the (rationally) expected price level.

Under such assumptions, the logarithm of output $y_t \equiv \ln Y_t$ is determined as

$$y_t = \frac{\eta}{1 - \eta}\left(\pi_t - \pi_t^e - \tau_t + \ln \eta\right)$$

where $\pi_t \equiv \dfrac{P_t - P_{t-1}}{P_t}$, π_t^e denotes the inflation rate expected by the private sector. Since $\dfrac{\eta}{1 - \eta}\ln \eta$ is a constant, we set $v \equiv \dfrac{\eta}{1 - \eta}$, and normalize y_t as follows

$$x_t \equiv y_t - v \ln \eta = v\left(\pi_t - \pi_t^e - \tau_t\right) \tag{18}$$

where (18) is the Lucas supply function.

In a rational expectations equilibrium ($\pi_t = \pi_t^e$), if there is no tax distortion ($\tau_t = 0$), the normalized output is given as $x_t = 0$. This normalized output level corresponds to the natural rate of employment, as mentioned in Fujiki *et al.* (1998). Moreover, the socially desirable output, $\tilde{x}_t$, without any distortion of resource allocation is positive, because the socially desirable employment is allowed to

Table 13.1 Japanese government bonds (classification by issuance methods and maturity) (Billion yen)

	Planned Issuance for FY2003 Initial Budget (a)	Planned Issuance for FY2004 Initial Budget (b)	(b) − (a)
30-year Bonds	1,600.0	2,000.0	400.0
20-year Bonds	4,800.0	6,900.0	2,100.0
15-year Bonds	5,500.0	6,000.0	500.0
10-year Bonds	22,800.0	22,800.0	−
5-year Bonds	22,800.0	22,900.0	100.0
2-year Bonds	20,960.0	19,250.5	−1,709.5
Treasury Bills	34,170.9	34,170.9	−
Inflation-indexed bonds	100.0	600.0	500.0
Total amount in the market	112,730.9	114,621.4	1,890.5
(excluding Treasury Bills)	(78,560.0)	(80,450.5)	(1,890.5)
Postal Savings	2,100.0	2,300.0	200.0
Bank of Japan	6,441.9	13,219.3	6,777.4
Fiscal Loan Fund	400.0	1,000.0	600.0
Fiscal Loan Fund Special Account Bonds (transitional measures)	18,550.0	29,600.0	11,050.0
Postal Savings	9,960.0	19,700.0	9,740.0
Pension Reserves	5,650.0	7,500.0	1,850.0
Postal Life Insurance	2,940.0	2,400.0	−540.0
Total amount in public sector	27,491.9	46,119.3	18,627.4
JGB for individual investors	1,200.0	1,600.0	400.0
Total	141,422.8	162,340.7	20,917.9

Source: Ministry of Finance 'Planned Bond Issuance for FY 2004'.

Notes:

Figures may not sum because of rounding.

The amount of buy-backs will be approximately 1,000.0 billion yen in FY2003, and approximately 2,000.0 billion yen in FY2004.

Figure in 'Bank of Japan' in 'Planned Issuance for FY2004 Initial Budget' includes 400.0 billion yen of refunding bonds to be issued for the same amount of buy-backs from the Bank of Japan.

Figure in 'Fiscal Loan Fund' indicates refunding bonds to be issued for the same amount of buy-backs from the Fiscal Loan Fund. At the Fiscal Loan Fund Special Account, funds for the Fiscal Investment and Loan Programme are managed.

Twenty-year bonds issuance in FY2003 will be increased by 600.0 billion yen, to meet requests from market participants, which will be transferred within refunding bonds (i.e. 2-year bonds issuance will be reduced by the same amount).

The issue amount of JGB for Individual Investors in FY2003 will exceed its initially planned amount (1,200.0 billion yen in 'Planned Issuance for FY2003 Initial Budget').

For New Financial Resource Bonds in the FY2003 Supplementary Budget, the Construction Bonds issuance will be increased by 273.0 billion yen and the Special Deficit-Financing Bonds issuance will be reduced by 273.0 billion yen from its initially planned amount shown in 'Planned Issuance for FY2003 Initial Budget'.

Maturity Structure of Government Bonds
Outstanding Basis
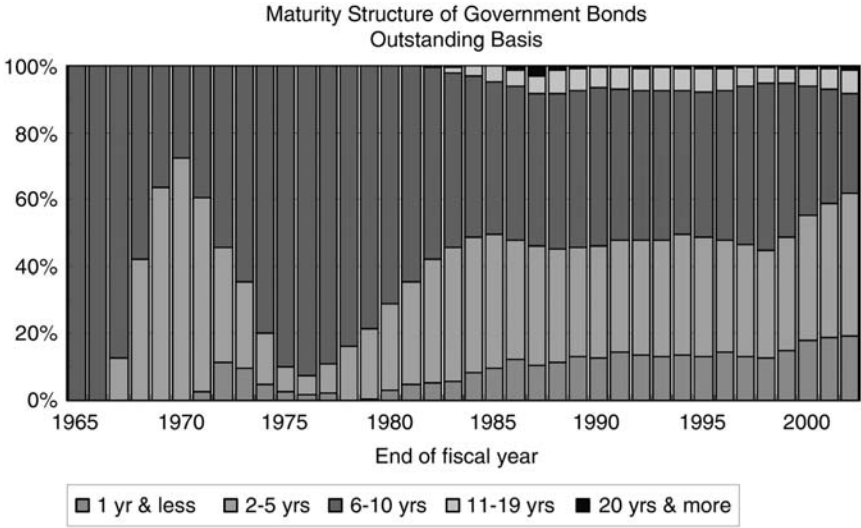
Figure 13.3 Maturity structure of government bonds (outstanding basis).

exceed the natural rate of employment, as pointed out in Beetsma and Bovenberg (1997a,b). Hereafter $\tilde{x}_t$ is assumed to be given as a positive constant exogenously.

Next, we describe the behaviour of the monetary authority. The monetary authority decides money supply in each period. We presume that the quantity theory of money holds;

$$\frac{M_t}{P_t} = \kappa \tilde{X}_t$$

where κ is a constant, M_t denotes nominal money supply, and $\tilde{X}_t \equiv \exp(\tilde{x}_t)$. Since $\tilde{X}_t$ is given exogenously, the monetary authority determines the inflation rate directly through controlling money supply. Therefore, $\dfrac{M_t - M_{t-1}}{M_t} = \pi_t$ in this model.

Finally, we consider the government's behaviour. The government (or fiscal authority) collects revenues from taxes, bond issuing and seigniorage. Its revenues are used for fiscal expenditures and repayment of government bond. The government can issue (inflation-indexed) bonds, and choose their maturity. We assume that the pure expectation hypothesis is held. In such a situation, the fiscal authority faces the following budget constraint in each period;

$$P_1 G_1 + (1 + r_{B1}) P_1 B_{01} = \tau_1 P_1 X_1 + (M_1 - M_0) + P_1 (B_{12} + B_{13})$$

$$P_2 G_2 + (1 + r_{B1})(1 + r_{B2}) P_2 B_{02} + (1 + r_{B2}) P_2 B_{12}$$

$$= \tau_2 P_2 X_2 + (M_2 - M_1) + P_2 B_{23}$$

$$P_3 G_3 + (1 + r_{B1})(1 + r_{B2})(1 + r_{B3})P_3 B_{03} + (1 + r_{B2})(1 + r_{B3})P_3 B_{13}$$

$$+ (1 + r_{B3})P_3 B_{23} = \tau_3 P_3 X_3 + (M_3 - M_2)$$

where G_t denotes real government expenditures, r_{Bt} denotes interest rate of bonds in period t, and B_{st} denotes the amount of bonds issued in period s with a prescribed payout in period t. Since B_{01}, B_{02}, and B_{03} are issued in period 0, they are exogenously given for the government. The government choose G_t, τ_t, B_{ts} $(t + 1 \leq s \leq 3)$.

Dividing both sides of the above budget constraints by $P_t \widetilde{X}_t$ gives the following budget constraints in share of non-distortionary (normalized) output:

$$g_1 + (1 + r_{B1})b_{01} = \tau_1 + \kappa \pi_1 + b_{12} + b_{13} \tag{19a}$$

$$g_2 + (1 + r_{B1})(1 + r_{B2})b_{02} + (1 + r_{B2})b_{12} = \tau_2 + \kappa \pi_2 + b_{23} \tag{19b}$$

$$g_3 + (1 + r_{B1})(1 + r_{B2})(1 + r_{B3})b_{03} + (1 + r_{B2})(1 + r_{B3})b_{13}$$

$$+ (1 + r_{B3})b_{23} = \tau_3 + \kappa \pi_3 \tag{19c}$$

where $g_t \equiv G_t / \widetilde{X}$, $b_{st} \equiv B_{st} / \widetilde{X}$. We presume that $X_t \approx \widetilde{X}_t \approx \widetilde{X}$ (a constant).

For simplicity, the real interest rate is assumed to be equal to the world interest rate ρ, which is constant over time: $r_{Bt} = \rho$. From (19a, b, c) we can obtain the integrated government budget constraints as follows:

$$g_1 + \frac{g_2}{1 + \rho} + \frac{g_3}{(1 + \rho)^2} + (1 + \rho)(b_{01} + b_{02} + b_{03})$$

$$= \tau_1 + \kappa \pi_1 + \frac{\tau_2 + \kappa \pi_2}{1 + \rho} + \frac{\tau_3 + \kappa \pi_3}{(1 + \rho)^2}. \tag{20}$$

Second-best solution

In this subsection, we analyse the most desirable case with distortionary taxes, where the two policy-makers are integrated and are committed to their policy announcements. We deal with the situation in which the government and the central bank are integrated and are credibly committed to their policy announcements. The credible commitment particularly implies that the policy makers announce an inflation rate and commit themselves to the announced rate at the beginning of each period before nominal wages are concluded.

The society has the social loss function V, which is represented by

$$V = \frac{1}{2} \sum_{t=1}^{3} \beta_S^{t-1} \left[\alpha_{\pi S} \pi_t^2 + (x_t - \tilde{x})^2 + \alpha_{gS}(g_t - \tilde{g}_t)^2 \right] \tag{21}$$

where $\alpha_{\pi s} > 0$, $\alpha_{gS} > 0$, and β_S denotes the discount factor, $0 < \beta_S \leq 1$. We define $\tilde{g}_t$ as the government spending target as the optimal share of the output realized without tax distortions or inflation surprises in period t.

The policy-makers minimize their loss function. The constraints of each period consist of the Lucas supply function (18), the government budget constraint (20), and the restriction generated by the rational expectations formation of the private sector ($\pi_t^e = \pi_t$). The optimality conditions are given as follows:

$$v^2\left(\tau_t + \frac{\tilde{x}}{v}\right) = \alpha_{gS}(\tilde{g}_t - g_t) = \frac{\alpha_{\pi S}}{\kappa}\pi_t \quad (t = 1, 2, 3) \tag{22a}$$

$$\pi_1 = \beta_S(1 + \rho)\pi_2 = \beta_S^2(1 + \rho)^2\pi_3 \tag{22b}$$

$$\tau_1 + \frac{\tilde{x}}{v} = \beta_S(1 + \rho)\left(\tau_2 + \frac{\tilde{x}}{v}\right) = \beta_S^2(1 + \rho)^2\left(\tau_3 + \frac{\tilde{x}}{v}\right) \tag{22c}$$

$$\tilde{g}_1 - g_1 = \beta_S(1 + \rho)(\tilde{g}_2 - g_2) = \beta_S^2(1 + \rho)^2(\tilde{g}_3 - g_3). \tag{22d}$$

Where (22a) is the static optimization condition in each period, (22b), (22c) and (22d) are the intertemporal optimization conditions for inflation, the tax rate, and government spending, respectively. For example, if $\beta_S(1 + \rho) = 1$ (the discount rate is equal to the rate of interest), it is desirable to have the same levels of inflation, tax rate, and government spending over time, respectively. This is a well-known smoothing condition over time à la Barro (1979). See also Barro (1995, 1997).

Several remarks are useful. First, as Beetsma and Bovenberg (1997a,b) mention, the social loss is affected by the initial level of government debt outstanding. The larger the initial debt $b_{01} + b_{02} + b_{03}$, the larger is the social loss. Second, the income tax and individual preferences of leisure and labour affect the production level of the nation. Third, the term of expiration affects neither the inflation rate, the tax rate, nor fiscal expenditures, but affects the desirable maturity level of issued bonds. Namely, so long as the total of the initial debt $b_{01} + b_{02} + b_{03}$ is fixed, the maturity structure of the initial debt b_{01}, b_{02}, b_{03} does not affect the optimal values of inflation, tax rate and government spending. However, the maturity structure of the initial debt b_{01}, b_{02}, b_{03} does affect the optimal values of b_{12}, b_{13}, b_{23}. The budget constraints (19a)(19b)(19c) determine the optimal values of b_{12}, b_{13}, b_{23} as a function of b_{01}, b_{02}, b_{03} once the optimal values of inflation, tax rate and government spending are determined by the smoothing conditions (22a, b, c, d). We may derive bond issuance equations from (19a, b, c) and (22a, b, c, d). Namely, bond issuance in each period is respectively given as

$$b_{12} + b_{13} = \frac{1}{1 + \beta_S(1 + \rho)^2 + \beta_S^2(1 + \rho)^4}\left\{\left[1 + \beta_S(1 + \rho)^2\right]\left[\tilde{K}_1 + (1 + \rho)b_{01}\right]\right.$$
$$\left. - \beta_S^2(1 + \rho)^2\left[\tilde{K}_3 + (1 + \rho)\tilde{K}_2 + (1 + \rho)^3(b_{02} + b_{03})\right]\right\} \tag{22e}$$

$$b_{23} = \frac{1}{1+\beta_S (1+\rho)^2} \left\{ \widetilde{K}_2 + (1+\rho)^2 b_{02} + (1+\rho)b_{12} - \beta_S(1+\rho) \right.$$

$$\left. \times \left[\widetilde{K}_3 + (1+\rho)^3 b_{03} + (1+\rho)^2 b_{13} \right] \right\} \qquad (22f)$$

where $\widetilde{K}_t \equiv \tilde{g}_t + \tilde{x}/v$.

Equation (22*e*) implies that the maturity structure at the beginning of the first period $\{b_{01}, b_{02}, b_{03}\}$ cannot determine the maturity structure on an issuing basis in the first period, or the optimal combination of $\{b_{12}, b_{13}\}$, but can determine the total amount of bond issuance in the first period $\{b_{12} + b_{13}\}$. According to (22*f*), the maturity structure on the issuing basis in the first period affects bond issuance in the second period. For example, an increase in b_{01} would raise the optimal values of b_{12}, b_{13} relatively. An increase in b_{02} would raise the optimal value of b_{23}. An increase in b_{03} would reduce the optimal values of b_{13}, b_{23}.

The intuition is as follows. To maintain the neutrality of bonds toward social welfare (social loss), it is necessary to issue bonds to cover the part of fiscal expenditures and redemption that cannot be covered from tax revenues and re-coinage profits while maintaining budget constraints and not distorting the inflation rate, tax rate or fiscal expenditures. For example, given the maturity structure, issuing bonds should act as a buffer in the budget. When b_{01} is large and b_{02}, b_{03} are small, it is desirable to issue b_{12}, b_{13} extensively.

Numerical analysis

In this subsection, we examine numerically the time-consistent debt management policy, which is theoretically analysed in the previous subsection. We can easily extend the analytical framework to a more general multi-period model. For the present numerical analysis, we use a 200-period model and incorporate nominal bonds as well.[2]

In doing the numerical analysis, it is necessary to specify values of some exogenous parameters in the theoretical model. Using data on the Japanese economy, we set $\eta = 0.7$, $\rho = 0.02$, $\beta_S = 0.985$, $\alpha_{\pi S} = \alpha_{gS} = 10$, $\tilde{x} = 0.01$, and $\tilde{g}_1 = 0.045$. We also let $\kappa = 0.36$, as mentioned in Fujiki *et al.* (1998). For the initial maturity structure of government bonds, values at the end of fiscal 1998 are used for calculation. Values of the maturity structure on the issuing basis in fiscal 1998 are used, as shown in Table 13.2. The initial level of outstanding debt is also an important figure in the analysis. We set the outstanding debt to (normalized) output ratio as 0.27, based on the value in 1998.

Under such parameter values, we derive numerical results by expanding the model to 200 periods. Figure 13.4 shows transitions of the debt dependence ratio (in the upper figure), and inflation rate, government expenditure (to the desirable output ratio) and tax rate (in the lower figure). The lower figure indicates the smoothing effects of these flow variables à la Barro (1979). The upper figure also reflects the smoothing rule. Following the maturity structure on the issuing basis in fiscal 1998, shown in Table 13.2, a 10-year-bond-centred maturity structure is

Table 13.2 Maturity structure of Japanese government bond (%)

	Issuance	Outstanding		
	FY1998	FY1987	FY2000	FY2001
Average Maturity (years)	7.22	10.15	5.02	5.35
Years				
1	24.91	8.15	37.00	18.71
2	3.55	5.65	16.76	11.58
3	0	4.53	0.37	6.92
4	5.71	1.18	3.08	10.87
5	0.34	2.53	12.35	10.66
6	5.85	0	3.08	8.14
7	0	0	0	10.16
8	0	0	0	5.94
9	0	0	0	5.58
10	56.25	59.46	20.09	4.50
11	0	0	0	0.43
12	0	0	0	0.27
13	0	0	0	0.41
14	0	0	0	1.06
15	0	0	3.45	1.62
16	0	0	0	0.58
17	0	0	0	0.50
18	0	0	0	0.48
19	0	0	0	0.74
20	3.39	18.50	2.96	0.43
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0.13
29	0	0	0	0.19
30	0	0	0.86	0.08

used for calculation. Hence rises in the bond dependence ratio are on a 10-year cycle. It is preferable to have an increase in bond issue when many (10-year) bonds are matured, rather than to have a sudden increase in tax revenue. Then the bond dependence ratio rises temporarily at this period.

Figure 13.5 also indicates optimal transitions of government debt outstanding (to the desirable output ratio), and the desired maturity structure of government debt. This figure suggests that it is desirable to reduce the bond dependence ratio gradually to redeem them fully in the 200th period.

Given the present structure of bonds by maturity (structure centring on 10-year bonds), the calculated desired schedule of issuing bonds implies a debt management policy based on the smoothing rule. Namely, as the termination date

Result of Numerical Analysis

β s	1 + ρ	η	κ	$\alpha \pi$ s	α gs
0.985	1.02	0.7	0.36	10	10
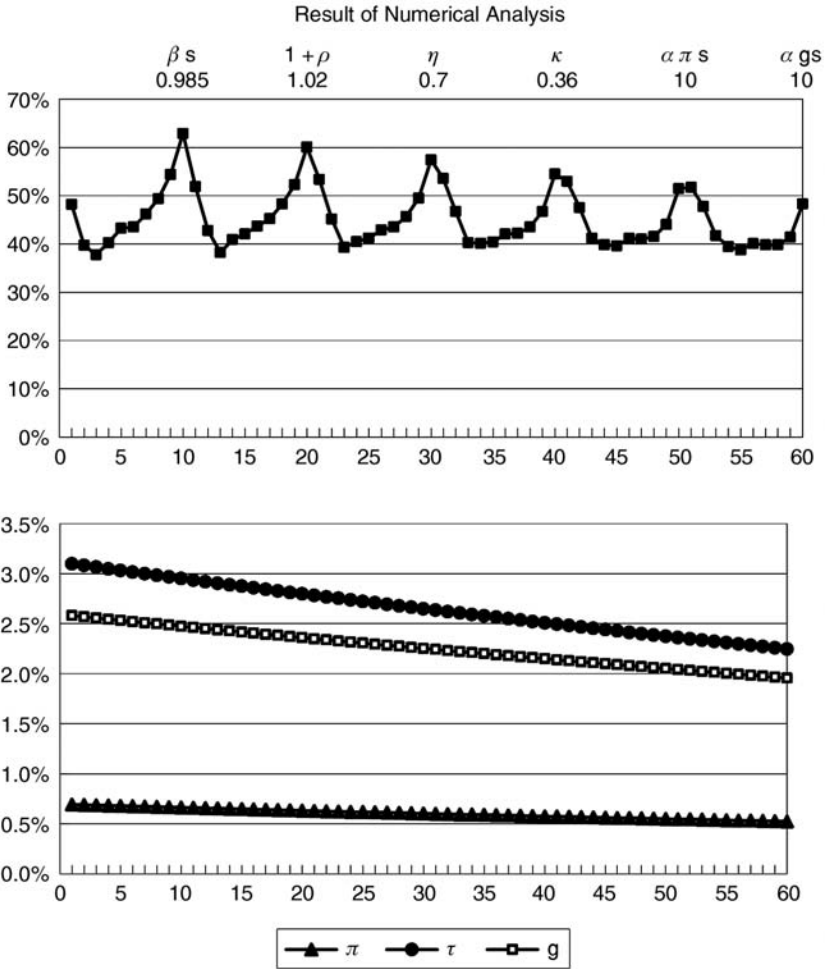
Figure 13.4 Result of numerical analysis.

concentrates within a 10-year period, it is preferable not to raise taxes or the inflation rate or to cut expenditures in this period only but to reserve the fiscal resources to a certain extent even if reliance on government bonds will rise temporarily. At the same time, it is necessary to reduce reliance on the government bonds gradually when there are relatively few expiring bonds. Moreover, it is indispensable to restrain the increasing trend of reliance on government bonds.

Policy coordination and fiscal reconstruction

As analysed by Beetsma and Bovenberg (1997a,b) among others, when monetary and fiscal authorities are not cooperative, an optimally designed conservative,

Government Debt Outstanding

Maturity Structure (Outstanding Basis)

■ 1 yr	■ 2 yrs	■ 3 yrs	□ 4 yrs
□ 5 yrs	■ 6 yrs	■ 7 yrs	■ 8 yrs
■ 9 yrs	■ 10 yrs	□ 11-19 yrs	■ 20+ yrs
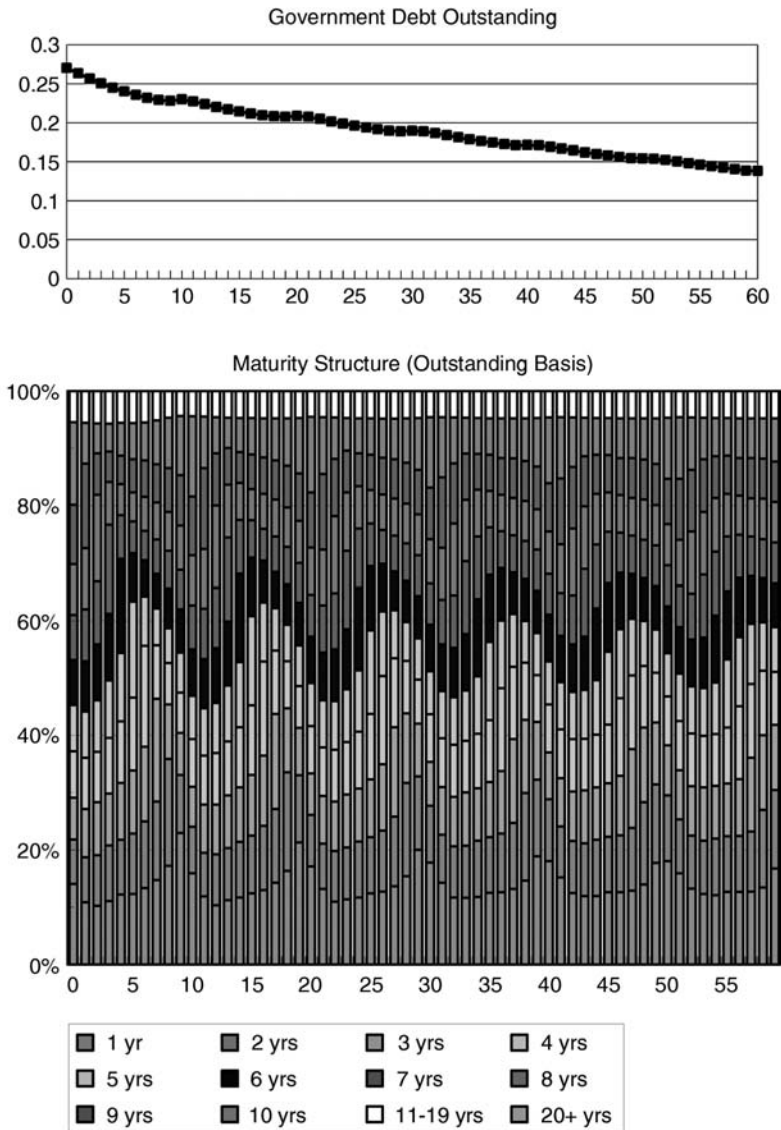
Figure 13.5 Result of numerical analysis (Continued).

independent central bank is necessary to establish the second best. The central bank must be made more conservative than society. They showed that correcting monetary policy preferences is a direct way to eliminate the distortions due to the inability to commit. Drudi and Giordano (2000) showed that since default risk increases as the maturity structure of the debt shortens, optimal maturity

under bankruptcy risk is in general longer than in the case in which debt repudiation policies can be precommitted or are very unlikely. See also Persson *et al.* (1987, 2005).

If we allow for political distortions, the preferences of the fiscal authority may depart from the preferences of society. In the presence of political distortions a debt target is also needed. For example, if the government discounts the future too heavily, the optimal debt target would de facto act as a ceiling on public debt. In Japan, the central bank now acts as an independent policy-maker and its concern on inflationary targeting is more conservative than the government. In this sense, we could say that the central bank behaves in a good manner to attain the second best. The problem in Japan is that the fiscal authority is too weak to cope with political pressures from various interest groups. Let us explain this aspect using a simple fiscal reconstruction model.

Based on Ihori and Itaya (2002, 2003), suppose there are many ($n \geq 2$) symmetric interest groups in a small open economy. Since the main concern here is with the fiscal authority facing interest groups, we do not incorporate monetary factors into the model. Or, the monetary authority could set the optimal rate of inflation and the private sector could rationally expect this policy, so that real output is exogenously given at the normalized level. The issue here is the allocation of output among private consumption, nation-wide public goods, and the specific privileges of public spending.

Each interest group enjoys a specific privilege of higher subsidies or private spending, L_i, where subscript i means agent i. The instantaneous utility of interest group i (or a median voter of group i) is assumed to be strictly increasing in private consumption c_i, expenditures on specific public spending L_i, and nation-wide public goods G, which is common to all agents and may be viewed as a pure public good. It is further assumed to be a twice-continuously differentiable and strictly quasi-concave function, which is expressed by

$$U = U(c_i, \varepsilon L_i, G)$$

where ε (<1) denotes an evaluation coefficient of specific public spending; ε may reflect the degree of usefulness (or flexibility) of public spending for the agent.

Moreover, we assume that all goods are normal ones. The relative price of each good is set to be unity for simplicity. Given the instantaneous utility function, the intertemporal utility of interest group i over an infinite-horizon starting at time 0 is given by

$$\int_0^\infty U\big[c_i(t), L_i(t), G(t)\big]e^{-\rho t}\,\mathrm{d}t$$

where ρ (>0) is a constant discount rate, which is common to all interest groups.

Public consumption of the overall government sector (or provision of nation-wide public goods) G at each point in time is determined according to

$$G(t) = G^* - rB(t) \tag{23}$$
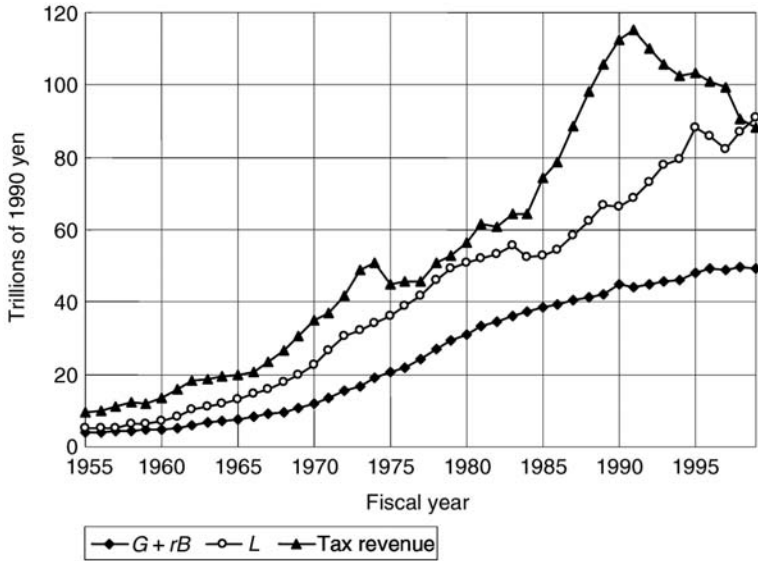
Figure 13.6 Real government expenditure and revenue. *G* is public spending by central and local governments including agencies, national defence, disposition of external affairs, and education and culture. *rB* is interest payments. ΣL is public investment and privileges to regions, including the remaining expenditures.

where G^* is an exogenously given ceiling level, r is the exogenously given world interest rate, and B is external government debt. Equation (23) is the fiscal reconstruction constraint, which means that the government spending on nation-wide public goods and interest payments is fixed at the level of G^* through time, so that a higher public good G is possible only by reducing the outstanding public debt B.

As shown in Figure 13.6, during the fiscal reconstruction process since the 1980s Japan has actually imposed a similar ceiling constraint on some of government spending (mainly provision of the nation-wide public goods such as spending on national agencies, national defence, disposition of external affairs, and education and culture) in order to prevent a further deterioration in budget deficits. Equation (23) formulates such a ceiling rule.

A representative, median voter in group i will face the instantaneous budget constraint.

$$Y = c_i + \omega Y \tag{24}$$

where Y is exogenously given income common to all agents, ω is the common income tax rate. To focus on the problem at hand, Y is assumed to be fixed over time. Although this assumption appears to be extremely strong within a dynamic setting, it can be justified by the observation that, facing large budget deficits, the

balanced budget movement takes place in Japan when the growth rate of GDP is close to zero (i.e. GDP is nearly fixed over time in recent years). In addition, we also assume for analytical simplicity that there is neither private saving nor private bequests. It follows that private consumption is always equal to disposal income. For simplicity, taxes are incorporated as income taxes.

The overall budget constraint of the central and local governments is given as

$$\dot{B} = G + rB - \sum_{j=1}^{n} g_j \tag{25}$$

with

$$g_i \equiv \omega Y_i - L_i \tag{26}$$

where g_i is net payment of 'taxes' (or contribution to tax revenue) provided by interest group i. More precisely, g_i is defined by the tax payment applied to all local interest groups ωY minus specific spending L_i. Since in the right hand side of (26) ωY_i is exogenously fixed, local interest group i can effectively control L_i by putting political pressures on reducing g_i.

The government is so weak that it is unable to reduce specific transfers directly. Such expenditures could be restrained only with the agreement of the local interest groups. The Japanese fiscal reconstruction process could be thought of as an outcome of voluntary concession on how the increases in net 'taxes' $\sum_{j=1}^{n} g_j$ are to be apportioned between various local interest groups. Each interest group can voluntarily set cuts in specific public spending to accomplish fiscal reconstruction at each point in time, given the expectations regarding the time path of others' concessions g_j for $j \neq i$.

From (23) and (25) we have

$$\dot{G} = r \sum_{j=1}^{n} g_j - rG^* \tag{25}'$$

Equations (24) and (26) mean that private consumption and the sum of L_i and g_i are exogenously fixed and common to all interest groups,

$$c_i + g_i + L_i = Y \tag{27}$$

which is the feasibility condition.

The fiscal reconstruction process formulated above does not internalize the free-riding behaviour of interest groups. If one interest group cooperates with fiscal reconstruction by accepting more cuts in subsidies, it would benefit all other groups in the economy. That is, the main reason for over-accumulation of public debt is that each interest group disregards a positive externality of cooperation with fiscal reconstruction in choosing its own contribution, which spills over into all other interest groups. Lobbying activities of interest groups are the main reason

why fiscal reconstruction does not perform very well in the sense that public debt is too much during transition and in the steady state.

Hence, in order to have successful fiscal reconstruction, we need a stronger debt target than the ceiling on public spending (23). Namely, in addition to the ceiling (23) it is desirable to have a ceiling on the primary balance. The Japanese government's current target is to eliminate the primary balance deficit by 2012. This objective is useful but the concrete process during the transition is not clear. It is important to specify explicitly the ceiling level of primary deficit in each year during the transition so that the government can commit the deficit-reduction programme over time.

Conclusion

If the expansionary trend in Japan's government spending continues at this pace, the fiscal deficit will inflate further and the ability to raise taxes in the future will be politically limited. Investors will lose confidence in Japan's public bonds if they believe that the nation's public finance is bound for long-term crisis. The result is that interest rates will rise and fiscal failure will become a more tangible reality.

This chapter has analysed sustainability issues of Japan's fiscal policy and then discussed the optimal inflation and debt management policy based on the maturity structure of government bonds using theoretical models and numerical studies. We also investigated the desirable coordination of fiscal and monetary authorities toward fiscal reconstruction.

Although the inflationary tax by expansionary open market operations is effective in alleviating fiscal crises, an increase in the subjective probability of inflationary tax does not necessarily have desirable effects in the case of nominal bonds. This is because debt is now perceived as more risky by the private sector and hence the gross rate of return on government debt increases. Thus, the issuance of indexed bond finance may be better than nominal bond finance when the private sector is concerned with the future fiscal crisis.

Given the present maturity structure of bonds Japan's debt policy should be based on the smoothing rule. As the termination date concentrated within a 10-year period, it is preferable not to raise taxes or the inflation rate or to cut expenditures in this period only but to reserve the fiscal resources to a certain extent even if the reliance on government bonds will rise temporarily. At the same time, it is necessary to reduce reliance on the government bonds gradually when there are relatively few expiring bonds. Moreover, it is indispensable to restrain the increasing trend of reliance on government bonds.

In Japan, the central bank now acts as an independent policy-maker and its concern on inflationary targeting is more conservative than the government. In this sense, we could say that the central bank behaves in a good manner to attain the second best. The problem in Japan is that the fiscal authority is too weak to cope with political pressures from various interest groups. In order to have successful fiscal reconstruction, we need a stronger debt target than the ceiling on

public spending. It is important to specify explicitly the ceiling level of primary deficit in each year during the transition so that the government can commit the deficit-reduction programme over time.

Notes

* We thank Horoshi Nakaso and other conference participants for useful comments.
1 The Fiscal Investment and Loan Programme (FILP) has been called 'the second budget' because the government initially used FILP to undertake projects it was unable to include in the general account budget. Doi and Hoshi (2003) have a good summary of the structure, components and history of FILP and PSS, and provide estimates of the costs FILP has and might impose on Japanese taxpayers; their appendix provides a further review of the literature. Also see Cargill and Yoshino (2000, 2003).
2 The reason why we set a 200-period model is to weaken effects of the terminal conditions in which all stock variables are zero, on this numerical analysis.

Discussion of Doi, Ihori and Mitsui – Bank of Japan's open market operations under the quantitative easing policy

Hiroshi Nakaso

The Bank of Japan has been struggling to overcome deflation since the asset bubble burst in the early 1990s with a substantial negative impact on the banking sector and thus on the economy. This was a stubborn deflation. The economy showed signs of recovery once in the mid 1990s and then later in 2000 amidst the so-called IT sector bubble. But both recoveries proved short-lived. The Bank of Japan cut policy rates successively until it became zero-bound without tangible effects on the economy. The Quantitative Easing Policy was introduced to replace the largely exhausted traditional framework of monetary policy. This brief note describes the outline of the Quantitative Easing Policy, the reasons behind the changing bidding behaviour of banks, and the challenges to the Bank of Japan's open market operations.

Outline of the Quantitative Easing Policy

Faced with the zero bound, the Bank introduced the Quantitative Easing Policy (QEP) in March 2001. This was an unprecedented form of monetary policy which is aimed at current account balances (i.e. reserves that banks hold with the Bank of Japan) instead of overnight rates. The initial target when QEP was introduced was ¥5 trillion. Subsequently, the target was raised in steps, reaching ¥30–35 trillion in January 2004, and since then has remained at that level (Figure 13.7). ¥30 trillion (approximately $270 billion at the current rate of exchange) is a substantial amount in comparison with the legally required minimum reserve, which is now around ¥6 trillion. This implies that the Bank of Japan is pumping more than ¥25 trillion of excess reserves into the banking system via open market operations. As indicated in Figure 13.7, the target has been met most of the time except for the two brief periods over the summer of 2005. Meanwhile, the overnight rates remained flat around 0% under this aggressively accommodative policy.

It might appear a wonder how the central bank managed to keep the current account balances so high above the minimum reserves. In fact, it was not so easy for the central bank to meet the target, even discounting the fact that the opportunity cost for banks of holding excess reserves was nil. The Bank started to face underbidding, where bids fall short of offers, in its open market operations

Trillion yen
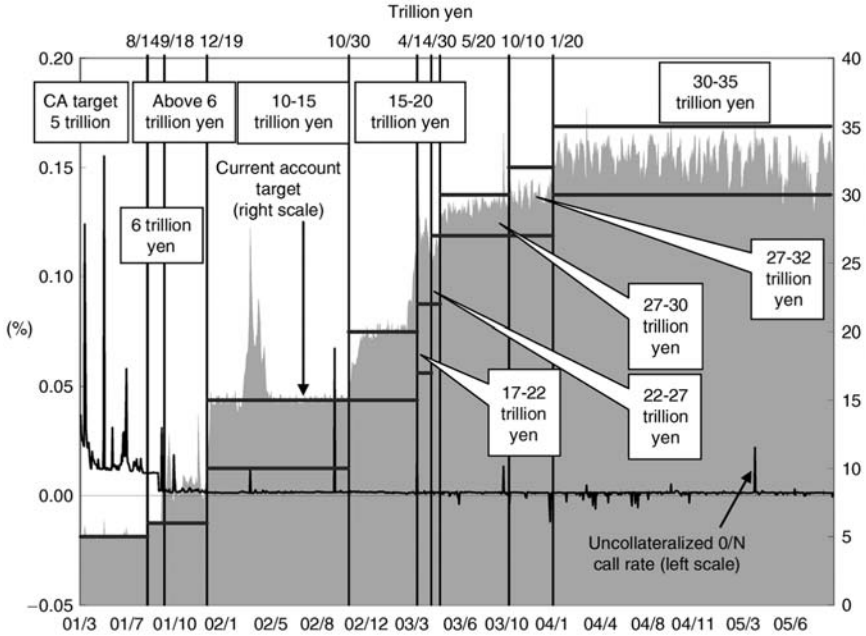
Figure 13.7 Current account targeting. *Source*: Bank of Japan.

from autumn 2004. The underbidding became so frequent in early summer that it caused technical difficulties in meeting the quantitative target.

The bars on Figure 13.8 represent the number of recurrences of underbidding. As is obvious from the Figure, there are two periods when underbidding is concentrated. The first period appears in early 2002. This period coincides with the successive rises in the quantitative target. The underbidding during this period was probably a reflection of a catching-up process with the rising target. Thus, the first period turned out to be temporary. The second period started early in 2005. The underbidding took place despite the fact that the target had remained unchanged at ¥30–35 trillion for over a year. This time, more structural factors seemed to be at work. Frequent underbidding caused serious operational difficulties and the Bank was unable to meet the quantitative target on two brief occasions in early summer, when the current account balances undershot the lower threshold of the target.

However, in August, due to a dramatic change in the bidding behaviour of financial institutions, the underbidding quite suddenly stopped. This shift is typically reflected in a bills-purchase operation that the Bank conducted on August 23. In this operation, the bid-to-offer ratio was 4.03 and the average successful bid rate was 0.007%. This compares with a similar operation conducted previously on June 9, where the corresponding figures were 0.67 and 0.001%, respectively. Similarly, the tender on August 23 attracted a large number of bidders, almost
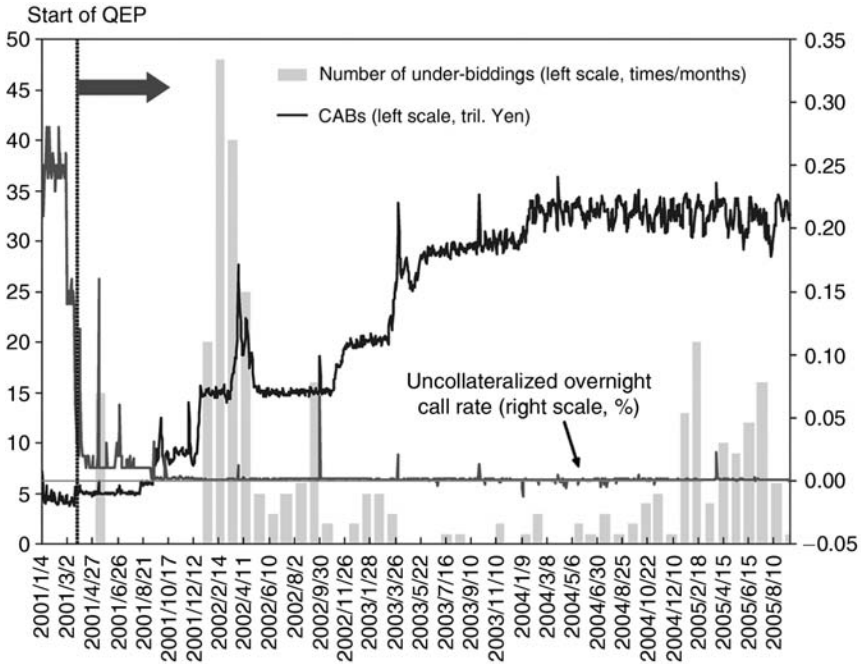
Figure 13.8 Number of underbiddings. *Source*: Bank of Japan.

double the number observed in the June 9 tender. Reasons for the apparent shift in bidding behaviour might be found by identifying the incentives for bidding.

Incentives for bidding

There are probably two major incentives for bidding. The first one is the liquidity demand based on concerns over the health of the financial system. During the banking crisis in the 1990s, many banks failed because of funding difficulties. Typically, a bank that faced reputation risks by, for example, being downgraded would start to suffer from funding difficulties. The bank would sell good assets to meet the immediate funding requirements. But this would only result in further impairment of the bank's asset quality, inviting further deterioration in credit standing. Thus, what started as a liquidity problem would develop into a solvency problem. It was this vicious circle that drove many banks to bankruptcy during the crisis. The surviving banks raised funds through the Bank of Japan's open market operations for precautionary reasons to withstand possible liquidity crunches. There were heightened concerns about the soundness of the financial system in 1998 and 2002 when credit spreads of banks widened substantially (Figure 13.9). Since 2003, the credit standing of Japanese banks has steadily improved as they made progress in disposing of non-performing loans. As a result, banks' credit
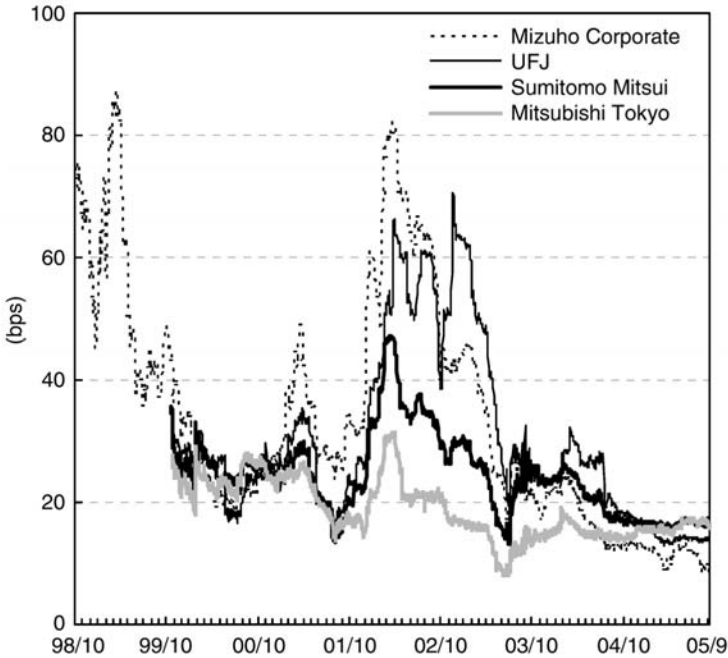
Figure 13.9 Senior bond spread (newly issued, 5 year). *Source*: Japan Securities Dealers
Association, Bloomberg, QUICK, Morgan Stanley, Credit Trade, Goldman
Sachs.

spreads have become sharply narrower and major banks' credit ratings are now
back at pre-crisis levels. Against the background of improved credit standing,
banks are no longer concerned about their access to the funding liquidity markets.
Thus, their demand for liquidity for precautionary reasons receded. This is the
primary reason why the Bank encountered frequent underbidding until July. The
Bank, in an effort to meet the quantitative target, progressively extended the matu-
rities of the fund-supplying operations to stimulate demand for bidding. Currently
the average maturity of all outstanding short-term operations stands at around
6 months, which is considerably longer than those conducted by central banks
elsewhere (Figure 13.10).

The second incentive for bidding is to extract the intrinsic benefit of open market
operations; Put in simpler terms, to make profits out of open market operations
conducted by the Bank of Japan. The mechanism is straightforward; banks raise
funds through the open market operations cheaply and invest in instruments with
higher yields. It can be generally observed from Figure 13.11 that higher bid-to-
offer ratios correspond with higher investment returns. What happened in early
August is that banks became more convinced of Japan's economic recovery as they
watched emerging data. They now expected interest rates to be higher in a year's
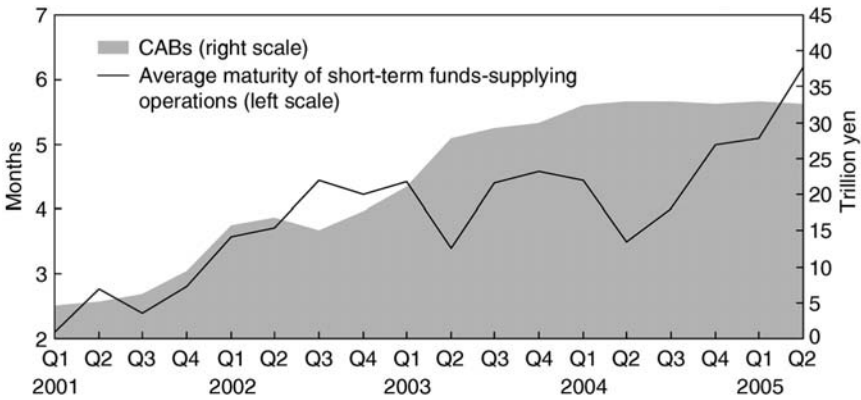
Figure 13.10 Average maturity. *Source*: Bank of Japan.
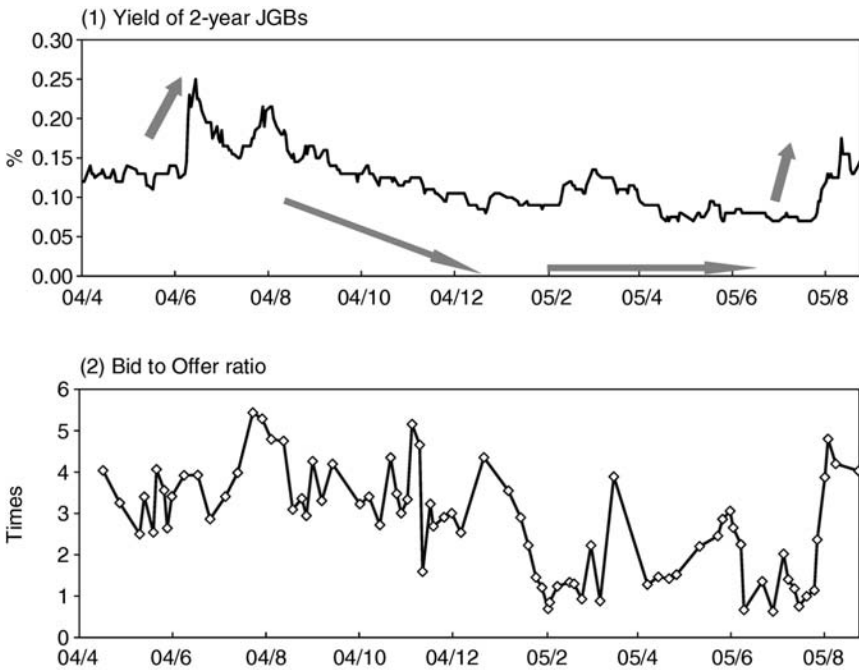
Figure 13.11 Yield of JGBs and bid-to-offer ratio. *Source*: Bloomberg, Bank of Japan.

time and seem to have realized that it is not a bad idea to raise funds cheaply now via the Bank of Japan's open market operations, particularly with long maturities, to invest later in instruments with higher yields, when interest rates actually start rising. This is the reason why banks have started to rush in for bidding in the open market operations since early August.

In summary, banks' demand for liquidity for precautionary reasons receded, as the financial crisis now fell behind. But this is more than off-set by the emerging new demand for liquidity driven by what might be called profit incentives. This is reflected in higher bid-to-offer ratios as well as in higher successful bid rates in the more recent tenders (Figure 13.12).

Duration of quantitative easing

The QEP is an extraordinary temporary policy introduced to prevent the economy from slipping into a deflationary spiral, and therefore was not intended to be a permanent measure. The Bank of Japan has committed itself to maintaining the policy until the core Consumer Price Index (CPI) registers stably positive year-on-year growth. Specifically, the Bank set forth three conditions that have to be met before terminating the policy.

- The year-on-year growth rate of the core CPI registers zero percent or above over a few months.
- The prospective core CPI will not be expected to register below zero percent.
- There may be cases where the BOJ will judge it appropriate to continue with quantitative easing even if the above two conditions are fulfilled.

When the Bank eventually exits from the QEP, it will return to the traditional framework of monetary policy, where the overnight rates will resume being the operating target. Recent economic indicators are supportive of the view that the economy is on track to sustained recovery and thus the exit is closer. The GDP gap is narrowing and the core CPI growth rate is expected to turn positive towards the end of the year 2005. Stock prices keep rising, helped by large-scale steady inward investment by overseas investors. Bank shares are among the foreign investors' favourite. This contrasts with a few years ago, when these very shares were dismissed as zombie banks by overseas investors.

Market participants' expectations as to how long the QEP is likely to last can be extracted from futures rates. By comparing the futures rates with money market rates at some points in the past, market expectation on the duration of the policy can be obtained. Figure 13.13 is an example that demonstrates that market participants expect an exit to be inching closer.

Challenges to open market operations

The QEP is a very unusual form of monetary policy, with no reference in text books. Therefore the eventual exit will be like a voyage through uncharted waters.

(1) Bid to Offer ratio

(2) Successful Bid Rates

Figure 13.12 Recent Bid-to-Offer ratio and successful bid rates. The *x*-axis shows the dates on which operations were offered. Excludes the outright purchases at all offices offered on both September 28 and March 29, which were offered for the purpose of providing short-term funds for the end of the fiscal year. *Source*: Bank of Japan.

(1) Euroyen Interest Rates Futures (3-month)

Legend:
- Feb. 12, 2004
- Aug. 2, 2004 ①
- Aug. 11, 2005 ②
- Aug. 31, 2005 ③

0.51% (Case 2)

0.19% (Case 1)

x-axis: 1 period ahead, 2 periods ahead, 3 periods ahead, 4 periods ahead, 5 periods ahead, 6 periods ahead, 7 periods ahead, 8 periods ahead, 9 periods ahead

(2) Market participants' expectations on the duration of Quantitative Easing

Year

Jan. 04   Jul. 04   Jan. 05   Jul. 05

Figure 13.13 Expectations on the duration of quantitative easing. Contract months in the figure (1) exclude 'serial months,' the months other than March, June, September and December. The time to the point on the yield curve of current euro-yen futures (3-month) where it exceeds the average of the euro-yen rates during the periods below is assumed to be the market's expectation of the duration of monetary easing. Case1. Bank of Japan maintained a 'zero interest rate policy' (Sep/99–Aug/00). Case2. The target for the uncollateralized overnight call rate was 0.25% (Aug/00–Feb/01). *Source*: Tokyo Financial Exchange, Bloomberg, Bank of Japan.

The challenges to the conduct of open market operations are multi-fold. For example, there is the question of how the Bank can reduce the current account balances from the current ¥30–35 trillion down to around ¥6 trillion, which is the legally required minimum reserve. In the process, the Bank intends to monitor closely how the reduction will affect market rates and prices.

References

Alesina, A., Prati, A. and Tabellini, G. (1989) 'Public confidence and debt management: a model and a case study of Italy', NBER Working paper, No. 3135.

Allen, F. and Santomero, A. (2001) 'What do financial intermediaries do?', *Journal of Banking and Finance*, 25(2): 271-94.

Allen, W. (2002) 'The Bank of England open market operations: introduction of a deposit facility', *BIS paper* No. 12, *Market Functioning and Central Bank Policy*, Basle: BIS.

Allen, W. (2004) 'Implementing monetary policy', *Central Banking*, November: 46-53.

Alworth, J.S. and Borio, C.E.V. (1993) 'Commercial paper markets: a survey', Economic Paper No. 37 (April), Basle: Bank for International Settlements.

Arestis, P. and Sawyer, M. (2004) 'Can monetary policy affect the real economy?', *European Review of Economics and Finance*, 3(3): 7-30.

Aspetsberger, A. (1996) 'Open market operations in EU countries', Staff Paper No. 3, Frankfurt: European Monetary Institute.

Avery, R.B and Kwast, M.L. (1993) 'Money and interest rates under a reserves operating target', *Economic Review* Federal Reserve Bank of Cleveland, (Summer): 24-34.

Ayuso, J. and Repullo, R. (2003) 'A model of the open market operations of the European Central Bank', *Economic Journal*, 113: 883-902.

Bagehot, W. (1873/1973) *Lombard Street*, in *The collected works of Walter Bagehot*, London: *The Economist*.

Ball, L. (1994) 'Credible disinflation with staggered price setting', *American Economic Review*, 84 (March): 282-9.

Banco de Mexico (various years) *Informes Anuales*, www.banxico.org.mx.

Bank for International Settlements (1980) *The Monetary Base Approach to Monetary Control*, Basle: Bank of International Settlements.

Bank for International Settlements (1986) 'Changes in money market instruments and procedures: objectives and implications', CB Document No. 385 (April), Basle: BIS.

Bank for International Settlements (1997a) 'Implementation and tactics of monetary policy', Conference Papers Vol. 3, Basle: BIS.

Bank for International Settlements (1997b) 'Monetary policy in the Nordic countries: experiences since 1992', Policy Paper No. 2 (October), Basle: BIS.

Bank for International Settlements (1999) 'Implications of repo markets for central banks', Report of a Working Group established by the Committee on the Global Financial System of the central banks of the Group of Ten countries, Basle: BIS.

Bank for International Settlements (2001) 'Comparing monetary policy operating procedures across the United States, Japan and the euro area', BIS Papers No. 9 (December), Basle: BIS.

Bank of England (1999) *Economic Models at the Bank of England*, London: Bank of England.

Bank of England (2002) *The Bank of England's Operations in the Sterling Money Markets*, London: Bank of England.

Bank of England (2004a) 'Reform of the Bank of England's operations in the sterling money markets', *Bank of England Quarterly Bulletin*, 44(Summer): 217-27.

Bank of England (2004b) 'Reform of the Bank of England's operations in the sterling money markets', a second consultative paper by the Bank of England.

Bank of Greece (various) *Monthly Statistical Bulletin*, Athens: Bank of Greece.

Bank of Greece (various). *Monetary Policy Report*, Athens: Bank of Greece.

Bank of Japan (1995) 'Reserve requirement systems and their recent reforms in major industrialized countries: a comparative perspective', *Quarterly Bulletin* (Bank of Japan), 3(2)(May): 53-75.

Bank of Japan (2001) 'Real-time gross settlement (RTGS) in Japan: an evaluation of the first six months', *Bank of Japan Quarterly Bulletin*, November: 1-19, available on the Bank of Japan internet site.

Bank of Japan (2005a) Financial Markets Department, 'Financial markets report – Developments during the First Half of 2005 –', August.

Bank of Japan (2005b) Financial Markets Department, 'Money market operations in fiscal 2004', Bank of Japan Research Papers, August.

Banker (1993) 'Europe wields the axe', September: 4-5.

Banque de France, Direction des Marchés de Capitaux (2001) 'Banques françaises et activité du marché monétaire', *Bulletin de la Banque de France*, No. 90, Juin.

Banque Nationale de Belgique (1985) 'Le nouveau mode de fixation des taux officials de la Banque', *Bulletin de la Banque Nationale de Belgique* (July/August): 3-28.

Banque Nationale de Belgique (various) *Revue économique*, Brussels: BNB.

Barro, R. and Gordon, D. (1983) 'Rules, discretion and reputation in a model of monetary policy', *Journal of Monetary Economics,* 12(1): 101-21.

Barro, R.J. (1979) 'On the determination of the public debt', *Journal of Political Economy*, 87: 940-71.

Barro, R.J. (1995) 'Optimal debt management', NBER *Working Paper* No. 5327.

Barro, R.J. (1997) 'Optimal management of indexed and nominal debt', NBER *Working Paper* No. 6197.

Bartolini, L. and Prati, A. (2003) 'Cross-country differences in monetary policy execution and money market rates' volatility', Staff Reports 175, Federal Reserve Bank of New York.

Bartolini, L., Bertola, G. and Prati, A. (2001) 'Banks' reserve management, transaction costs, and the timing of Federal Reserve intervention', *Journal of Banking and Finance*, 25, 1287-317.

Bartolini, L., Bertola, G. and Prati, A. (2002) 'Day-to-day monetary policy and the volatility of the federal funds rate', *Journal of Money, credit and Banking*, 34(1): 137-59.

Basel Committee on Payment and Settlement Systems (2003) 'Payment and settlement systems in selected countries', *Basel Committee on Payment and Settlement Systems Publications* no. 53, April, available on the Bank for International Settlements internet site.

Batten, D.S., Blackwell, M.P., Kim, I-S. Nocera, S.E. and Ozeki, Y. (1990) 'The Conduct of Monetary Policy in the Major Industrial Countries: Instruments and Operating Procedures', Occasional Paper No. 70 (July), Washington, DC: International Monetary Fund.

Beetsma, R.M.W.J. and Bovenberg, A.L. (1997a) 'Central bank independence and public debt policy', *Journal of Economic Dynamics and Control*, 21: 873-94.

Beetsma, R.M.W.J. and Bovenberg, A.L. (1997b) 'Designing fiscal and monetary institutions in a second-best world', *European Journal of Political Economy*, 13: 53-79.

Bell, M. (2005) 'Communicating monetary policy in practice', text of speech to Manchester Business School, 17 May. (http://www.bankofengland.co.uk/publications/speeches/2005/speech244.pdf).

Bernanke, B. (2002) 'Deflation: making sure "it" doesn't happen here', Speech delivered before the National Economists Club, Washington, D.C., 21 November.

Bernanke, B.S. and Mishkin, F.S. (1992) 'Central Bank behavior and the strategy of monetary policy: observations from six industrial countries', in (O. Blanchard and S. Fischer, eds), *NBER Macroeconomics Annual*, 138-228, Cambridge: MIT Press.

Bernanke, B. and Woodford, M. (1997) 'Inflations forecasts and monetary policy', *NBER Working Paper*, No. 6157.

Bertola, G. and Drazen, A. (1993) 'Trigger points and budget cuts: explaining the effect of fiscal austerity', *American Economic Review*, 83: 11-26.

Bindseil, U. (2000) 'Central bank liquidity management and the signal extraction problem on the money market', *Jahrbűcher fűr Nationalőkonomie und Statistik*, 220: 284-301.

Bindseil, U. (2004a) 'The operational target of monetary policy and the rise and fall of reserve position doctrine', ECB Working Paper Series, No. 372.

Bindseil, U. (2004b) *Monetary Policy Implementation, Theory, Past, Present*, Oxford: Oxford University Press.

Bindseil, U. (2005) 'Over- and underbidding in central bank open market operations conducted as fixed rate tender', *German Economic Review*, 6: 95-130.

Bindseil, U. and Würtz, F. (2005) 'Open market operations – their role and specification today', chapter 4 in this book.

Bisignano, J. (1996) 'Varieties of monetary policy operating procedures: balancing monetary objectives with market efficiency', Working Paper No. 35 (July), Basle: Bank for International Settlements.

Blanchard, O.J. and Weil, P. (1992) 'Dynamic efficiency, the riskless rate, and debt Ponzi games under uncertainty', NBER Working Paper No. 3992.

Blinder, A.S. (1999) *Central Banking in Theory and Practise*, Cambridge MA: MIT Press.

Board of Governors of the Federal Reserve System (2001) 88th Annual Report.

Bohn, H. (1991) 'The sustainability of budget deficits with lump-sum and with income-based taxation', *Journal of Money, Credit, and Banking*, 23: 580-604.

Bohn, H. (1998) 'The behavior of U.S. public debt and deficits', *Quarterly Journal of Economics*, 113: 949-63.

Boianovky, M. and Trautwein, H-M. (2005) 'Wicksell after Woodford', *Journal of the History of Economic Thought* (forthcoming).

Bollerslev, T. (1987) 'A conditionally heteroskedastic time series model for speculative prices and rates of return', *Review of Economics and Statistics*, 69: 542-7.

Bonser-Neal, C., Roley, V.V., Sellon, G.H. Jr. (2000) 'The effect of monetary policy actions on exchange rates under interest-rate targeting', *Journal of International Money and Finance*, 19: 601-31.

Borio, C.E.V. (1997) 'The implementation of monetary policy in industrial countries: a survey', BIS Economic Paper No. 47.

Borio, C.E.V., Blenck, D., Hasko, H., Hilton, S. and Masaki, K. (2001) 'Comparing monetary policy operating procedures across the United States, Japan and the euro area', BIS Paper No. 9.

Böschenstein, R. (1977) 'Die Anwendung der kreditpolitischen Instrumente der Mindestreservenpolitik und der Kreditbegrenzung in der Schweiz', Ph.D. thesis, University of Zurich, also published as: European University Papers 149, Bern: Herbert Lang.

Boyle, A. (1967) *Montagu Norman*, London: Cassel.

Britton, E., Fisher, P. and Whitley, J. (1998) 'The Inflation Report projections: understanding the fan chart', *Bank of England Quarterly Bulletin*, February: 30-37.

Broaddus, J.A. and Goodfriend, M. (2000) 'What assets should the Federal Reserve buy?', *Annual Report*, Federal Reserve Bank of Richmond.

Brunner, K. (1973) 'A diagrammatic exposition of the money supply process', *Schweizerische Zeitschrift für Volkswirtschaft und Statistik*, (December): 481-533.

Brunner, K. and Meltzer, A.H. (1989) 'The Federal Reserve's attachment to the free reserve concept', Washington D.C. House Committee on Banking and Currency, 1964. Reprinted in *Monetary Economics*, K. Brunner and A.H. Meltzer (eds), London: Blackwell.

Buiter, W.H and Sibert, A. (2005) 'How the ECB's open market operations weaken fiscal discipline in the eurozone (and what to do about it), EBRD working paper, June.

Buiter, W.H. and Kletzer, K.M. (1992) 'Government solvency, Ponzi finance and the redundancy and usefulness of public debt', NBER Working Paper No. 4076.

Bulow, J. and Rogoff, K. (1989) 'Sovereign debt: is to forgive to forget?', *American Economic Review*, 78: 43-50.

Burbidge, J.B. (1983) 'Social security and savings plans in overlapping generations models', *Journal of Public Economics*, 21: 79-92.

Calvo, G.A. (1983) 'Staggered prices in a utility maximizing framework', *Journal of Monetary Economics*, 12(3): 383-98.

Calvo, G.A. (1988) 'Serving the public debt: the role of expectations', *American Economic Review*, 78: 647-61.

Campbell, J.Y. (1987) 'Money announcements, the demand for bank reserves, and the behaviour of the Federal funds rate within the statement week', *Journal of Money, Credit and Banking*, 19(1): 56-67.

Canzeroni, M.B. and Dellas, H. (1998) 'Real interest rates and central bank operating procedures', *Journal of Monetary Economics*, 42(3)(December): 471-94.

Cargill, T. and Yoshino, N. (2000) 'The postal savings system, fiscal investment and loan program, and modernization of Japan's financial system', in T. Hoshi and H. Patrick (eds), *Crisis and Change in the Japanese Financial System*: 201-30, Dordrecht: Kluwer Academic Publishers.

Cargill, T. and Yoshino, N. (2003) *Postal Savings and Fiscal Investment in Japan*, Oxford: Oxford University Press.

Carpenter, S. and Demiralp, S. (2005) 'The liquidity effect in the federal funds market: evidence from daily open market operations', *Journal of Money, Credit, and Banking*, (forthcoming).

Caruana, J. (2005) 'Monetary policy and Basel II', Speech delivered at the 33rd Economics Conference, Vienna.

Castellanos, S. (2000), 'El efecto del 'corto' sobre la estructura de tasas de interés', Banco de México, *Serie Documentos de Investigación*, No. 2000-1.

Central Bank of Ireland (various) *Quarterly Bulletin*, Dublin: Central Bank of Ireland.

Chari, V.V. and Kehoe, P.J. (1993) 'Sustainable plans and mutual default', *Review of Economic Studies*, 60: 175-95.

Clarida, R., Gali, J. and Gertler, M. (1999) 'The science of monetary policy: a New Keynesian perspective', *Journal of Economic Perspectives*, 37(4): 1661-707.

Clews, R. (2005) 'Implementing monetary policy: reforms to the Bank of England's operations in the money market', *Bank of England Quarterly Bulletin* (Summer): 211-20.

Clouse, J.A. and Small, D.H. (2004) 'The scope of monetary policy actions authorized under the Federal Reserve Act', mimeo, Board of Governors of the Federal Reserve, July.

Clouse, J.A., Henderson, D., Orphanides, A., Small, D. and Tinsley, P. (2000) 'Monetary policy when the nominal short-term interest rate is zero', *Working Paper*, Board of Governors of the Federal Reserve Bank, November.

Cobham, D. (2003) 'Why does the Monetary Policy Committee smooth interest rates?', *Oxford Economic Papers*, 55(3): 467-93.

Cobham, D. (2006) 'The overvaluation of sterling since 1996: how the policy makers responded and why', *Economic Journal*, 116(June): F185-207.

Coffinet, J. (2005) 'Politique monétare unique et canal des taux d'intérêt en France et dans la zone euro', *Bulletin Mensuel de la Banque de France*, No. 136, April.

Cogley, T. and Sargent, T.J. (2005) 'Drifts and volatilities: monetary policies and outcomes in the post WWII US', *Review of Economic Dynamics* 8, (April): 262-302.

Coleby, A.T. (1983) 'The Bank of England's operational procedures for meeting monetary objectives', *Bank of England Quarterly Bulletin*: 23(2), (June), 209-15.

Commission of the European Communities (1999) 'EU repo markets: opportunities for change' (Report of the Giovannini Group), Euro Paper No. 35 (October), Brussels: CEC.

Congdon, T. (2005) 'Broad money vs. narrow money', Lombard Street Research *Monthly Review* No. 192, (June/July): 3-16.

Cook, T. and Hahn, T. (1989) 'The Effect of changes in the federal funds rate target on market interest rates in the 1970s', *Journal of Monetary Economics*, November, 24(3): 331-51.

Coppel, J. and Connolly, E. (2003) 'What do financial market data tell us about monetary policy transparency?', Reserve Bank of Australia, *Research Discussion Paper* 2003-05.

Cosimo, T.F. and Sheehan, R.G. (1994) 'The Federal Reserve operating procedures, 1984-1990: an empirical analysis', *Journal of Macroeconomics*, 16: 573-88.

Cox, A.H. and Leach, R.F. (1964) 'Defensive open market operation and the reserve settlement periods of member banks', *Journal of Finance*, 19(1): 76-93.

Currie, L. (1934) *The Supply and Control of Money in the United States*, Cambridge MA: Harvard University Press.

Dalziel P. (2002) 'The triumph of Keynes: what now for monetary policy research?', *Journal of Post Keynesian Economics*, 24(4): 511-27.

Danmarks Nationalbank (1992) 'New monetary and liquidity-policy instruments', *Danmarks Nationalbank Monetary Review*, (May): 8-9.

Danmarks Nationalbank (1999) 'Adjustment of the monetary-policy instruments', *Danmarks Nationalbank Monetary Review*, (2nd Quarter): 15-25.

Danmarks Nationalbank (various) *Kvartalsoversigt*, Copenhagen: Danmarks Nationalbank.

Davies, H. (1998) 'Averaging in a framework of zero reserve requirements: implications for the operation of monetary policy', Bank of England Working Paper No. 84.

De Bondt, G., Mojon, B. and Valla, N. (2005) 'Term structure and the slugishness of retail bank interest rates in euro area countries', *ECB Working Paper series*, forthcoming.

De Broeck, M., Guillaume, D. and Van der Stichele, E. (1998) 'Structural reforms in government bond markets', Working Paper No. 98/108 (August), Washington, DC: International Monetary Fund.

de Jong, R. and Herrera, A.M. (2004) 'Dynamic censored regression and the open market desk reaction function', unpublished working paper.

De Nederlandsche Bank (various) *Quarterly Bulletin*, Amsterdam: DNB.

de Pinho, P.S. (2000) 'The impact of deregulation on price and non-price competition in the Portuguese deposits market', *Journal of Banking and Finance*, 24(9): 1515-33.

Demiralp, S. and Farley, D. (2005) 'Declining required reserves, funds rate volatility, and open market operations', *Journal of Banking and Finance*, 29(5)(May): 1131-52.

Demiralp, S. and Jorda, O. (2002) 'The announcement effect: evidence from open market desk data', Federal Reserve Bank of New York *Economic Policy Review*, 8(1)(May): 29-48.

Demiralp, S., Preslopsky, B. and Whitesell, W. (2004) 'Overnight interbank loan markets', Board of Governors of the Federal Reserve System working paper.

Diamond, P.A. (1965) 'National debt in a neoclassical growth model', *American Economic Review*, 55: 1126-50.

Doi, T. and Hoshi, T. (2003) 'Paying for the FILP', in M. Blomström, J. Corbett, F. Hayashi and A. Kashyap (eds), *Structural Impediments to Growth in Japan*, 37-69, Chicago: University of Chicago Press.

Doi, T. and Ihori, T. (2002) Fiscal reconstruction and local interest groups in Japan, *Journal of the Japanese and International Economies*, 16(4): 492-511.

Doi, T. and Ihori, T. (2003) 'Sustainability of government deficits in Japan: including trends in local government finance', NIRA Discussion paper.

Dow, J.C.R. and Saville I. (1988) *A Critique of Monetary Policy*, Oxford: Oxford University Press.

Dow, S.C. (1995) 'Uncertainty about uncertainty', in S.C. Dow and J. Hillard (eds), *Keynes, Knowledge and Uncertainty*, 117-36, Cheltenham: Edward Elgar.

Dow, S.C. (2004) 'Uncertainty and monetary policy', *Oxford Economic Papers*, 56(3): 539-61.

Drudi, F. and Giordano, R. (2000) 'Default risk and optimal debt management', *Journal of Banking and Finance*, 24: 861-91.

Durré, A. and Nardelli, S. (2005) 'The overnight interest rate volatility: an analysis of the Eurosystem operational framework', *ECB Working Paper Series*, forthcoming.

Economist (1992) 'Not yet Norway', November 14th: 94-5.

Edey, M. and Hviding, K. (1995) 'An assessment of financial reform in OECD countries', Economics Department Working Paper No. 154, Paris: OECD.

Engert, W. and Selody, J. (1998) 'Uncertainty and competing paradigms of the transmission mechanism', Working Paper 98-7, Ottawa: Bank of Canada.

Engle, R.F. and Ng, V.K. (1993) 'Measuring and testing the impact of news on volatility', *Journal of Finance* 48: 1749-78.

European Central Bank (1998) *The Single Monetary Policy in Stage Three*, General Documentation on ESCB Monetary Policy Instruments and Procedures (September), Frankfurt: ECB.

European Central Bank (2002) 'The liquidity management of the ECB', ECB Monthly Bulletin, May: 41-53.

European Central Bank (2004) *The Monetary Policy of the ECB*, European Central Bank.

European Central Bank (2005) *Euro Money Market Study 2004*, Frankfurt: ECB.

Eusepi, S. (2005) 'Central bank transparency under model uncertainty', *Staff Reports* 199, Federal Reserve Bank of New York.

Ewerhart, C., Cassola, N., Ejerskov, S. and Valla, N. (2004a) 'Liquidity, information, and the overnight rate', European Central Bank Working Paper, No. 378 (July).

Ewerhart, C., Cassola, N., Ejerskov, S. and Valla, N. (2004b) 'Sporadic manipulation in money markets with central bank standing facilities', *ECB Working paper series*, No. 399, October.

Federal Reserve Bank of New York (2005) 'Domestic open market operations during 2004', http://www.newyorkfed.org/markets/omo/omo2004.pdf.

Federal Reserve Board (2001), 'Fedwire funds transfer system: self-assessment of compliance with the core principles for systemically important payment systems', Washington D.C., December 19, available on the Federal Reserve internet site.

Forssbæck, J. and Oxelheim, L. (2006) 'On the link between exchange-rate regimes, capital controls, and monetary policy autonomy in small european countries 1979-2000', *The World Economy*, 29(3): 341-68.

Freedman, C. (2000) 'Monetary policy implementation: past, present and future. Will the advent of electronic money lead to the demise of central banking?', *International Finance*, 3: 211-27.

French-Davies, R. (2005) Reformas para América Latina. Después del fundamentalismo neoliberal, CEPAL, editorial siglo XXI.

Friedman, B.M. (1999) 'The future of monetary policy: the central bank as an army with only a signal corps?', *International Finance*, 2(3): 321-38.

Friedman, B. (2000) 'Decoupling at the margin: the threat to monetary policy from the electronic revolution in banking', *NBER Working paper*, No. 7955, October.

Friedman, B. (2004a) 'The LM curve: a not so fond farewell', in Bank of Canada, *Macroeconomics, Monetary Policy, and Financial Stability: a Festschrift in Honour of Charles Freedman*, Ottawa: Bank of Canada.

Friedman, B. (2004b) 'Why the Federal Reserve should not adopt inflation targeting', *International Finance*, 7(1): 129-36.

Friedman, M. (1956) 'The quantity theory of money a restatement', in M. Friedman (ed.), *Studies in the Quantity Theory of Money*, pp. 1-21, Chicago: University of Chicago Press.

Friedman, M. (1959) 'The demand for money – some theoretical and empirical results', *Journal of Political Economy*, 67(June): 327-51.

Friedman, M. (1960) *A Program for Monetary Stability*, New York: Fordham University Press.

Friedman, M. (1969) *The Optimum Quantity of Money and Other Essays*. Chicago: Aldine Publishing.

Friedman, M. (1982) 'Monetary policy: theory and practice', *Journal of Money, Credit and Banking*, 14: 98-118.

Friedman, M. and Schwartz, A. (1963) *A Monetary History of the United States, 1867-1960*, Princeton: Princeton University Press.

Fuhrer, J.C. and Moore, G.R (1995) 'Inflation persistence', *Quarterly Journal of Economics*, 110(1): 127-59.

Fujiki, H., Osano, H. and Uchida, H. (1998) 'Optimal contracts for central banker and public debt policy', Institute of Economic Research, Kyoto University Discussion Paper No. 478.

Furfine, C. (1998) 'Interbank payments and the daily federal funds rate', The Federal Reserve Board Finance and Economics Discussion Series Paper 1998-31.

Furfine, C.H. (1999) 'The microstructure of the federal funds market', *Financial Markets, Institutions & Instruments*, 8(5)(December): 24-44.

Furfine, C.H. (2000) 'Interbank payments and the daily federal funds rate', *Journal of Monetary Economics*, 46(2): 535-53.

Furfine, C.H. (2001) 'The reluctance to borrow from the Fed', *Economics Letters*, 72: 209-13.

Furfine, C. (2003) 'Standing facilities and interbank borrowing: evidence from the Fed's new discount window', Working paper, WP 2004-01, Federal Reserve of Chicago, October.

Gale, D. (1973) 'Pure exchange equilibrium of dynamic economic models', *Journal of Economic Theory*, 6: 12-36.

Garfinkel, M and Thornton, D.L. (1991) 'The multiplier approach to the money supply process: a precautionary note', *Review of the Federal Reserve Bank of St Louis*, July/August: 47-64.

Garrison, R. (2001) *Time and Money: the Macroeconomics of Capital Structure*, London: Routledge.

Gaspar, V., Pérez-Quirós, G. and Rodríguez-Mendizábal, H. (2004) 'Interest rate determination in the interbank market', Working paper series 351, European Central Bank.

Gavin, W.T. and Karamouzis, N.V. (1982) 'The Reserve market and the information content of M1 announcements', Federal Reserve Bank of Cleveland *Economic Review* 21(Spring): 11-28.

Gavin, W.T., Keen, B.D. and Pakko, M.R. (2005) 'The monetary instrument matters', Federal Reserve Bank of St. Louis *Review* 87 (September/October): 633-58.

Geraats, P.M. (2002) 'Central bank transparency', *Economic Journal*, 112(483): F532-65.

Giavazzi, F. and Pagano, M. (1989) 'Confidence crises and public debt management', NBER working paper No. 2926.

Glosten, L.R. and Milgrom, P.R. (1985) 'Bid, ask and transaction prices in a specialist market with heterogeneously informed traders', *Journal of Financial Economics* 14: 71-100.

Glück, H. (1994) 'The Austrian experience with financial liberalization', in (J. Bonin and I. Szekely, eds), *The Development and Reform of Financial Systems in Central and Eastern Europe*, 179-95, Aldershot: Edward Elgar.

Goodfriend, M. (2003) *Review of Allan Meltzer's A History of the Federal reserve, Volume 1: 1913-1951*, Federal reserve Bank of Minneapolis, *The Region*, December.

Goodfriend, M. and King, R.G. (1988) 'Financial deregulation, monetary policy, and central banking', *Federal Reserve Bank of Richmond Economic Review*, 74(3) May-June: 216-53.

Goodhart, C.A.E. (1989) 'The conduct of monetary policy', *Economic Journal*, 99: 193-346.

Goodhart, C.A.E. (2000) 'Can central banking survive the IT revolution', *International Finance*, 3: 189-2009.

Goodhart, C.A.E. (2001) 'The endogeneity of money', in P. Arestis, M. Desai, and S. Dow (eds), *Money, Macroeconomics and Keynes*, Routledge.

Goodhart, C.A.E. (2004) 'The Bank of England, 1970-2000', in R. Michie and P. Williamson (eds), *The British Government and the City of London in the Twentieth Century*, Cambridge University Press, forthcoming.

Goodhart, C.A.E. and Viñals, J. (1994) 'Strategy and tactics of monetary policy: examples from Europe and the Antipodes', in J.C. Fuhrer (ed.), *Goals, Guidelines, and Constraints Facing Monetary Policymakers*, 139-87, Boston: Federal Reserve Bank of Boston.

Grilli, V., Masciandaro, D. and Tabellini, G. (1991) 'Political and monetary institutions and public financial policies in the industrial countries', *Economic Policy*, 13(October): 342-92.

Grønvik, G. (1994) 'Bankregulering og bankatferd 1975-1991', Occasional Paper No. 22 (PhD dissertation), Oslo: Norges Bank.

Guthrie, G. and Wright, J. (2000) 'Open mouth operations', *Journal of Monetary Economics*, 46(2)(October): 489-516.

Gurley, J.G. and Shaw, E.S. (1960) *Money in a Theory of Finance,* Washington: The Brookings Institution.

Hamilton, J.D. (1996) 'The daily market for federal funds', *Journal of Political Economy*, 104(1): 26-56.

Hamilton, J.D. (1997) 'Measuring the liquidity effect', *American Economic Review*, 87(1)(March): 80-97.

Hamilton, J. and Flavin, M. (1986) 'On the limitations of government borrowing: a framework for empirical testing', *American Economic Review*, 76: 808-16.

Hansen, L.P. and Sargent, T.J. (2004) *Robust Control and Economic Model Uncertainty*, Princeton, NJ: Princeton University Press.

Hardy, D.C. (1997) 'Market information and signaling in central bank operations, or, how often should a central bank intervene?', IMF Working Paper WP/97/28.

Harvey, A. (1993) *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge: Cambridge University Press.

Harvey, C.R. and Huang, R.D. (2002) 'The impact of the Federal Reserve Bank's open market operations', *Journal of Financial Markets*, 5: 223-57.

Hasko, H. (1996) 'Instruments of monetary policy', *Bank of Finland Bulletin*, (special issue), 49-53.

Hasko, H. and Kuisma, M. (1995) 'Recent changes in monetary policy instruments', *Bank of Finland Bulletin* No. 10/95 (October): 3-6.

Hawtrey, R.G. (1932) *The Art of Central Banking* London: Longmans Green.

He, P., Huang, L. and Wright, R. (2005) 'Money and banking in search equilibrium', mimeo, University of Pennsylvania.

Herring, R.J. and Litan, R.E. (1995) *Financial Regulation in the Global Economy*, Washington, DC: Brookings Institution.

Heymann, D. and Leijonhufvud, A. (1995) *High Inflation*, Oxford: Oxford University Press.

Hoenig, T. (2000) 'Monetary policy in a changing world', lecture presented to the Money Marketers in New York City, Federal Reserve Bank of Kansas City.

Holbik, K., ed. (1973) *Monetary Policy in 12 Industrial Countries*, Boston: Federal Reserve Bank of Boston.

Holbik, K. (1991) 'Aspects of U.S. financial deregulation', *Rivista Internazionale di Scienze Economiche Commerciale*, 38(5): 393-404.

Hoover, K.D. (2005) 'A neoWicksellian in a new classical world: the methodology of Michael Woodford's *Interest and Prices*', *Journal of the History of Economic Thought*, (forthcoming).

Hooyman, C. (1994) 'The use of foreign exchange swaps by central banks', *IMF Staff Papers*, 41(1): 149-62.

Hope, K. (1993) 'Athens fires the starting gun', *The Banker*, July: 22-26.

Hörngren, L. (1994) 'The Riksbank's new interest rate management system', *Sveriges Riksbank Quarterly Review,* No. 2: 40-45.

Huizinga, J. (1993) 'Inflation uncertainty, relative price uncertainty and investment in US manufacturing', *Journal of Money, Credit and Banking*, 23(3): 521-49.

Ihori, T. (1988) 'Debt burden and intergeneration equity', in K.J Arrow, and M.J. Boskin (eds), *The Economics of Public Debt*: Proceedings of a Conference held by the International Economic Association at Stanford, 149-200, Basingstoke: Macmillan.

Ihori, T. and Itaya, J. (2002) 'A dynamic model of fiscal reconstruction', *European Journal of Political Economy*, 17: 1057-97.

Ihori, T. and Itaya, J. (2003) 'Fiscal reconstruction and local government financing', *International Tax and Public Finance*, 10: 1-13.

Ihori, T. and Sato, M. (eds) (2002) *Government Deficit and Fiscal Attempt in Japan*, Dordrecht: Kluwer Academic Publishers.

Ihori, T., Doi, T. and Kondo, H. (2001) 'Japanese fiscal attempt: fiscal reconstruction and fiscal policy', *Japan and the World Economy*, 13: 351-70.

Ihori, T., Nakazato, T. and Kawade, M. (2002) 'Japan's fiscal policies in the 1990s', *The World Economy*, 26: 325-38.

Iivarinen, T., Leinonen, H., Lukka, M. and Saarinen, V. (2003) 'Regulation and control of payment system risks: a Finnish perspective', *Bank of Finland Studies* A:106, available on the Bank of Finland internet site.

In, F., Kim, S., Yoon, J.H. and Viney, C. (2001) 'Dynamic interdependence and volatility transmission of Asian stock markets: evidence from the Asian crisis', *International Review of Financial Analysis*, 10: 87-96.

In, F., Brown, R. and Fang, V. (2003) 'Links among interest rate swap markets: the U.S., U.K. and Japan', *The Journal of Fixed Income*, 13: 84-95.

Issing, O. (2004) *The ECB and the Euro: The First Five Years*, London: Institute of Economic Affairs.

Issing, O. (2005) 'One size fits all: a single monetary policy for the euro area', speech at the ECB International Research Forum, Frankfurt am Main, 20 May, available on the European Central Bank internet site.

Jenny, K. (1973) 'Der Schweizerische Geldmarkt', Ph.D. thesis, University of St. Gallen, also published as: Bankwirtschaftliche Forschungen 15, Bern: Paul Haupt.

Jordan, T. (2005) 'Risikominimierung und Liquiditätssicherung mittels Einsatz von Repo-Transaktionen', presentation given on the SNB Conference 'Liquidität – eine Herausforderung für die Banken', Basel, January 11.

Jordan, T. and Kugler, P. (2004) 'Implementing Swiss monetary policy: steering the 3M-Libor with repo transactions', mimeo, Swiss National Bank.

Kasman, B. (1992) 'A comparison of monetary policy operating procedures in six industrial countries', *Federal Reserve Bank of New York Quarterly Review*, (summer): 5-24.

Keynes, J.M. (1930/1971) *A Treatise on Money*, *2nd Volume: the Applied Theory of Money*, in *The Collected Works of John Maynard Keynes*, Vol. VI, London: Macmillan/Cambridge University Press.

Keynes, J.M. (1936) *The General Theory of Employment, Interest and Money*, London: Macmillan.

Keynes, J.M. (1945) 'Notes to the National Debt Inquiry', in D. Moggridge (ed.), *The Collected Writings of John Maynard Keynes Vol. XXVII Activities 1940-1946: Shaping the Post-War World, Employment and Commodities,* London: Macmillan and Cambridge University Press 1980.

Khoury, S. (1990) *The Deregulation of World Financial Markets*, New York and London: Quorum Books.

Kim, C.J. (1993) 'Unobserved-component time-series models with Markov-switching heteroskedasticity: changes in regime and the link between inflation rates and inflation uncertainty', *Journal of Business and Economic Statistics*, 11(3): 341-9.

Kim, S.J. and Sheen, J. (2000) 'International linkages and macroeconomic news effects on interest rate volatility – Australia and the US', *Pacific-Basin Finance Journal*, 8: 85-113.

Kim, S.J., Kortian T., Sheen, J. (2000) 'Central bank intervention and exchange rate volatility-Australian evidence', *Journal of International Financial Markets, Institutions and Money*, 10: 381-405.

King, M. (1999) 'Challenges for monetary policy: new and old', in *New Challenges for Monetary Policy*, Kansas City: Federal Reserve Bank of Kansas City.

King, R. and Levine, R. (1993) 'Financial intermediation and economic development' in C. Mayer and X. Vives (eds), *Financial Intermediation and the Construction of Europe* London: Centre for Economic Policy and Research.

King, W.T.C. (1936) *History of the London Discount Market*, London: Frank Cass.

Kiyotaki, N. and Wright, R. (1989) 'On money as a medium of exchange', *Journal of Political Economy*, 97: 927-54.

Klaes, M. (2006) 'Founding economic concepts', *Storia del Pensiero Economico* n.s. 3 (Special Issue on Philosophy and Economics), forthcoming.

Klaes, M. and Sent, E.-M. (2005) 'A conceptual history of the emergence of bounded rationality', *History of Political Economy*, 37(1): 27-59.

Kneeshaw, J.T. and Van den Bergh, P. (1989) 'Changes in central bank money market operating procedures in the 1980s', Economic Paper No. 23 (January), Basle: Bank for International Settlements.

Knell, M. and Stix, H. (2005) 'The income elasticity of money demand: a meta-analysis of empirical results', *Journal of Economic Surveys*, 19(3): 513-33.

Kopcke, R.W. (2002) 'The practice of central banking in other industrialized countries', *New England Economic Review*, (Second Quarter): 3-9.

Kran, L-C. (2001) *Norges Bank's System for Managing Interest Rates*, Economic Bulletin, Q2 01, Norges Bank.

Kregel, J. (2004) 'Do we need alternative financial strategies for development in Latin America', paper presented in Cuarto Seminario de Economía Financiera, IIE, UNAM, México.

Kullberg, R. (1991) 'Finansmarknadens avreglering – ett mognadsprov', *Journal of the Economic Society of Finland*, No. 1: 29-46.

Kuosmanen, H. (1996) 'Experiences with reserves averaging', *Bank of Finland Bulletin*, No. 12 (December): 9-13.

Kuttner, K.N. (2001) 'Monetary policy surprises and interest rates: evidence from the Fed funds futures market', *Journal of Monetary Economics*, 47: 523-44.

Kydland, F. and Prescott, E. (1977) 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy*, 85(3): 473-92.

Lahdenperä, H. (1995) 'The Finnish money market from the mid-1980s to the present day', *Bank of Finland Bulletin*, No. 2 (February): 3-8.

Laidler, D. (1997) *Money and Macroeconomics: The Selected Essays of David Laidler*, Cheltenham: Edward Elgar.

Laidler, D. (2003) 'The price level, relative prices and economic stability: aspects of the inter-war debate', BIS Working Paper 136, Basel: BIS.

Laidler, D. (2004a) *Macroeconomics in Retrospect: The Selected Essays of David Laidler*, Cheltenham: Edward Elgar.

Laidler, D. (2004b) 'Monetary policy without money: Hamlet without the ghost, in Bank of Canada', *Macroeconomics, Monetary Policy and Monetary Stability: a Festschrift in honour of Charles Freedman*, Ottawa: Bank of Canada.

Laidler, D. (2005) 'Woodford and Wicksell on *Interest and Prices*: the place of the pure credit economy in the theory of monetary policy', *Journal of the History of Economic Thought* (forthcoming).

Laidler, D. and Robson, W.B.P (2004) *Two Percent Target: Canadian Monetary Policy since 1991,* Toronto: CD Howe Institute.

Leijonhuvfud, A. (1981) 'The Wicksell connection: variations on a theme', in *Information and Co-ordination*, Oxford: Oxford University Press.

Levin, A.T. and Williams, J.C. (2003) 'Robust monetary policy with competing reference models', *Journal of Monetary Economics*, 50(5): 945-75.

Levy, N. (2005) 'El comportamiento de la inversión en economías peque nas y abiertas y los desafíos para la política económica: la experiencia mexicana', paper presented in the International Seminar on Institutions for Development, Mexico City, UNAM, March 16-17th.

Lindsey, D.E., Orphanides, A. and Rasche, R.H. (2005) 'The reform of October 1979: how it happened and why', *Finance and Economics Discussion Series* 2005-02, Divisions of Research and Statistics and Monetary Affairs, Federal Reserve Board, Washington D.C..

Lomax, R. (2005) 'Inflation targeting in practice: models, forecasts and hunches', paper presented to the 59th Atlantic Economic Conference, London.

Lucas, R.E. (Jr.) (1972) 'Expectations and the neutrality of money', *Journal of Economic Theory*, 4(2): 101-24.

Lucas, R.E. Jr, (1996) 'Nobel lecture: "monetary neutrality"', *Journal of Political Economy* 104(August): 661-82.

Lucas, R.E. and Stokey, N.L. (1983) 'Optimal fiscal and monetary policy in an economy without capital', *Journal of Monetary Economics*, 12: 55.

McCallum, B.T. (1984) 'Are bond financed deficits inflationary? A Ricardian analysis', *Journal of Political Economy*, 92: 123-35.

McCallum, B.T. (2005) 'Michael Woodford's *Interest and Prices:* a review article', mimeo, Carnegie Mellon University.

McCallum, B.T. and Goodfriend, M. (1987) 'Demand for money: theory', in *The New Palgrave: a Dictionary of Economics*, London: Macmillan.

McCauley, R. N. (2001) 'Benchmark tipping in the money and bond markets', *BIS Quarterly Review*, (March): 39-45.

McCloskey, D.N. (2000) 'Other things equal: Alan Greenspan doesn't influence interest rates', mimeo, Eastern Economic Association, Winter.

Maeda, E., Fujiwara, B., Mineshima, A. and Taniguchi, K. (2005) 'Japan's open market operations under the quantitative easing policy', Bank of Japan Working Paper Series 05-E-3.

Mantey, G. and Levy, N. (eds) (1999) 'Indicadores gráficos de inestabilidad financiera en América latina y el sudeste de Asia', ENEP-Acatlán, Facultad de Economía; DGAPA, UNAM, México.

Mehlbye, P.D. and Topp, J. (1996) 'Money market development', *Danmarks Nationalbank Monetary Review*, (August): 37-53.

Mehran, H., Laurens, B. and Quintyn, M. (eds) (1996) *Interest Rate Liberalization and Money Market Development: Selected Country Experiences*, Washington, DC: International Monetary Fund.

Mehrling, P. (2005) 'Mr Woodford and the challenge of finance', *Journal of the History of Economic Thought* (forthcoming).

Meigs, A.J. (1962), *Free Reserves and the Money Supply*, Chicago: University of Chicago Press.

Meltzer, A.H. (2003) *A History of the Federal Reserve, volume 1: 1913–1951*, University of Chicago Press.

Menger, C. (1892) 'On the origin of money', *Economic Journal*, 2(June): 239-55.

Meulendyke, A-M. (1998) *US Monetary Policy and Financial Markets*, New-York: Federal Reserve Bank of New-York.

Meyer, L.H. (1998) 'The payment of interest on demand deposits and on required reserve balances', Testimony before the Committee on Banking, Housing and Urban Affairs, US Senate, March 3.

Minushkin S. (2005) 'Banqueros a casabolseros: la transformación estructural del sector financiero mexicano' in G. del Ángel Mobarak and C. Bazdrech y Francisco Suárez Parada (eds), *Cuando el estado se hizo banquero: Consecuencias de la nacionalización bancaria en México*, Lecturas del Trimestre Económico, No. 96. Fondo de Cultura Económica, México.

Mishkin, F.S. (1995) *The Economics of Money, Banking, and Financial Markets*, : Harper Collins College Publishers.

Mishkin, F. (2004a), *The Economics of Money, Banking and Financial Markets*, 7th ed. Boston: Pearson-Addison Wesley.

Mishkin, F.H. (2004b) 'Can central bank transparency go too far?', in Reserve Bank of Australia, *NBER Working Paper*, no. 10829.

Miyanoya, A. (2000) 'A guide to Bank of Japan's market operations', Bank of Japan Financial Markets Department Working Paper Series 00-E-3.

Mølgaard Pedersen, A. and Sand, M. (2002) 'The Danish money market', *Danmarks Nationalbank Monetary Review*, (2nd Quarter): 19-36.

Morris, S. and Shin, H.S. (2005) 'Central bank transparency and the signal value of prices', Paper prepared for the September 2005 meeting of the Brookings Panel on Economic Activity, available at http://www.brookings.edu/es/commentary/journals/bpea_macro/forum/200509bpea_shin.pdf.

Moschitz, J. (2004) 'The determinants of the overnight interest rate in the euro area', *ECB Working Paper Series*, No. 393.

Nelson, D. (1991) 'Conditional heteroskedasticity in asset returns: a new approach', *Econometrica*, 59: 347-70.

Nelson, E. (2003) 'The future of monetary aggregates in monetary policy analysis', *Journal of Monetary Economics*, 50: 1029-59.

Nikolov, K. (2002) 'Monetary policy rules at the Bank of England', paper presented at the ECB 'The Role of Policy Rules in the Conduct of Monetary Policy' Workshop, Frankfurt, March.

Norges Bank (1995) 'Norwegian monetary policy and financial markets', Occasional Paper No. 24, Oslo: Norges Bank.

Norges Bank (1997) *Penger & Kreditt*, (available in English as the *Economic Bulletin*), Oslo: Norges Bank.

Organisation for Economic Cooperation and Development (1989) 'Recent trends in financial regulation', *Financial Market Trends*, No. 44 (October), Paris: OECD.

Organisation for Economic Cooperation and Development (1995) *Securities Markets in OECD Countries: Organisation and Regulation*, Paris: OECD.

Organisation for Economic Cooperation and Development (various) *Financial Market Trends*, Paris: OECD.

Orphanides, A. (2003) 'The quest for prosperity without inflation', *Journal of Monetary Economics*, 50(3)(April): 633-63.

Oxelheim, L. (1990) *International Financial Integration*, Berlin: Springer Verlag.

Oxelheim, L. (1996) *Financial Markets in Transition: Globalization, Investment, and Growth*, London: Routledge and International Thomson Press.

Padoa-Schioppa, T. (2002) 'Securities and banking: bridges and walls', Lecture delivered at the London School of Economics, ECB.

Pagan, A.R. and Robertson, J.C. (1995) 'Resolving the liquidity effect', Federal Reserve Bank of St. Louis *Review*, 77(3)(May/June): 33-54.

Pagano, M. and Volpin, P. (2001) 'The political economy of finance', *Oxford Review of Economic Policy*, 17(4): 502-19.

Palley, T.I. (2004) 'Assets-based reserve requirements: reasserting domestic monetary control in an era of financial innovation and instability' *Review of Political Economy*, 16(1): 43-58.

Papademos, L. (2005) 'The political economy of the reformed Stability and Growth Pact: implications for fiscal and monetary policy', speech at the conference 'The ECB and its watchers VII', 3 June, available on the European Central Bank internet site.

Patinkin, D. (1956) *Money Interest and Prices*, New York: Harper and Row (2nd edn. 1965).

Patinkin, D. (1972) 'Financial intermediaries and the logical structure of monetary theory' in *Studies in Monetary Economics*, New York: Harper and Row.

Pech, H. (1994) 'The interest-rate policy transmission mechanism—the case of Austria', in (Bank for International Settlements), 'National differences in interest rate transmission', CB Document No. 393 (March), Basle: BIS.

Pérez-Quirós, G. and Rodríguez-Mendizábal, H. (2001) 'The daily market for funds in Europe: what has changed with the EMU', Working paper series 67, European Central Bank.

Perez-Quirós, G. and Rodríguez-Mendizábal, H. (2003) 'The daily market for funds in Europe: what has changed with the EMU?', mimeo, Universitat Autonoma de Barcelona, February.

Perez-Quiros, G. and Mendizabel, H.R. (2004) 'Interest rate determination in the interbank market', working paper no. 351, European Central Bank.

Persson, M., Persson, T. and Svensson, L.E.O. (1987) 'Time consistency of fiscal and monetary policy', *Econometrica*, 55: 1419-31.

Persson, M., Persson, T. and Svensson, L.E.O. (2005) 'Time consistency of fiscal and monetary policy: a solution', NBER *Working Paper* No. 11088.

Pesek, B. and Saving, T. (1967) *Money, Wealth and Economic Theory*, New York: Macmillan.

Phillips, C.A. (1920) *Bank Credit*, New York: Macmillan.

Pinto, A.M. (1996) 'Changing financial systems in small open economies: the Portuguese case', in (Bank for International Settlements), 'changing financial systems in small open economies', Policy Paper No. 1 (December): 96-113, Basle: BIS.

Poole, W. (1968) 'Commercial bank reserve management in a stochastic model: implications for monetary policy', *Journal of Finance*, 23(December): 769-91.

Poole, W. (1970) 'Optimal choice of monetary policy instruments in a small stochastic macro model', *Quarterly Journal of Economics*, 84(May): 197-216.

Poole, W. (1975) 'The making of monetary policy: description and analysis', *New England Economic Review* (March/April): 21-30.

Poole, W. (2000) 'Monetary aggregates and monetary policy in the twenty-first century', in (Kopcke, R.W. and Browne, L.E., eds), *The Evolution of Monetary Policy and the Federal System over the Past Thirty Years: A Conference in Honor of Franck E. Morris*, Boston: Federal Reserve Bank of Boston.

Poole, W., Rasche, R.H. and Thornton, D.L. (2002) 'Market anticipations of monetary policy actions', Federal Reserve Bank of St. Louis *Review*, 84(4)(July/August): 65-93.

Rabin, A.A. (2004) *Monetary Theory*, Cheltenham: Edward Elgar.

Ragnartz, C. and Östberg, J. (1997) 'The Swedish repo market', *Sveriges Riksbank Quarterly Review* No. 3: 36-48.

Rajan, R.G. and Zingales, L. (2003) 'The great reversals: the politics of financial development in the twentieth century', *Journal of Financial Economics*, 69: 5-50.

Rautava, J. (1994) 'The Finnish experience with financial market liberalization', in (J. Bonin and I. Szekely), *The Development and Reform of Financial Systems in Central and Eastern Europe*: 197-213, Aldershot: Edward Elgar.

Remolona, E. and Wooldridge, P. (2003) 'The euro interest rate swap market', *BIS Quarterly Review*, March: 47-56.

Reserve Bank of Australia (2002) 'Operations in financial markets, RBA annual Report.

Rogers, C. (2005) 'Doing without money: a critical assessment of Woodford's analysis', mimeo, University of Adelaide.

Romer, C. and Romer, D. (1990) 'New evidence on the monetary transmission mechanism', *Brookings Paper on Economic Activity*, 1: 149-213.

Rosa, C. and Verga, G. (2005a) 'Is ECB communication effective?', *CEP Discussion Paper* No. 682.

Rosa, C. and Verga, G. (2005b) 'The importance of the wording of the ECB', *CEP Discussion Paper* No. 694.

Rudebusch, G. (1998) 'Monetary policy and the term structure of interest rates: an overview of some recent research', in (I. Angeloni and R. Rovelli, eds), *Monetary Policy and Interest Rates*, 263-71, London: Macmillan Press.

Runde, J. (1990) 'Keynesian uncertainty and the weight of arguments', *Economics and Philosophy*, 6(2): 275-92.

Samuelson, P.A. (1958) 'An exact consumption-loan model of interest with or without the social contrivance of money', *Journal of Political Economy*, 66: 467-82.

Santillán, J., Bayle, M. and Thygesen, C. (2000) 'The impact of the euro on money and bond markets', Occasional Paper No. 1, Frankfurt: European Central Bank.

Sargent, T.J. and Wallace, N. (1975) '"Rational" expectations, the optimal monetary instrument, and the optimal money supply rule', *Journal of Political Economy*, 83(2): 241-54.

Sargent, T.J. and Wallace, N. (1988) 'Some unpleasant monetarist arithmetic', *Federal Reserve Bank of Minneapolis Quarterly Review*, 5(Fall): 1.

Sayers, R.S. (1957) *Central Banking After Bagehot*, Oxford: Clarendon Press.

Sayers, R.S. (1976) *The Bank of England, 1891-1944*, 3 volumes, Cambridge: Cambridge University Press.

Schwartz, A. (1992) 'The misuse of the Fed's discount window', *Federal Reserve Bank of St. Louis Review*, (Sep./Oct.): 58-69.

Schweizerishe Nationalbank (various) *Bulletin mensuel de statistiques économiques*, Berne: SNB.

Schweizerishe Nationalbank (various) *Bulletin Trimestriel*, Berne: SNB.

Selgin, G. and White, L. (2002) 'Mengerian perspectives on the future of money', in M. Latzer and S. Schmitz (eds), *Carl Menger and the Evolution of Payments systems: From Barter to Electronic Money*, 133-58, Cheltenham: Elgar.

Sellon, G.H. (2002) 'The changing U.S. financial system: some implications for the monetary transmission mechanism,' *Economic Review*, First quarter, Federal Reserve Bank of Kansas City.

Sellon, G.H. and Weiner, S.E. (1996) 'Monetary policy without reserve requirements: analytical issues', *Economic Review of the Federal Reserve bank of Kansas City*, Fourth Quarter.

Sellon, G.H. and Weiner, S.E. (1997) 'Monetary policy without reserve requirements: case studies and options for the United States', *Economic Review of the Federal Reserve bank of Kansas City*, Second Quarter.

Simons, H.C. (1946) 'Debt policy and banking policy', in *Economic Policy for a Free Society*, Chicago: Chicago University Press.

Smith, A. (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations*, Edinburgh: William Strahan.

Soumelis, G. (1995) 'Greece: reforming financial markets', *OECD Observer*, No. 193 (April/May): 40-41.

Stallings, B., with Studart, R. (2006) *Finance for Development: Latin America in Comparative Perspective*, Washington: Brookings Institution Press and the Economic Commission for Latin America and the Caribbean (ECLAC).

Steindl, J. (1982) 'The role of household saving in the modern economy', *Banca Nazionale del Lavoro Quarterly Review*, 35(140)(March): 69-88.

Sternlight, P.D. (1991) 'Monetary policy and open market operations during 1990', Federal Reserve Bank of New York, *Quarterly Review*, 16(1)(Spring): 52-78.

Sternlight, P.D. (1992) 'Monetary policy and open market operations during 1991', Federal Reserve Bank of New York, *Quarterly Review*, 17(1)(Spring): 72-95.

Stevens, E.J. (1981) 'The new procedure', *Economic Review* Federal Reserve Bank of Cleveland, Summer: 1-17.

Stigum, M. (1983) *The Money Market*, Homewood: Dow Jones Irwin.

Stigum, M. (1990) *The Money Market*, 3rd. ed. Homewood, Ill: Dow Jones-Irwin.

Strongin, S. (1995) 'The identification of monetary policy disturbances. Explaining the liquidity puzzle', *Journal of Monetary Economics*, 35: 463-97.

Svensson, L. (1985) 'Money and asset prices in a cash in advance economy', *Journal of Political Economy*, 93(October): 919-44.

Sveriges Riksbank (1994) 'The Riksbank's new system of interest rate policy instruments', Press release, May 26.

Sveriges Riksbank (various) *Penning- och valutapolitik*, (available in English as the *Economic Review*), Stockholm: Sveriges Riksbank.

Swank, J. (1995) 'Averaging provisions', mimeo The Netherlands Bank.

Swiss National Bank (1982) *75 Jahre Schweizerische Nationalbank, Die Zeit von 1957 bis 1982*.

Swiss National Bank (1983-2004) *Annual Report*, various issues.

Taylor, J.B. (1979) 'Estimation and control of macroeconomic model with rational expectations', *Econometrica*, 47(September): 1267-86.

Taylor, J.B. (1993) 'Discretion versus policy rules in practice', *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.

Taylor, J.B (2001) 'Expectations, Open market operations, and changes in the federal funds rate', Federal Reserve Bank of St. Louis *Review*, 83(4)(July/August): 33-47.

The Economist (2005) 'All at sea? The Fed's interest rate rudder isn't working', August 13th, p. 14.

Thornton, D.L. (1988a) 'The borrowed-reserves operating procedure: theory and evidence', *Review* Federal Reserve Bank of St. Louis, 70(January/February): 30-54.

Thornton, D.L. (1988b) 'The effect of monetary policy on short-term interest rates', Federal Reserve Bank of St. Louis *Review*, 70(3)(May/June): 53-72.

Thornton, D.L. (1995) 'Does the Fed control short-term interest rates?', *Monetary Trends*, December.

Thornton, D.L. (2000) 'Money in a theory of exchange', *Federal Reserve Bank of St. Louis Review*, (January/February): 35-60.

Thornton, D.L. (2001a) 'Identifying the liquidity effect at the daily frequency', Federal Reserve Bank of St. Louis *Review*, 83(4)(July/August): 59-78.

Thornton, D.L. (2001b) 'The Federal Reserve's operating procedure, nonborrowed reserves, borrowed reserves and the liquidity effect', *Journal of Banking and Finance*, 25(9)(September): 1717-39.

Thornton, D.L. (2004) 'The Fed and short-term rates: is it open market operations, open mouth operations or interest rate smoothing?', *Journal of Banking and Finance*, 28(3)(March): 475-98.

Thornton, D.L. (2005) 'A new federal funds rate target series: September 27, 1982 – December 31, 1993', Federal Reserve Bank of St. Louis Working Paper 2005-032A.

Thornton, D.L. (2006) 'When did the FOMC begin targeting the federal funds rate? What the verbatim transcripts tell us', *Journal of Money, Credit, and Banking*, 38(8)(December): 2039-71.

Thornton, H. (1802/1962) *An Inquiry into the Nature and Effects of Paper Credit of Great Britain*, Reprint 1962, New York: Kelley.

Tinsley, P.A., Spindt, P.S. and Fries, G. (1981) 'A stochastic sensitivity analysis of staggered reserve settlements', Office Correspondence, Board of Governors of the Federal Reserve System, August 24.

Tirole, J. (1985) 'Asset bubbles and overlapping generations', *Econometrica*, 53: 1071-100.

Toporowski, J. (2005) 'Las limitaciones de los bancos centrales en al estabilidad financiera' in G. Mantey and N. Levy (eds), *Inflación, Créditos y salarios: Nuevos de la Política Monetaria para México para mercados imperfectos*', Porrúa, Mexico: FES-Acatlan.

Toporowski, J. (2006) 'Open market operations: beyond the new consensus', *Bank of Finland Discussion Paper* 14/2006.

Toporowski, J. (2007) 'Asset-based reserve requirements – some reservations', *Review of Political Economy* (forthcoming).

Tucker, P. (2004) 'Managing the central bank's balance sheet: where monetary policy meets financial stability', speech to mark the fifteenth anniversary of Lombard Street Research, London, 28 July, reprinted in *Bank of England Quarterly Bulletin*, Autumn: 359-82, available on the Bank of England internet site.

Turner, P. and van't dack, J. (1996) 'Changing financial systems in open economies: An overview', in (Bank for International Settlements), 'Changing financial systems in small, open economies', Policy Paper No. 1 (December): 5-61, Basle: BIS.

Vale, B. (1995) 'Finansmarkedens rolle, penge- og valutapolitikken', *Norske finansmarkeder, norsk penge- og valutapolitikk*, Oslo: Norges Bank.

Välimäki, T. (2002) 'Bidding in fixed rate tenders: theory and experience with the ECB tenders', Bank of Finland Discussion Papers 1/2002.

Välimäki, T. (2003) 'Fixed rate tenders and the overnight money market equilibrium', Ph.D thesis, Helsinki School of Economics and Bank of Finland.

Veyrassat, A. (2004) 'The Swiss Franc money market: instruments and market participants', *SNB Quarterly Bulletin* 3/2004: 42-55.

Vihriälä, V. (1997) *Banks and the Finnish Credit Cycle 1986-1995*, PhD Dissertation, University of Helsinki (reprinted as Bank of Finland Study No. E:7, 1997, Helsinki: Bank of Finland).

Virolainen, K. (1996) 'The derivatives market', *Bank of Finland Bulletin*, (special issue): 49-53.

Wallace, N. (2005) 'Monetary theory at the beginning of the 21st century', mimeo, Penn. State University.

Walsh, C.E. (2004) 'Implications of a changing economic structure for the strategy of monetary policy, in *Monetary Policy and Uncertainty: Adapting to a Changing Economy*, Jackson Hole Symposium, 297-348, Kansas City: Federal Reserve Bank of Kansas City.

Warner, A. (1993) 'Push comes to shove', *The Banker*, December: 27-30.

Weil, P. (1989) 'Overlapping families of infinitely-lived agents', *Journal of Public Economics*, 38: 183-98.

Wheelock, D. (1990) 'Member bank borrowing and the Fed's contractionary monetary policy during the great depression', *Journal of Money, Credit, and Banking*, 22(November): 409-26.

Wicksell, K. (1898/1936) *Interest and Prices. A Study of the Causes Regulating the Value of Money*, London: Macmillan, 1936. Translation R.F. Kahn for the Royal Economic Society.

Winkler, B. (2000) 'Which kind of transparency? On the need for clarity in monetary policy-making', *ECB Working Paper* No. 26.

Wojnilower, A.M. (2000) 'Life without treasury securities', *Business Economics*, 35(4) (October): 10-16.

Woodford, M. (2000) 'Monetary policy in a world without money', mimeo, Princeton University, June.

Woodford, M. (2001) 'Monetary policy in the information economy', in Economic *Policy for the Information Economy*, Kansas City: Federal Reserve Bank of Kansas City.

Woodford, M. (2002) 'Financial market efficiency and the effectiveness of monetary policy', mimeo, Department of Economics, Princeton University, March.

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy,* Princeton NJ: Princeton University Press.

Woodford, M. (2005a) 'After monetary theory', mimeo, Columbia University.

Woodford, M. (2005b) 'Comments on the symposium on *Interest and Prices*', *Journal of the History of Economic Thought* (forthcoming).

Würtz, F.R. (2003) 'A comprehensive model of the euro overnight rate', ECB Working Paper Series, No. 207.

Wyplosz, C. (2001) 'Financial restraints and liberalization in postwar Europe', in (G. Caprio *et al.*, eds), *Financial Liberalization: How Far? How Fast?*: 125-58, Cambridge: Cambridge University Press.

Zimmermann, G. (2003) 'Optimal monetary policy: a New Keynesian view', *Quarterly Journal of Austrian Economics*, 6(4): 61-72.

Zurlinden, M. (1996), 'Devisenmarktinterventionen der Schweizerischen Nationalbank 1986-1994', *Schweizerische Nationalbank Quartalsheft*, 14(2): 163-87.

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