Monetary Policy Strategy and the Behaviour of Exchange Rates: an Empirical Investigation

by

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Abstract

This thesis studies several aspects of the strategy which central banks follow in implementing monetary policy and its implications for the behaviour of exchange rates. The first chapter provides an introduction to the thesis and a review of the relevant literature. The following two chapters analyse the effects of information releases on the high frequency behaviour of the DEM/USD exchange rate, and investigate how these effects are related to the central banks' policy decisions and their strategy for disclosing information to the market. Chapter 2 studies the effects of monetary policy signals released by the Deutsche Bundesbank and the US Federal Reserve, showing that they have a strong impact on exchange rates, and that these effects depend on the channel used to release the policy information, and on when the information is released. Chapter 3 extends this analysis by examining the reaction to publicly announced macroeconomic information emanating from Germany and the US, and associates this reaction with market expectations regarding future monetary policy decisions and the timing of the announcement of those decisions.

Alternative monetary policy frameworks and their implication for the behaviour of exchange rates are the topic of the following three chapters. Chapter 4 examines the policy framework in 44 developing countries, covering topics such as the choice of price stability as the objective for monetary policy, the potential conflicts between achieving this objective and other functions of the central bank (in particular the maintenance of financial stability), and central bank independence. Chapter 5 analyses the experience of seven countries that have adopted a policy strategy centered on inflation targets, and investigates how this affected the behaviour of the central banks. Chapter 6 investigates the implications of the strategies analysed in the previous chapters for the stability of financial markets, using price data for several financial assets from a panel of eighteen OECD countries. Finally, Chapter 7 summarises the conclusions of the thesis and provides suggestions for further work.

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Chapter 1

Introduction

This thesis studies several aspects of the strategy which central banks follow in implementing monetary policy and its implications for the behaviour of exchange rates. There is an extensive body of literature that seeks to explain exchange rate movements with reference to observable macroeconomic variables, including variables directly associated with monetary policy, like the money supply or interest rates. The results of those studies suggest that the link between exchange rate movements and macroeconomic variables is weak. Existing structural models have little explanatory power, and their forecasting ability is poor when compared to very simple alternatives. Nevertheless, the theoretical argument linking exchange rates and macroeconomic variables, in particular the money supply or interest rates, is apparently strong. Since the exchange rate is the relative price of two moneys, the monetary policies followed by both central banks and the market's perception of the direction of future policy actions should play an integral role in the determination of the exchange rate.

The recent availability of good quality high frequency exchange rate data led some researchers to explore the possibility that the failure of previous studies to identify significant influences of macroeconomic variables on exchange rates could be a result of the low frequency of the data used (usually quarterly or monthly). Analysis of the behaviour of exchange rates at daily or intra-daily frequencies might reveal patterns that are not observable at lower frequencies.[1] This thesis brings together a number of studies written over the last three years that aim to contribute to this branch of the literature by associating the behaviour of exchange rates to the strategy of monetary policy, the elaboration of the process through which the policy objectives are to be achieved (Begg, 1997, p. 4). As described in Section 1.2 below, economists have been interested in many aspects of this process. The research described in this thesis focus on the disclosure of policy decisions to the markets, and the basic principles and rules guiding those decisions.

This chapter provides a brief review of the existing literature on the topics covered in this thesis, and motivates the research contained in subsequent chapters. Section 1.1 reviews the literature on the behaviour of exchange rates, while Section 1.2 reviews the literature on monetary policy strategy. Section 1.3 describes the structure of the thesis.

1.1 The Behaviour of Exchange Rates

Exchange rate economics has been one of the most active areas of economic research over the last three decades, but so far this research has been unable to produce a well established theory on what determines exchange rate movements.[2] The traditional macroeconomic models of exchange rates did not provide satisfactory explanations of variations in exchange rate data: estimated equations provide poor fits, exhibit incorrectly signed coefficients, and their predictive ability was poor (Meese and Rogoff, 1983, Taylor, 1995). In light of these results, some researchers suggested that one should test the relevance of economic fundamentals for exchange rate movements through an examination of the effect of 'news' about fundamentals on unexpected exchange rate movements.

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[1] For a survey of the properties and applications of high-frequency financial data, with particular reference to foreign exchange markets, see Goodhart and O'Hara (1997).

[2] Recent surveys on exchange rate economics may be found in Frankel and Rose (1995), Isard (1995), MacDonald and Taylor (1991), or Taylor (1995).

1.1.1 Structural exchange rate model in 'news' form

An advantage of the 'news' approach is that it allows one to test the influence of the underlying fundamentals without having to specify a precise functional form for the exchange rate equation. One may start from a generic model, where the reduced form for the exchange rate is

$$S_t = \mathrm{B} X_t + \varepsilon_t \qquad 1.1$$

where S_t is the spot exchange rate at time t, X_t is a vector of fundamental economic variables prevailing at time t, B is a vector of coefficients, and ε_t is an error term. Rational market agents will act as if they know the (true) underlying exchange rate model, and make no systematic forecast errors. Under those conditions, and assuming efficient markets,

$$_{t-k}f_t = E_{t-k}(S_t) = \mathrm{B}\, E_{t-k}(X_t) \qquad 1.2$$

where $_{t-k}f_t$ is the forward rate for period t formed at t-k, and E_{t-k} denotes expectations formed at t-k. Combining equations 1.1 and 1.2 one gets the structural exchange rate model in 'news' form:

$$S_t - {}_{t-k}f_t = \mathrm{B}\left[X_t - E_{t-k}(X_t)\right] + \varepsilon_t \qquad 1.3$$

Equation 1.3 is simplified in a high-frequency setting, when k is small (1 day or less). The structure of the foreign exchange market implies that in that case $_{t-k}f_t = S_{t-k}$.[3] The high-frequency structural exchange rate model in 'news' form is then

$$S_t - S_{t-k} = \mathrm{B}\left[X_t - E_{t-k}(X_t)\right] + \varepsilon_t \qquad 1.4$$

i.e., high-frequency changes in the exchange rate should be caused by 'news' about the fundamentals.

[3] Foreign exchange transactions are settled two working days after the deal is arranged. This implies that the costs of holding and carrying currency for very short periods of time (inside the business day) are non-existent, since both operations are to be settled at the same time. Then, $E_{t-k}(S_t) = S_{t-k}$, otherwise excess returns could be made by buying at t-k and selling at t, or vice-versa. For transactions occurring in two consecutive days, there are costs of holding and carrying currency, but in normal circumstances these are too small to affect the analysis.

1.1.2 The impact of announcements on exchange rates

Using the model in equation 1.4, and a variety of choices for the variables in X_t, researchers sought to identify the importance of fundamentals in explaining exchange rate movements. The main difficulty in applying equation 1.4 is to identify the expectations regarding the fundamentals. Typically, researchers have used either time-series methods (Frenkel, 1981, Eichenbaum and Evans, 1995) or survey data to form $E_{t-k}(X_t)$. In this latter case, the market expectation is usually measured by the median of expectations of market agents questioned by commercial enterprises that collect and distribute this information. Money Market Services, International (MMS) provides the most popular survey.

The use of equation 1.4 with survey data is particularly common in studies of the impact of announcements of macroeconomic data on exchange rates. One major advantage of the studies using announcement data is that one can pinpoint the precise time of day when the announcement was made. One can then observe the exchange rate immediately before and after the announcement, to see the effect. With such precise timing, one can hope to isolate the impact of one particular bit of information, before it is diffused in a stream of other information arriving to the market.

The early studies of announcement data concentrated on the reaction of USD exchange rates to US money supply announcements. Using daily data, Cornell (1982), Engel and Frankel (1984), Frankel and Hardouvelis (1985), and Tandon and Urich (1987) all found that positive money surprises were associated with appreciation of the USD. This analysis was later extended to other US announcements by Hardouvelis (1988), Harris and Zabka (1995), and Edison (1997), also using daily data, and Hakkio and Pearce (1985), Hogan, Melvin, and Roberts (1991), and Hogan and Melvin (1994), using data sampled 3 or 4 times daily. The results from these studies suggest that the only macroeconomic announcements that significantly and systematically affect USD exchange rates are the money supply, trade balance and employment statistics.

In principle, the movements in any bilateral exchange rate depend on 'news' originating from both countries concerned. However, most empirical studies only investigate the effect of US news on bilateral USD exchange rates, with Ito and Roley (1987) being the major exception.[4] Chapter 3 intends to fill this gap by examining the effect on the DEM/USD exchange rate of macroeconomic announcements from the US and Germany.[5] This chapter also improves on existing literature on US macroeconomic announcements because it uses exchange rate data sampled at higher frequencies (five minutes, instead of several hours). Results show that in a high-frequency setting, several US and German releases have significant impacts on the DEM/USD, but for most of these announcements the effects are quickly drowned in subsequent exchange rate fluctuations. This explains the limited findings of previous studies that used coarser exchange rate samplings.

The statistical significance of US money supply 'news' suggests that monetary policy is one key factor driving exchange rates. Then, a natural extension of the announcement studies would be to analyse the effects on exchange rates of announcements by central banks regarding the current and future stance of monetary policy. This is done in Chapter 2, where the impact on the DEM/USD exchange rate of monetary policy signals from the Deutsche Bundesbank and the US Federal Reserve is analysed. The links between central bank's activities and high frequency exchange rate behaviour are further explored on Chapter 3, where it is shown that the impact of macroeconomic announcements on the DEM/USD exchange rate is associated with the timing of monetary policy decisions, and the expectation regarding those decisions.

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[4] Ito and Roley (1987) examined the effect on the USD/JPY exchange rate of money supply, producer prices, and industrial production innovations from the US and Japan, and found that only the US money innovations had a significant effect.

[5] This chapter is based on Almeida, Goodhart, and Payne (1998).

1.1.3 The exchange rate volatility process

Although most of the attention of academics and practioners is usually concentrated on the *level* of the exchange rate, its *volatility* is also of interest. Higher exchange volatility increases the risk and uncertainty in international transactions, which should reduce the welfare of risk-averse agents. The evidence on the real costs of exchange rate volatility is not clear-cut (see, for example, Grauwe, 1989, ch. 12), but since agents buy costly financial instruments to hedge against exchange risk, the amounts involved in these transactions are an indication of how costly exchange rate volatility is. It is then important to understand the determinants of exchange rate volatility, to be able to propose policies that might reduce it.

Equation 1.4 implies that high-frequency exchange rate movements are associated with the arrival of new information to the market. Using their Mixture of Distribution Model (MODM), Tauchen and Pitts (1983) have shown that assuming a random information arrival process, both volume and volatility are directly proportional to the number of information events in a given interval of time. Therefore, the MODM predicts that one will observe large temporal variations in exchange rate volatility associated with variations in the arrival of information to the market. This pattern of conditional heteroscedasticity is what is observed in actual exchange rate data, and this topic has become one of the most widely researched areas in exchange rate behaviour.

Traditionally, the time-varying volatility in exchange rates has been modelled using the Autoregressive Conditional Heteroscedasticity (ARCH) framework introduced by Engle (1982), generally under some variation of the GARCH(1,1) model developed by Bollerslev (1986). Examples of applications of this model in modelling exchange rate volatility include Hsieh (1989), for daily data, Baillie and Bollerslev (1991), for hourly data, and Andersen and Bollerslev (1997), for high-frequency (five minutes) data.[6]

[6] A survey of applications of the ARCH class of models to financial data can be found in Bollerslev, Chou, and Kroner (1992).

One disadvantage of these models is that they are entirely univariate, i.e., they explain volatility only in terms of its own history and not in relation with any exogenous variables. However, it is clear that some observable exogenous factors may cause significant changes in volatility, and some researchers tried to explore this fact. For example, DeGennaro and Shrieves (1995) related intra-day volatility to measures of public information arrivals, derived from the Reuters news headline pages. The impact on exchange rate volatility of announcements of US macroeconomic statistics was analysed by Harvey and Huang (1991), Ederington and Lee (1993), and Payne (1996).

Chapter 2 extends their analysis in two ways. First, the announcements covered in the chapter refer to monetary policy announcements from the Bundesbank and the Federal Reserve, instead of macroeconomic statistics. Second, it uses the GARCH framework, while Harvey and Huang (1991) and Ederington and Lee (1993) used variance ratios, and Payne's model was based on the Stochastic Volatility approach. The GARCH-based methodology developed in Chapter 2 provides for an easier way of simultaneously estimating the impact of the policy announcements and the strong intra-daily seasonality in exchange rate volatility, that was also found by Ederington and Lee (1993) and Payne (1996).

Another factor that may cause significant changes in exchange rate volatility is the monetary policy strategy. Different monetary policy strategies may be associated with different degrees of uncertainty regarding future policy. Assuming that monetary policy is relevant for exchange rate behaviour, these differences in uncertainty are likely to translate into differences in the frequency and magnitude of exchange rate changes. An example of this relation has been demonstrated by Lastrapes (1989), using the ARCH framework, that has shown that shifts in US monetary policy regimes significantly affected the volatility of USD exchange rates. Chapter 6 explores this possible link between monetary policy and asset price volatility, using price data for several financial assets from a panel of 18 OECD countries.

1.2 The Strategy of Monetary Policy

1.2.1 Monetary policy objectives

As the monopolist supplier of high-powered money, the central bank has potentially considerable power over the economic conditions of the region where its money is used. Central banks around the world have always been required to use monetary policy, the management of the supply of high-powered money, to achieve a variety of objectives. The earliest central banks were set up to finance their governments, and to develop the financial system. In the nineteenth century, central banks took on the primary responsibility for protecting the external value of the currency and the stability of the financial system. During the 1930s and 1940s central banks were required to promote monetary stability, full employment and maximum levels of production.[7]

Economic research and economic developments in the last thirty years led to a growing consensus among economists and central bankers that price stability should be the overriding long-term objective of monetary policy. The case for price stability may be summarised as the corollary of two basic propositions.[8] The first proposition states that attempts to reduce unemployment using monetary policy are likely to be unsuccessful. As Friedman (1968) and Phelps (1967) have pointed out, there is no medium (or longer) term inflation-output trade-off to exploit. A downward sloping Phillips curve may exist in the short run, but attempts to exploit it are likely to be destabilising, since the effects of monetary policy on the economy are not known with sufficient precision (Friedman's, 1959, 'long and variable lags'), and self-defeating, since they might generate expectations of higher inflation, and thus higher actual inflation, without any reduction in unemployment (the time-inconsistency problem of Kydland and Prescott, 1977, and Barro and

[7] For an historical review of central bank's functions and mandates see Capie, Goodhart, and Schnadt (1994).

[8] See, for instance, Mishkin (1997) for an extensive discussion of the case for price stability.

Gordon, 1983a). The second proposition states that price stability in the long run promotes a higher level of economic output and more rapid economic growth. This negative relationship between inflation and growth has been documented empirically (Barro, 1995, Gregorio, 1996), and is associated with the fact that inflation increases uncertainty about relative prices and the future price level, and, when associated with a non-indexed tax system, increases the cost of capital, both effects reducing investment below its optimal level (Fischer, 1994).[9]

Still, price stability is not the only objective of monetary policy. For example, in the short run monetary policy has real effects, and these short run effects matter. Even those central banks that give primacy to medium term price stability have, in most cases, other concerns, although these assume a secondary status (Goodhart and Viñals, 1994). The objectives of monetary policy have recently been reviewed in Fischer (1994) and Goodhart (1994), in the context of the largest (G-7) developed economies. Chapter 4 extends this analysis for a group of 44 developing countries.[10] Central banks in developing countries tend to face a different set of economic problems and conditions, that may justify diverting monetary policy to a different set of objectives. As it is shown in this chapter, the primary objective of most central banks in developing countries is also, in principle, price stability. However, these central banks face strong pressures to deliver results in other areas (e.g., financing the government, maintaining inappropriate exchange rates), that in some cases force them to relegate price stability to a secondary position in their list of priorities.

One objective that is common to central banks in developed and developing countries is the responsibility for the systemic stability of the financial system (see Fischer, 1994, Goodhart, 1994, and Chapter 4 of this thesis). Even those central banks that do not have responsibility for the supervision of financial institutions see themselves as safeguards of

[9] Fischer (1994) provides an extensive discussion of the costs of inflation. The author identifies other channels through which inflation may reduce the level and growth of output (e.g., shoe-leather costs, menu costs), but argues that those associated with the tax system and inflation uncertainty are the ones that are quantitatively more important.

[10] Chapter 4 is based on Fry, Goodhart, and Almeida (1996).

financial stability (Goodhart and Viñals, 1994, Table 1). In the long run, the pursuit of price stability is likely to strengthen the stability of the financial system, since financial disruptions and crises are frequently linked to instability of inflation and interest rates. However, in special circumstances, the central banks' acceptance of lender-of-last-resort responsibilities might require a monetary policy response that is in conflict with the macroeconomic objective, at least in the short run. Substantial increases in interest rates may cause liquidity problems in marginal banks, that force the central bank to inject more liquidity into the system than the macroeconomic objective would require (Cukierman, 1994). Concerns about financial stability may also drive central banks to smooth interest rates more than it would be desirable from the inflation point of view (Goodhart, 1996).

1.2.2 Strategies for achieving price stability

Achieving price stability without endangering the financial system requires a carefully designed strategy. The features of this strategy that have been the focus of most discussions in the literature are the legal and institutional framework of monetary policy, in particular the question of whether the central bank should be independent from the political power, and the use of rules and intermediary targets. Less discussed, but not a less important feature of the policy strategy, is the choice of the operating procedures for policy implementation. This subsection reviews the main issues in these discussions.

Central bank independence

One of the strategies that have been suggested by many as being able to deliver low inflation is to change the institutional framework of the central bank in order to make it more independent from the government.[11] The case for an independent central bank is based on two arguments. The first is the theoretical literature on the time-inconsistency problem. Making the central bank independent, with a clear mandate to achieve price stability would remove any incentives to generate surprise inflation, i.e., it would elimi-

[11] Discussions on the topic of central bank independence may be found in Cukierman (1992, 1994), Fischer (1994), and Goodhart (1993).

nate the inflation bias. The second is the empirical evidence that suggests that central banks that are more independent are able to deliver lower inflation. Some empirical research has shown that there is evidence of a negative correlation between various proxies for central bank independence and inflation, at least within the group of industrial countries (Grilli, Masciandaro, and Tabellini, 1991, Alesina and Summers, 1993). Perhaps more relevant for the widespread support for central bank independence, is the fact that the central bank with the best anti-inflationary reputation, the Bundesbank, is also one of the most independent central banks in the world.

However, the case for central bank independence is not as strong as the widespread support it has received might suggest. There is some empirical evidence (e.g., Capie and Wood, 1991, Cukierman, Webb, and Neyapti, 1992, Eijffinger and de Haan, 1996) suggesting that the negative relationship between independence and inflation found in some studies is sample specific, and does not hold when other countries are used in the analysis. Campillo and Miron (1996), for example, have shown that central bank independence has no explanatory power for cross-country variation in average inflation once other potential determinants of inflation are included in the analysis. Furthermore, even if such negative correlation exists, correlation is not causality. Some authors (e.g., Posen, 1995) argue that low inflation and central bank independence may be both products of a strong constituency for low inflation. On another level, the lack of democratic accountability of an independent central bank has been criticised. It is argued that such an important tool of economic policy, like monetary policy, should be under the control of those who are going to be judged by the overall performance of the economy, the elected politicians, and not under the control of non-elected central bank officials.

The issue of central bank independence is re-examined in the context of the study of monetary policy in 44 developing countries described in Chapter 4. The relevant section of this chapter explores whether differences in the constitutional status of the central bank have made a significant difference to their behaviour, especially with respect to their relative rate of money expansion and inflation, in line with previous work by Cukierman (1992), Cukierman, Webb, and Neyapti (1992), Cukierman *et al.* (1993), and Gregorio (1996).

Monetary policy rules and targets

There is a vast academic literature on whether monetary policy should be guided by stable *rules*, or whether central banks should be given the *discretion* to decide what is the optimal policy at each moment in time. A monetary rule specifies policy actions as a simple function of economic or monetary conditions, and is selected as the outcome of a multiperiod optimisation process. Kydland and Prescott (1977) and Barro and Gordon (1983a) saw their demonstration of the time-inconsistency problem as making the case for a monetary policy rule. By adopting a rule the central bank could precommit to avoiding monetary surprises, and the problem of dynamic inconsistency would disappear. The problem with a monetary rule is that in an uncertain world, it is impossible to design ex-ante a rule that would deliver the optimal response to all possible contingencies. In contrast, discretion implies period-by-period reoptimisation on the part of the monetary authority, without any prior restrictions on the actions that the central bank can take at each date. This led some authors (e.g., Fischer, 1990) to argue that discretion is preferable to rules, because the benefit of having the flexibility to respond to unanticipated contingencies is greater than any advantage gained from pre-commitment to a fixed rule.

As McCallum (1997) points out, the distinction between rules and discretion is straightforward in the context of the theoretical models of Kydland and Prescott (1977) and subsequent writers, but it is less clear when it comes to practical application to the behaviour of actual central banks. Taylor (1993) distinguishes 'rule-like' from discretionary behaviour in practice, by describing the former as 'systematic' in the sense of "methodical, according to a plan". This is a necessary, but not sufficient, condition for a rule, since the period by period optimisation process of the discretionary central bank of Kydland and Prescott (1977) may be presented as a systematic application of a formula. The needed additional criterion for a rule, according to McCallum (1997), is that the central bank takes account of the private sector's expectational behaviour, committing not to attempt to exploit temporary inflation-output trade-offs. This could be achieved by announcing a (preferably quantified) target, and sticking to it. The same line is taken by Laidler (1996), when he claims that a target value for a variable is one of the things we might signify when we speak of a policy rule.

Goodhart and Viñals (1994), McCallum (1997), Mishkin (1997), Cottarelli and Giannini (1997) and the survey by the Federal Reserve Bank of New York (1990) are some examples of the vast literature reviewing the issues involved in the choice of a monetary policy target. A good policy target should be reliably under the central bank control, should have a predictable relationship with the final target, and must be capable of affecting the public's expectations. Although other variables have been proposed (e.g., nominal GNP, interest rates), the variables that have been widely used by central banks as policy targets are the inflation rate, a monetary aggregate or the exchange rate.[12]

The choice of the exchange rate as a target depends on what is perhaps the most basic of all monetary policy choices, whether or not to adopt a fixed exchange rate.[13] The initial discussion in this area related to the optimal currency area literature began by Mundell (1961), McKinnon (1963) and Kenen (1969), and was widely extended recently by research associated with the move towards monetary integration in Europe (see survey in Isard, 1995, ch. 11). The main problem of a fixed exchange rate is the loss of an independent monetary policy, i.e., the loss of the ability to use monetary policy to achieve the desirable levels for the domestic macroeconomic objectives. The key advantage is its simplicity and clarity, which makes it easily understood by the public. An exchange rate peg anchors price inflation for internationally traded goods, and when the peg is credible, this helps bring inflation expectations in line with that of the targeted country. It is also easily controllable by the central bank.

The use of monetary aggregates as intermediary targets become very popular among central bankers after the collapse of the fixed exchange rate Bretton Woods regime, and was the subject of intense discussions in the 1970s and 1980s (see Goodhart, 1989b, for

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[12] It follows from the previous paragraph that the expression 'policy target' is being used in the sense of an 'intermediate' or 'final' target, that the central bank sets for the medium term and commits to stick to it. It does not cover 'operating targets', which are frequently adjusted. Several central banks have used money market interest rates as 'operating targets', but not as 'policy targets', in the sense being used here.

[13] Exchange rate targets do not imply fixed exchange rates. A crawling peg in which the currency is allowed to depreciate at a steady rate is also a form of exchange rate targeting. Because the implications of a crawling peg for the conduct of monetary policy are very similar to that of a fixed exchange rate, at least when the depreciation rate is kept unchanged, the discussion in the main text assumes fixed exchange rates on the grounds of simplicity.

a survey). A major advantage of money targets is that they enable a central bank to adjust its monetary policy to cope with domestic considerations. Money targets can also provide good anchors for inflation expectations, although not as good as exchange rate targets: they are less easily understood by the public, and information about monetary aggregates is only known with a lag of a couple of weeks, at least. However, money aggregates can only be good targets if they can be well controlled by the central bank, and if there is a strong and reliable relationship between the final objective and the targeted aggregate. These two conditions were seldom verified, and during the 1980s most central banks abandoned money targeting.

The interest in inflation targeting is more recent, but it has already been the topic of vast economic research, of which the books edited by Leiderman and Svensson (1995) and Haldane (1995a), and the works of Ammer and Freeman (1995) and McCallum (1996) are some examples. However, most of this work is either theoretical, or concentrates on the experience of only one or two countries. Chapter 5 discusses inflation targeting in the light of the experience of the seven countries that have adopted this policy strategy. The chapter analyses how the adoption of inflation targets has affected the behaviour of the central banks, and the credibility of their policies, and compares their inflation record with other countries that did not adopt this strategy.[14]

In the literature on the choice of the optimal policy target, the most popular approach is to determine how well the various targets would perform in terms of yielding desirable values for macroeconomic variables such as inflation or real GDP relative to trend. Recent examples of this kind of approach are Henderson and McKibbin (1993), Feldstein and Stock (1994), Haldane and Salmon (1995), and the individual authors in Bryant, Hooper, and Mann (1993). Chapter 6 analyses this issue from the perspective of the effect of policy targets on the stability of the financial system. Using data for exchange rates, interest rates and stock prices from a panel of 18 OECD countries, the chapter examines the volatility of these prices under different policy targets, and identifies which

[14] Chapter 5 is a slightly revised version of Almeida and Goodhart (1998). An earlier version of this study appeared in Almeida and Goodhart (1997).

targets are more likely to be associated with 'financial crises', periods of abrupt and very large changes in financial asset prices.

Operating procedures

One aspect of the monetary policy strategy often neglected in academic research is the choice of instruments and operating targets of monetary policy. Most of the academic interest has been concentrated on the basic choice regarding which variables the central bank should directly control, namely the relative weight to give to the quantity of bank reserves or market interest rates.[15] But other aspects of the operating procedures deserve attention. One example is the way central banks disclose to the markets information about the current and future stance of monetary policy, the 'policy signals'.

The choice of policy signals is particularly important for the stability of financial markets. For instance, the US Federal Reserve has at times argued that some degree of secrecy in the implementation of monetary policy is necessary to avoid abrupt changes in interest rates, and thus reduce market risk.[16] This argument was formalised by Dotsey (1987) and Rudin (1988), that showed that the unconditional variance of the money market rate is smaller when the central bank does not provide precise signals about the current stance of policy.[17]

Chapter 2 studies the impact of monetary policy signals on financial markets by looking at the reaction of the USD/DEM exchange rate to signals issued by the US Federal Reserve and the Deutsche Bundesbank. The chapter analyses the effect on the level and

[15] For a discussion of this topic, see Friedman (1990), Goodhart (1994), and McCallum (1997). Borio (1997) provides a survey of the operating procedures of monetary policy in industrial countries.

[16] This argument was initially made during the hearings of the 'Merrill vs. FOMC' case, in the late 1970s. David R. Merril, a student at Georgetown University, filled a complaint in 1975 charging the Federal Open Market Committee (FOMC) of violation of the Freedom of Information Act by deferring the public availability of its Records of Policy Action beyond the date of their adoption. The FOMC argued that immediate disclosure of its policy decisions would jeopardise the government's interests. After a long legal battle, the US District Court ruled in favour of the FOMC in 1981 (see Goodfriend, 1986). The argument was repeated in 1993, in a statement by the Chairman of the Board of Governors of the Federal Reserve System, Alan Greenspan, before the Committee on Banking, Finance and Urban Affairs, US House of Representatives (Greenspan, 1993, p. 1107-1108).

[17] However, this result seems to be model specific, since Tabellini (1987) obtained the opposite result.

volatility of the exchange rate of different types of policy signals issued by the two central banks. The high frequency of the exchange rate data used and the differences in the nature of the policy signals concerned allow for the precise identification of the exchange rate response pattern. The topic of policy signalling is also covered in Chapter 3, where it is shown that the reaction of the USD/DEM exchange rate to German macroeconomic announcements is associated with the timing of the release of Bundesbank's policy signals.

1.3 Structure of the Thesis

The remainder of this thesis is structured as follows. Chapters 2 and 3 analyse the effects of information releases on intra-daily exchange rate movements, using DEM/USD exchange rate quotes sampled at a 5-minute frequency, and investigate how these effects are related to the central banks' policy decisions and their strategy for disclosing information to the market.[18] Chapter 2 studies the effects of monetary policy signals released by the Deutsche Bundesbank and the US Federal Reserve on the level and volatility of the DEM/USD exchange rate, and examines how the reaction of the exchange rate depends on the channel used to release the policy information, and on when the information is released. Chapter 3 extends this analysis by examining the reaction of the exchange rate to a wide range of macroeconomic information emanating from Germany and the US, and associates this reaction with market expectations regarding future monetary policy decisions and the timing of the announcement of those decisions.

The focus of chapters 4 to 6 are the basic principles and rules guiding monetary policy decisions, and their implication for the behaviour of exchange rates. Chapter 4 examines the policy framework in 44 developing countries. The analysis covers topics such as the

[18] I would like to thank MMS International in London and Belmont, CA, for the provision of the expectations survey data and Olsen & Associates, in Zurich, for providing the exchange rate data and the Reuters' news headlines file used in Chapters 2 and 3 of this thesis.

choice of price stability as the primary objective for monetary policy, the potential conflicts between achieving this objective and other functions of the central bank (in particular the maintenance of financial stability), and central bank independence. Chapter 5 is dedicated to inflation targeting. The chapter analyses the experience of seven countries that have adopted this policy strategy, and investigates how this affected the behaviour of the central banks. Chapter 6 builds on the analysis of the policy strategies in the previous chapters, and investigates the implications of these strategies for the stability of financial markets, using price data for several financial assets from a panel of eighteen OECD countries. Chapter 7 summarises the conclusions of the thesis and provides suggestions for further work.

Chapter 2

The Reaction of Exchange Rates to Monetary Policy Signals

Monetary policy should be an important factor in the determination of exchange rates, since the exchange rate is the relative price of two moneys. Thus, when information regarding the current and future stance of monetary policy arrives to the market, agents are likely to revise their expectations and desired currency holdings. Agents will then trade to rebalance their portfolios accordingly, and that trading process is likely to lead to increased volatility and changes in the level of the exchange rate. The purpose of this chapter is to test this hypothesis using DEM/USD exchange rate data covering the period 1/1/92 to 31/12/94, sampled at a five minute frequency, and a corresponding set of monetary policy signals emanating from the US and German Central Banks. This analysis improves on previous work in this area in three main respects. First, this is, to my knowledge, the first study which covers a broad set of policy interest rates, both from Germany and the US, in a unified framework. Previous work in this area has focused only on some of these signals, mainly US Discount rate announcements. This allows for a more comprehensive understanding of the links between policy signals and high frequency exchange rate behaviour, and for comparisons of the relative importance of the different policy signals from each central bank, and the relative influence of the two central banks in the DEM/USD. Second, the study is conducted using very high frequency data, whereas most earlier work has used exchange rate data sampled at a daily frequency. One major advantage of such high frequency data is that one can pinpoint the time of day when the announcement was made, and thus isolate the impact of one particular bit of information. Empirical results show that effects typically diffuse rapidly in a stream of other information that the researcher is not able to observe, so that statistical significance disappears when exchange rates are measured at lower frequencies. Third, it covers the effects on both the level and volatility of the exchange rate. This allows for more precise characterisation of the exchange rate dynamics.

Most of the earlier work on the effects of monetary policy on exchange rates was on the reaction of the exchange rate to money supply surprises.[1] However, innovations in key interest rates are usually a better measure of shocks to monetary policy than innovations in the stock of money, at least relative to the high-order monetary aggregates like M1 and M2 that were the object of those studies (as Bernanke and Blinder, 1992, have shown for the US). As monopoly suppliers of base money, central banks can control its price, at least in the very short run (control the price of this money at the short end of the market). So they define their 'operating targets' usually in terms of the overnight (day-to-day) money market (interbank) rate, and the monetary policy stance can be determined by the level of some instrument interest rates that exercise a close influence on the market rate. In the case of the German Bundesbank these are the Discount, Lombard and Repo rates, and for the US Federal Reserve (Fed), these are the Fed Funds rate target and the Discount rate (although the importance of each these rates as a policy instrument differs significantly, as it is discussed in Section 2.1).

Previous empirical work, based on low frequency (usually monthly) VAR models, has provided some evidence supporting the hypothesis that interest rates have a strong influence on exchange rates. Eichenbaum and Evans (1995) found that US monetary policy contractionary shocks, measured by statistical innovations in the Federal Funds rate, lead to significant and sharp appreciations in the USD (of around 3.3% for each 100 b.p. surprise), and that these shocks explain a large proportion (around 25%) of the

[1] See Frankel and Rose (1995) for a review of this literature.

variability of the exchange rate. Copeland (1989) also found that unanticipated increases in the German T-bill interest rate led to an appreciation of the DEM, and that these changes in T-bill rates explain up to a quarter of the unanticipated movements in the DEM/USD exchange rate.

Meanwhile, there is some literature that shows that monetary policy announcements have a significant influence on the high frequency behaviour of financial asset prices. Evidence from the 1970s shows that changes in the Fed Funds rate target had a significant effect on bond and T-bill rates (Cook and Hahn, 1989) and on stock prices (Thorbecke and Alami, 1994). There is also evidence that US Discount rate announcements affect T-bill rates (Cook and Hahn, 1988, Thornton, 1994) and stock prices (Smirlock and Yawitz, 1985, May, 1992). Neumann and Weidmann (1996) found that unexpected changes in the German Discount rate have a significant effect on money market rates.

It is then natural to expect that the high frequency dynamics of exchange rates are significantly affected by monetary policy announcements. However, the evidence on this hypothesis has been limited to specific policy signals, mainly US Discount rate announcements. Using daily data from 1975 to 1983, Batten and Thornton (1984) showed that non-technical Discount rate increases caused an appreciation of the USD weighted index (of around 1% for each 100 b.p. increase).[2] Hardouvelis (1988) also found a positive effect of unexpected Discount rate increases on USD appreciation, but this effect was only significant for two (the French franc and the Italian lira) of the seven dollar exchange rates considered. Harvey and Huang (1994) consider the impact of Federal Reserve open market operations on financial markets, but do not uncover any significant effects of these operations on the level or the volatility of several USD exchange rates.

The existing evidence on the reaction of exchange rates to monetary policy signals is

[2] The distinction between technical and non-technical Discount rate changes is based on the wording of the Fed's press release announcing the change. Technical changes are those purportedly taken entirely to bring the Discount rate in close alignment with money market rates. Non-technical are justified with reference to some policy objectives.

clearly scarce. The objective of this chapter is to extend this line of research to a wide range of monetary policy signals, namely those associated with the US Fed Funds target and all the German policy signals. The results of this chapter show that these signals have a significant influence on the DEM/USD, in particular the US Fed Funds target and the German Lombard rate, and thus need to be considered in any characterisation of the high frequency exchange rate behaviour.

The remainder of the chapter is organised as follows. Section 2.1 describes the policy signals used by the two central banks, the German Bundesbank and the US Federal Reserve. The effect of monetary policy news in the DEM/USD level is analysed in Section 2.2, while in Section 2.3 the focus is on the impact of the policy signals on exchange rate volatility. The chapter closes with some concluding remarks which are presented in Section 2.4.

2.1 Monetary Policy 'Signals' and 'News'

The monetary policy stance can be defined by the level of the operating target, usually the money market overnight rate. However, such operating targets are not always announced, and the monetary policy stance has to be inferred from a set of central bank actions, consisting of formal statements and market activity. Obviously, not all central bank actions have policy implications, and some actions are not informative from a monetary policy perspective. In this chapter, any central bank action that potentially conveys information to the markets about the stance of current or future monetary policy will be classified as a 'policy signal'. Subsection 2.1.1 describes the policy signals issued by the Deutsche Bundesbank, and subsection 2.1.2 the policy signals issued by the Board of Governors of the US Federal Reserve System (Fed). Subsection 2.1.3 distinguishes policy 'signals' from policy 'news' and describes the measure of 'news' used in this chapter.

2.1.1 Deutsche Bundesbank's policy signals

The key variable in the daily management of German monetary policy is the day-to-day money market rate, that the Bundesbank directly influences by controlling a set of key interest rates. The day-to-day money market rate is kept within a band, with the ceiling set by the Lombard rate and the floor set by the Discount rate.[3] However, the money market rate seldom reaches either of the edges of the band, as it tends to follow the rate of the most recent weekly securities repurchase agreements (repos) tender, which makes the 'Repo' rate the key operating rate for the Bundesbank (Clarida and Gertler, 1996, p.12).[4] Usually the weekly repos are sufficient to keep market rates on the desired path, but if the rates threat to diverge substantially from that path, the Bundesbank may make use of fine-tuning operations: injections of 'day-to-day' money under section 17 of the Bundesbank act,[5] foreign exchange swaps and repurchase agreements, 'quick tenders',[6] or liquidity Treasury bills ('Bulis').[7]

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[3] The Lombard rate is the ceiling for market rates because credit institutions can utilise the Lombard loan facility on their own initiative, and the collateral to be deposited is a binding constraint for individual institutions in isolated cases only, and never for the banking system as a whole. Most of the times the Discount rate acts as a floor to money market rates, but during situations of massive liquidity surpluses, the banks are unable to eliminate these surpluses by refraining from discounting further bills. In these situations the Bundesbank uses 'liquidity paper' ('Bulis') to absorb the excess funds, and the selling rate for the 'Bulis' becomes the floor for money market rates.

[4] As a rule, the weekly repo tenders take the form of a variable-rate tender, but sometimes when the Bundesbank wants to send an unequivocal policy signal sets fixed-rate tenders. In this latter case, the banks can only indicate the quantity they wish to bid for at the interest rate set by the Bundesbank. In the variable-rate tenders participants bid in terms of both the amount of funds they require and the rates they are prepared to pay, and the Bundesbank allots an amount compatible with the desired interest rate level.

[5] The injections of 'day-to-day' money under section 17 of the Bundesbank act consisted of shifts of Federal balances with the banks that were the main counterparts in these transactions. This instrument was no longer available from the beginning of 1994 due to the abolition of the Federal and Länder governments' obligation to deposit their liquid funds at the Bundesbank.

[6] 'Quick tenders' take the form of variable or fixed-rate tenders offered only to banks that are active players in the money market, and are settled within about one hour.

[7] Changes in minimum reserve requirements may in some circumstances be used as a monetary policy instrument. During the 1992/94 period the Bundesbank lowered these requirements twice (March 1993 and March 1994), but the primary purpose was reducing competitive disadvantages of German banks, and not for monetary policy reasons; as such, those changes were coupled with compensatory issues of liquidity paper to reduce their impact on market interest rates. For this reason, in this chapter the changes in minimum reserve requirements are not included as policy instruments.

The Repo rate is the key operating rate, but the Lombard and Discount rates are also very important, because they highlight the basic stance of the Bundesbank's monetary policy (although policy driven changes in interest rates are usually initiated by open market operations). Fine-tuning measures are used on a very limited scale, and only in situations when the market conditions threat interest rate fluctuations that are undesirable for policy reasons; the main goal of the fine-tuning interventions is to maintain a clearly discernible monetary policy stance (Deutsche Bundesbank, 1994, p. 69). Thus, the hierarchy of Bundesbank rates may be described as follows: the Repo rate sets the stance of German monetary policy, which is highlighted by the Lombard and Discount rates, and reaffirmed by the occasional use of the fine-tuning instruments.

Monetary policy decisions are made by the Bundesbank council, composed by the Bundesbank Board and the Presidents of the German Länder Central Banks. The council meets every fortnight, on Thursdays, usually in the morning.[8] Changes in the Lombard or Discount rates are announced at a news conference or by press release after the council meeting.[9] The announcement of the terms of the weekly repo is usually made each Tuesday, around 09:00 local time, (or, less frequently, at the end of a previous council meeting),[10] with the results of the tender being announced on the Wednesday (around 10:00 local time).[11] Being exceptional measures, fine-tuning operations may be announced at any time.

The Bundesbank's main regular policy signals are the announcement of the outcome of the council meetings, the Tuesday announcement of the repo tender terms and the

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[8] There are some exceptions to this rule: the council does not meet over the Christmas or Easter holidays, or in the beginning of August, so there is usually a 3 or 4 weeks interval between meetings at those times; also, in those weeks when the Thursday is a public holiday, the meeting is held on other day of the week, usually the Wednesday.

[9] During the period 1992/94, the only exception to this rule occurred during the September 1992 ERM crisis. The Bundesbank announced a 25 b.p. cut in the Lombard rate and a 50 b.p. cut in the Discount rate in 13/9/92, a Sunday, at the end of the emergency meetings held between the participants in the ERM to avoid the collapse of the system.

[10] Sometimes the Bundesbank announces the conditions of the tender after a council meeting, if it wants to send a clear signal to the market. For example, in November 1993 the Bundesbank announced its intention of offering a fixed-rate tender, and the rate it was going to apply, for several transactions in advance.

[11] These dates are sometimes shifted to avoid a clash with holidays.

Wednesday announcement of the repo results. The key pieces of policy information included in those announcements are:

- council meeting outcome: changes in the Discount and Lombard rates; occasionally, announcement of fixed-rate tenders, and respective rate;
- Tuesday repo terms: if a fixed-rate tender has not been previously announced, whether the tender will be held at a variable or fixed rate (changes from variable to fixed-rate, or vice-versa, are usually seen as indicating a policy change) and, in the case of fixed-rate tenders, at what rate;
- Wednesday repo results: in the case of variable-rate tenders, the marginal allotment rate.

Since the policy information content of the announcement of repo results, when the tender is held at a fixed rate, or of the repo terms, when the rate had been fixed at a previous council meeting, will be low (as no information on interest rates will be revealed in those announcements), in such occasions the Tuesday and Wednesday announcements are not considered to be policy signals. All council meeting announcements are assumed to be policy signals.

2.1.2 US Federal Reserve's policy signals

The key variable in US monetary policy is the Federal Funds rate, that the Fed influences through direct open market purchases and sales of US government securities. The formal operating target for US monetary policy is the level of borrowed reserves, but the Fed Funds rate is regarded as the most useful indicator of the stance of Federal Reserve policy.[12] The Discount rate is also a key interest rate, although its importance has been declining over time.[13]

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[12] The Fed Funds market is the market for immediately available reserve balances at the Fed, and it is particularly sensible to changes in reserve availability caused by open market operations. The policy decisions made by the Fed have an implicit target range for the Funds rate (Meulendyke, 1989), and the so-called 'Fed watchers' and money market participants can usually tell what this target is by observing where the funds rate trades in conjunction with the Fed's market operations. Thus, policy changes are usually described by changes in the target for the Fed Funds rate, and not by changes in the 'degree of pressure on reserves', which is the formal target for US monetary policy. Bernanke and Blinder (1992) also propose treating the Funds rate as the operating instrument for US monetary policy.

[13] Many analysts view the Discount rate as merely 'cosmetic'. Others claim the Discount rate is still an

The Fed's policy regarding open market operations is decided by the Federal Open Market Committee (FOMC), and executed by the domestic trading desk of the Federal Reserve Bank of New York. The 7 members of the Board of Governors, the 12 presidents of the regional Reserve Banks (and several staff) attend the 8 meetings per year of the FOMC, although only the 7 Governors and 5 of the presidents of the regional Reserve Banks are voting members.[14] Discount rate changes are initiated by the regional Reserve Banks and approved by the Federal Reserve Board. Although the formal decision procedures for the two instruments differ slightly, the people involved in the process are the same, and thus it is reasonably safe to assume (and market participants usually do) that Federal Reserve monetary policy is decided at FOMC meetings.

Since February 1994, FOMC decisions are announced at the end of the meetings through formal statements and, since then, these statements represent the fundamental policy signal sent by the Fed.[15] Any change in the stance of monetary policy, including changes between meetings, is announced on the day it is made (usually at the end of the FOMC meeting), through a statement that includes the approved change in the Discount rate, if any, and the change in the degree of reserve pressure and its implications for the Fed Funds rate.[16] When no change is made at a meeting, the FOMC will normally just

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important indicator of the Fed's policy intentions: it is the only interest rate the Fed formally admits to controlling, and thus changes in the Discount rate are particularly strong statements about the Fed's intentions (Ferris and Jones, 1994, p. 135).

[14] Except for the president of the New York Fed, who always has voting power, the presidents of the regional Reserve Banks serve 1 year terms as voting members, on a rotating basis.

[15] The changes in the procedure for disclosing policy decisions by the FOMC were first introduced on February 4, 1994, when the FOMC decided to announce immediately an increase in the degree of reserve pressure, which represented a departure from past FOMC practice. At the time this change in disclosing policy was justified by the need to avoid any misunderstanding in the FOMC's intentions, since this was the first firming of policy since 1989, but the FOMC made clear that it 'did not intend this announcement to set any precedents or imply any commitments regarding the announcement of its decisions in the future' (Federal Reserve Bulletin, May 1994, p. 408). However, the same immediate disclosing procedure was adopted for all policy changes throughout 1994. Finally, on February 2, 1995, the practice of immediate announcement was adopted as the formal procedure for disclosure of FOMC's policy decisions.

[16] A typical example is the announcement of March 22, 1994 (Federal Reserve Bulletin, May 1994, p. 393):

> "Chairman Alan Greenspan announced on March 22, 1994, that the Federal Open Market Committee had decided to increase slightly the degree of pressure on reserve positions. This action was expected to be associated with a small increase in short-term money market interest rates."

The fact that the Fed includes on its formal policy announcements the effect of policy decisions on the Funds rate, although without referring explicitly the new target range, highlights the importance of the Fed Funds rate as the central element on the Fed's monetary policy.

announce when the meeting ended and that there are no further announcements (Federal Reserve Bulletin, March 1995, p. 265).[17]

Until the end of 1993, FOMC decisions were only disclosed formally on the Friday after the following meting (a delay of about six weeks). As a posted rate, Discount rate changes were formally announced by press release (although not necessarily when the decision was made but only when it become effective), but changes in the Funds rate target were not. Policy changes would be revealed to market participants by the so-called 'Fed watchers', who would recognise changes in the Funds rate target by observing where the funds rate traded in conjunction with the Fed's money market operations.[18] Thus, the key policy signals were the Fed's open market operations, especially on the days following FOMC meetings. The New York Fed's open market operations usually occur at 'Fed time', around 11:30, local time. Although the Fed makes several outright purchases or sales, most policy actions consist of temporary purchases (repurchase agreements, or repos) or temporary sales (matched sales) of government securities. Monetary policy information would be conveyed by open market operations inconsistent with the prevailing Fed funds rate. In the 1992/93 period, an easing would be usually signalled by an overnight 'system repo' when the funds rate is near (or slightly below) its previous target, but above the intended target, or a 'customer repo' when market expectations have already driven the funds rate towards its new target level; a tightening could be signalled by overnight matched sales at a rate near the previous target, but below the new one, or no action in response to a funds rate well above the previous target (Ferris and Jones, 1994, p.137).[19]

[17] However, in some infrequent circumstances, the Committee might decide to issue a statement even when no policy action is taken.

[18] The Fed had an informal target for the Funds rate, but deviations of the actual Funds rate from the target rate were frequent. The actual Funds rate was a noisy indicator (although a good one) of the policy stance, and some degree of expertise was necessary to isolate Fed's open market operations (and rate changes) caused by 'technical' factors from 'policy' actions. However, under Chairman Alan Greenspan policy changes were always signalled sufficiently clearly to avoid any divergence of opinion among 'Fed watchers' (Ferris and Jones, 1994, p. 137).

[19] System repos are temporary purchases (with repurchase agreements attached) of government securities conducted for accounts within the Fed; customer repos are purchases made on behalf of customers, that is, central banks and supra-nationals. Matched sales are temporary sales of government securities (with purchase agreements), usually only for accounts within the Fed.

The Fed's policy signals are, thus:

(a) the statements at the end of FOMC meetings;

(b) any occasional statements announcing changes in the Discount rate and/or in the 'degree of pressure on reserve positions';

(c) the daily open market operations, especially on the days following FOMC meetings.

As described above, the relative importance of these signals changed significantly in the beginning of 1994. Before 1994, (b) (for the Discount rate changes) and (c) were the relevant policy actions;[20] from 1994 onwards, (c) conveyed almost no policy information. For this reason, on some (but not all) of the exercises performed, it will be considered as policy signals the actions included in (a) only after February 1994, and the actions included in (c) only before that date.

2.1.3 Monetary policy 'news'

Monetary policy 'news' are revealed when the content of a policy signal differs from what the market had been expecting. The 'news' content of policy signal of type i at period t, $x^n_{i,t}$ is defined as $x^n_{i,t} = x_{i,t} - x^e_{i,t}$, where $x_{i,t}$ is the actual signal and $x^e_{i,t}$ is a measure of the market expectation regarding that signal. Since most of the actions considered in this chapter may be associated with setting a value for some interest rate, $x_{i,t}$ may be seen as the actual rate change and $x^e_{i,t}$ as the expected rate change. Exchange rate volatility may be affected by any policy signal, but only signals with non zero 'news' should have an impact on the exchange rate level.[21]

Market expectations were obtained from surveys conducted by MMS International or from the financial press. Available from MMS International were survey data for the US

[20] Before 1994, most of the times there were no statements after FOMC meetings.

[21] This does not mean that the impact on volatility of expected and unexpected signals is similar. The point here is that both may have an impact on volatility, although this effect might be different across subsets of signals. See Section 2.3 for a discussion of the impact of policy signals on exchange rate volatility.

Discount and Fed Funds rate, and the Bundesbank's Wednesday repo tender results announcement. The expectations series for the Bundesbank's council meeting and Tuesday announcements were based on information provided in the Financial Times, on the day of the announcement. From the FT's description of market sentiment on the previous day, a series of market expectations regarding the changes in the Discount and Lombard rates, and the likelihood of announcing a fixed-rate repo tender, were constructed.

Appendix 2.A describes the expectations series used, and assesses their accordance with the rational expectations hypothesis. None of the tests performed reject the null of the expectations being rational for the Fed's Discount (*Discfed*) and *Funds* rate, nor for the Bundesbank's Discount (*Discbb*) and Lombard (*Lomb*) rates. However, in one of the tests the null of rational expectations was rejected for the repo terms (*Fix*) and *Repo* rates expectations series, and that may cast some doubts on the robustness of the results involving these variables. Also, the evidence in Appendix 2.A suggests that the market did a poor job at predicting interest rate changes. For the Fed rates, and the Bundesbank's *Discbb* and *Lomb* rates, there is a high correlation between the actual changes and the news, which implies that it will be difficult to empirically distinguish whether the exchange rate is reacting to the actual change or to the news component of the change. The efficient markets theory implies that the exchange rate reacts to the news and not to the actual change, and this is what it will be assumed throughout this chapter (see section 2.2.4 for a further discussion on this issue).

2.2 The Impact of Interest Rate 'News' on the Exchange Rate Level

Under the REEM (Rational Expectations Efficient Markets) hypothesis, asset prices should reflect all available information. Therefore, the predominant cause of exchange rate movements should be the arrival of new information that has not been anticipated, i.e., 'news' (Hoffman and Schlagenhauf, 1985). If monetary policy is an important determinant of exchange rates, monetary policy 'news' should have a significant impact on the level of the exchange rate. In this section, this hypothesis is analysed. Subsection 2.2.1 describes the methodology used and subsections 2.2.2 to 2.2.5 present the results of the analysis.

2.2.1 Methodology

The analysis of the impact of monetary policy news on the exchange rate level was performed using data for the period 1/1/92 to 31/12/94. The exchange rate data consisted of DEM/USD quotations (q_t), posted on the Reuters' FXFX screen. Exchange rate returns, R_t, are defined as $R_t = q_t - q_{t-1}$, i.e., the change in the exchange rate over the return period. The length of the return period was allowed to vary from 5 minutes to 24 hours. See Appendix 2.B for a full description of the data.

If the REEM hypothesis is true, exchange rate changes should be caused by news about the variables that market agents believe are relevant for the determination of the exchange rate (see subsection 1.1.1 in the previous chapter). Let X^n_t be a vector of 'news' (as defined in section 2.1.3) on all the relevant variables, that arrived at the market in the return period t. Then, testing for the existence of systematic (linear) effects of the variables in X^n on the exchange rate entails testing the difference from zero of the elements in B in equation 2.1, where ε_t is an error term.[22]

$$R_t = \mathrm{B}\, X_t^n + \varepsilon_t \qquad 2.1$$

The vector X^n_t includes all monetary policy news from the two central banks (see Appendix 2.B). Note that estimations of the above equation are not strict time-series regressions as the observations are not temporally consecutive. An observation for a given series is added at every point when a policy 'news' event occurs and the associated return is then constructed. This allows for estimation by OLS, using heteroscedasticity-consistent standard errors as in White (1980). Also, if each return period includes only signals from one of the central

[22] Equation 2.1 is equivalent to equation 1.4 in Chapter 1, with $R_t=S_t-S_{t-k}$, and $X^n_t = X_t-E_{t-k}(X_t)$.

banks, the impact of the two sets of signals may be estimated separately, since they will be independent. This allows for the impact of the Fed's and Bundesbank's news to be estimated in two different regressions.

Since the quotes are defined as DEM per 1 USD, a positive return denotes an appreciation of the dollar (depreciation of the mark). According to the main structural models of exchange rate determination, an increase in interest rates will cause an appreciation of the domestic currency. That implies that the expected sign of the B coefficients is positive for the Federal Reserve news, and negative for the Bundesbank news (including *Fix*).[23]

In section 2.2.2, the regressions use as elements of X^n_t alternatively the news on the Fed's monetary policy, measured by unexpected signals regarding the Discount (*Discfed*) and Fed Funds (*Funds*) rates, and the news from the Bundesbank, described by the unexpected announcements on the Discount (*Discbb*) and Lombard (*Lomb*) rates, the terms of the repo tender (*Fix*), and the results of the repo tender (*Repo*). There, it is assumed that all policy news relative to a given interest rate will have the same effect on the exchange rate, regardless of how and when they are signalled, and thus each rate variable includes all observations of news on that rate.[24] However, the effect of news about a given interest rate might differ across some sub samples, defined according to how and when a given piece of news is signalled. In section 2.2.3, some hypotheses of different behaviour across sub-samples are tested. For this purpose, sub sample variables are defined by multiplying the news on the interest rate with a dummy variable taking the value 1, if the observation belongs to the sub sample. Sub sample variables are identified

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[23] *Fix* is the variable associated with the repo tender terms (see Appendix 2.B for details). A positive value for *Fix* denotes that a fixed-rate repo was set, when a variable-rate repo was expected. In the period analysed in this chapter, all the fixed-rate repos were set at a time when there was a clear downward trend in German rates. In these conditions, if the Bundesbank announces a fixed-rate repo for several weeks in advance, it is signalling the market that the downward trend will be halted during that period. This amounts to keeping the interest rates higher than the current downward trend would suggest, i.e., it may be interpreted as an unexpected increase in interest rates. Hence, the negative expected sign.

[24] The regressions for the Bundesbank do not include the interest rate changes announced in 13/9/92, the Sunday before 'Black Wednesday'. Since these changes were announced during the weekend, the pattern of response of the exchange rate will necessarily be different from the other announcements made during weekdays, when all traders are operating.

by a specific suffix, the name of the dummy variable used in their construction.[25] Test of different behaviour in the sub sample consist of tests of the significance of the sub sample variable.

An efficient market is one in which prices reflect all available information, such that asset prices will be unaffected by the revelation of previously available information. Thus, R_t should not be related to any information available before the policy signal was revealed, and that includes the market expectation about the signal. It also implies that there should be no systematic bias on the reaction of the exchange rate to policy signals. These implications supply two (weak) tests of the REEM hypothesis, which are explored in section 2.2.4. First, under the REEM exchange rates changes should be random, and thus the average exchange rate change after policy signals should not be significantly different from zero.[26] Second, when equation 2.2 is estimated, the constant α and the coefficients associated with the market expectation (γ) should not be significantly different from zero.

$$R_t = \alpha + \beta X_t^n + \gamma X_t^e + \varepsilon_t \qquad 2.2$$

2.2.2 The impact of policy news on the level of the exchange rate

Table 2.1 presents the results of the estimation of equation 2.1, using several definitions of the return period.[27] Note that as long as the exchange rate adjustment is quick, then the ability to statistically identify the effect of a policy signal will be higher for a shorter return interval, since over shorter periods the variance of the returns is smaller but the

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[25] For example, *Lombnor* is the vector of news on *Lomb* in the sub sample 'normal' period (to be defined below). It is constructed using the dummy variable *'nor'*, that takes the value 1 for observations in the 'normal' period, and 0 otherwise: *Lombnor=Lomb*nor*.

[26] If the policy signal was expected, there is no new information conveyed to the market. In this situation, there is no reason for the exchange rate to change, so the change should be zero on average. If the policy signal was not expected, the exchange rate should change, appreciating if the news are 'good' and depreciating if the news are 'bad'. But 'good' news are as likely as 'bad' news, if expectations are rational (i.e., expectations are not biased). Thus, it is as likely that the exchange rate will appreciate as it will depreciate, so that the expected exchange rate change should be zero.

[27] All the regressions in this section were estimated using the following definitions of the return period: 5, 10, 15, 20, 25, 30 and 45 minutes, and 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20, 22 and 24 hours. The tables present only a selection of these regressions. The results for the other regressions may be obtained from the author.

mean effect will be similar.[28] Previous work showed that the DEM/USD exchange rate fully adjusts in less than 15 minutes to news in scheduled macroeconomic announcements (Ederington and Lee, 1993, Payne, 1996), but it may take up to 3 hours to adjust if the announcements are unscheduled (see Chapter 3, section 3.5). This evidence suggests that the key results will be those for the 15m returns, if the policy signals are scheduled, and those for the 1h-3h returns if the policy signals are unscheduled.

Table 2.1 **Effects of monetary policy news on the DEM/USD rate**

	FED			BUNDESBANK				
Period	*Discfed*	*Funds*	R^2	*Discbb*	*Lomb*	*Fix*	*Repo*	R^2
5 m	0.00050	0.00825	0.34	-0.00211	-0.00879	-0.00034	-0.00875	0.25
	0.41	*2.27*		*-0.70*	*-1.56*	*-1.30*	*-1.43*	
15 m	0.00176	0.02005	0.53	0.00444	-0.01611	-0.00099	-0.00038	0.38
	0.63	*3.56*		*1.33*	*-3.36*	*-2.09*	*-0.06*	
30 m	-0.00347	0.02817	0.53	0.00297	-0.01300	-0.00099	0.00876	0.25
	-0.73	*3.56*		*0.77*	*-3.63*	*-1.77*	*1.13*	
1 h	-0.00280	0.03433	0.68	0.00471	-0.01160	-0.00168	0.02015	0.10
	-0.76	*5.01*		*0.87*	*-1.49*	*-2.71*	*1.82*	
3 h	-0.00433	0.04356	0.59	0.00776	-0.01013	-0.00002	0.02529	0.01
	-0.72	*4.12*		*0.80*	*-0.93*	*-0.02*	*2.26*	
6 h	0.00331	0.03619	0.49	0.01532	-0.01327	-0.00007	0.01132	0.04
	0.50	*3.14*		*1.29*	*-1.03*	*-0.04*	*0.41*	
12 h	0.00808	0.03747	0.45	0.02154	-0.01661	-0.00070	0.07325	0.09
	1.47	*2.61*		*1.95*	*-1.32*	*-0.31*	*1.49*	
24 h	0.00436	0.04530	0.25	0.02455	-0.01493	-0.00054	0.07687	0.10
	0.26	*2.07*		*1.90*	*-1.11*	*-0.20*	*1.96*	
# news	4	9	11	30	28	19	29	74

Notes: Column 1 describes the length of the period over which R_t was measured. The following columns present the coefficients and respective t-statistics (in italics) for each of the news variables. The effect of the news from the Fed and the Bundesbank were estimated separately. The critical values for the t-tests are 2.26 (1.83), for the Fed regression, and 2.00 (1.67), for the Bundesbank regression, at the 5% (10%) level. The last line of the table describes the number of non-zero observations in the sample, for each variable, and the total number of observations in the regression.

In the regressions for the Fed's news, the *Funds* coefficient is significant at the conventional significance levels, but *Discfed* is not. The signs of the *Funds* coefficients are the expected (positive) in all the regressions, but *Discfed* has the 'wrong' sign in the regres-

[28] The impact on the power of the tests of increasing the return interval may be severe. For instance, Campbell, Lo and MacKinlay (1997, p. 175) show that in event studies 'there is a substantial payoff in terms of increased power from reducing the length of the event window'. This should make the results for the regressions using as return interval the shortest period necessary for full adjustment much more reliable than the results of the other regressions.

sions computed using returns between 30m and 3h.[29] This result suggests that the market agents see the Funds rate as the key indicator of the Fed's monetary policy, and treat the Discount rate as if it contained no relevant information, which is consistent with the view of the analysts that consider the Discount rate merely 'cosmetic' (see section 2.1.2). The magnitude of the *Funds* coefficients suggests that unexpected announcements of a 1 percentage point increase in this interest rate will appreciate the USD by almost 4.5 'pfennigs', roughly 3% of the exchange rate. The R^2 are sufficiently high (above 0.5 for many of the regressions) to suggest that the Fed's interest rate news are the key factor explaining DEM/USD changes on the day of their release.

The results for the very short term regressions (up to 30m) of the Bundesbank's news are somewhat similar to the Fed's.[30] Two types of policy news (*Lomb* and *Fix*) have a significant effect on the DEM/USD, with the coefficients having the expected (negative) sign, and the other two (*Discbb* and *Repo*) do not have significant coefficients, with in some cases the 'wrong' sign. Also, the coefficients for the key interest rates of both central banks (*Lomb* and *Funds*) are of similar magnitudes, although the *Lomb* coefficients tend to be smaller in absolute value: unexpected announcements of a 1 percentage point increase in the *Lomb* rate will appreciate the DEM by about 1% (less than 2 'pfennigs'). Similar conclusions are valid for the goodness of fit measure, R^2. While the non significance of the Discount rate could have been expected,[31] it is apparently surprising that one could not find a significant impact of Repo rate news.[32] As described in section 2.1.1, the Repo rate is considered by the Bundesbank their key operating rate, and thus one would expect it to have a strong effect on the exchange rate. It seems that the markets did not share the same view, and paid attention only to the Lombard rate.

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[29] Note that these should be the key regressions, since the Fed's signals are not scheduled. This is supported by the higher R^2 on these regressions.

[30] The Bundesbank's signals included in the regressions are all scheduled, so one should expect that the impact of news should be clearer on the 15 to 30 m regressions. Again, this is supported by the higher R^2 on these regressions.

[31] Discount rate changes are announced at the end of the Bundesbank council meetings, as are Lombard rate changes. It is likely then that the information contained in each of these rates is very similar, and that the markets could concentrate in only one of them.

[32] The fact that the variable *Fix* was found to have a significant (although quantitatively small) impact on the DEM/USD is evidence that the market agents do not ignore the information contained in the repo tenders.

However, although the markets reaction might be surprising, the results in Table 2.1 are less so, because these differences between the market focus and the Bundesbank's view had already been noticed in some of the press of that period.[33]

If one accepts that the results for the 1 h and 15 m returns are the most representative for the policy signals emanating from the Fed and the Bundesbank, respectively,[34] and that the sample used is representative of the normal response of the DEM/USD to those signals, the conclusion must be that news regarding the key indicators of the monetary policy stance have a fundamental impact in the level of exchange rates. The key interest rates from both the Fed (Funds rate) and the Bundesbank (Lombard) were found to cause a statistically significant change in the DEM/USD, of around 3% (1%) per percentage point of unexpected change in the *Funds* (*Lomb*) rate, an effect that may be considered as very important.[35] The quantitatively lower impact of the news from the Bundesbank may be explained by the fact that the markets may see this central bank as following a more long term approach than the Fed. In this case, each individual interest rate change will be less important.

However, these conclusions only apply for the regressions computed using the most representative returns, especially in the case of the Bundesbank. The results for periods above 1 hour are somewhat different. While for the Fed's regressions the significance levels and R^2 increase, for the Bundesbank they drop dramatically. Although the *Lomb*

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[33] One example may be found in *The Economist* of 20/3/93. In the article "Cutting it fine: German interest rates", it is claimed that:

> "...the Bundesbank would like to play down the importance of its fortnightly council meetings as the occasion for changing policy. It has been trying to encourage the financial markets to look less at its headline interest rates and more at the securities repurchase rate - the rate at which it offers wholesale funds to banks. For the moment, however, the markets remained obsessed with Thursdays."

In fact, it is possible that the quoted Deutsche Bundesbank (1994) paper that highlights the importance of the Repo rate may be part of an effort made by the Bundesbank to concentrate the attention of market agents on the Repo rate, and away from the Lombard and Discount rates.

[34] As explained above, this is consistent both with what other work (Ederington and Lee, 1993, Payne, 1996, and Chapter 3 of this thesis) would suggest and with the measure of goodness of fit obtained in the regressions performed.

[35] Eichenbaum and Evans (1995) found that the long run effect of a 100 b.p. surprise in the Fed Funds rate was an appreciation of the USD of around 3.3%. Although the results may be not directly comparable, this figure provides a reference to how important the high frequency reaction of the exchange rate is.

and *Fix* coefficients still have the expected negative sign, they are not significant. The *Discbb* and *Repo* coefficients are positive, and sometimes significant, which contradicts the predictions of the theory. Since the shorter term returns are more likely to accurately portray the effects of the policy signals, the differences in the results for the longer term regressions suggest that other factors may be affecting the exchange rate. Understanding the reasons for these differences might provide interesting insights on the relations between monetary policy signals and exchange rate behaviour.

One possible explanation for some of these results is the existence of problems in the data used, like multicolinearity and the presence of large outliers. In the data, there is a strong correlation between some of the news series, in particular between *Discbb* and *Lomb* (coefficient of correlation 0.53), and thus including one of these variables in the regression might seriously reduce the explanatory power of the other. In order to assess the impact of this feature of the data, the effect of each of the variables in the DEM/USD was estimated separately, instead of running one single multiple regression for each of the central banks. The results, presented in Table 2.2, suggest that multicolinearity is not a serious problem, since the overall picture is similar to the one obtained with the multi-

Table 2.2 **Effects of monetary policy news (simple regressions)**

	FED		BUNDESBANK			
Period	*Discfed*	*Funds*	*Discbb*	*Lomb*	*Fix*	*Repo*
5 m	0.0024	0.00842	-0.00643	-0.00999	-0.00036	-0.00875
	1.52	*2.49*	*-1.69*	*-1.94*	*-1.34*	*-1.43*
15 m	0.00638	0.02063	-0.00343	-0.01369	-0.00109	-0.00038
	1.17	*3.77*	*-0.67*	*-3.17*	*-2.10*	*-0.06*
30 m	0.00303	0.02701	-0.00335	-0.01140	-0.00107	0.00876
	0.38	*3.73*	*-0.76*	*-3.87*	*-1.83*	*1.13*
1 h	0.00512	0.03340	-0.00084	-0.00907	-0.00177	0.02015
	0.78	*5.23*	*-0.13*	*-1.26*	*-2.68*	*1.82*
3 h	0.00572	0.04212	0.00273	-0.00581	-0.00013	0.02529
	0.55	*4.39*	*0.27*	*-0.59*	*-0.10*	*2.26*
6 h	0.01166	0.03729	0.00874	-0.00473	-0.00027	0.01132
	1.07	*3.35*	*0.65*	*-0.39*	*-0.14*	*0.41*
12 h	0.01672	0.04016	0.01339	-0.00464	-0.00096	0.07325
	2.08	*2.96*	*0.95*	*-0.38*	*-0.41*	*1.49*
24 h	0.01482	0.04675	0.01721	-0.00127	-0.00082	0.07687
	1.05	*2.38*	*1.16*	*-0.10*	*-0.30*	*1.96*
# news	4	9	30	28	19	29

Notes: See Table 2.1. The critical values for the t-tests are 3.18 (2.35) for *Discfed*, 2.31 (1.86) for *Funds*, 2.05 (1.70) for *Discbb*, *Lomb* and *Repo*, and 2.10 (1.73) for *Fix*, at the 5% (10%) level.

ple regressions. The results improve slightly, with most of the significance levels of the coefficients with the right sign being higher, and the ones of the coefficients with the wrong sign being lower, but the conclusions to be drawn from Table 2.2 are not quantitatively and qualitatively different from the ones obtained from Table 2.1.

Another potential problem arises from the relatively small sample available. With so few observations, each one may potentially have a decisive impact, and some of the results may be strongly influenced by one large outlier. Figure 2.1 plots the policy news against the 1 h returns associated with the news for all observations in the sample. In some of the charts large outliers can be identified, and it would be reasonable to expect that some of these could be affecting the results. In order to analyse the sensitivity of the estimates in Table 2.1 to the inclusion of each individual observation in the sample, n (11 for the Fed and 74 for the Bundesbank) regressions were run using n-1 observations in each, by dropping one of the observations at a time. Table 2.3 presents summary statistics of the distribution of estimates thus obtained for each of the parameters. The evidence suggests that most of the main results of the previous subsection are not affected qualitatively by the inclusion in the sample of particular observations, especially the ones regarding the

Table 2.3 **Sensitivity of the results to individual observations**

	5 m	15 m	30 m	1 h	3 h	6 h	12 h	24 h
FED								
Discfed								
Max	0.00124	0.00399	0.00184	0.00120	0.00305	0.01001	0.01331	0.01609
Min	-0.00021	-0.00045	-0.00744	-0.00520	-0.00727	-0.00286	0.00521	-0.01610
Med	0.00036	0.00148	-0.00364	-0.00294	-0.00466	0.00330	0.00764	0.00571
T-discfed								
Max	1.03	1.02	0.45	0.35	0.77	1.43	2.60	0.85
Min	-0.14	-0.22	-1.95	-1.29	-1.10	-0.69	0.71	-2.09
Med	0.29	0.54	-0.72	-0.78	-0.76	0.45	1.34	0.33
Funds								
Max	0.00996	0.02275	0.03461	0.03914	0.05050	0.04356	0.04550	0.05595
Min	0.00515	0.01556	0.02301	0.03028	0.03502	0.02844	0.02881	0.03184
Med	0.00849	0.01968	0.02819	0.03470	0.04350	0.03570	0.03831	0.04772
T-funds								
Max	2.69	3.96	5.67	6.56	5.19	4.04	3.24	2.56
Min	1.79	3.08	3.03	4.33	3.58	2.66	2.10	1.55
Med	2.17	3.35	3.25	4.76	3.82	2.90	2.43	2.04
R^2								
Max	0.43	0.62	0.75	0.80	0.72	0.63	0.57	0.38
Min	0.23	0.41	0.39	0.54	0.47	0.35	0.25	-0.29
Med	0.33	0.53	0.53	0.68	0.59	0.49	0.46	0.26

Table 2.3 (continued)

	5 m	15 m	30 m	1 h	3 h	6 h	12 h	24 h
BUNDESBANK								
Discbb								
Max	0.00002	0.00680	0.00601	0.00794	0.01294	0.02207	0.02920	0.03258
Min	-0.00453	0.00203	-0.00003	0.00157	0.00018	0.00562	0.01488	0.01544
Med	-0.00211	0.00444	0.00298	0.00471	0.00778	0.01533	0.02160	0.02460
T-discbb								
Max	0.01	2.34	1.77	1.78	1.36	2.21	3.39	3.03
Min	-1.42	0.57	-0.01	0.24	0.02	0.43	1.08	1.03
Med	-0.70	1.33	0.77	0.86	0.80	1.29	1.96	1.90
Lomb								
Max	-0.00396	-0.01370	-0.01062	-0.00773	-0.00489	-0.00462	-0.00682	-0.00467
Min	-0.01222	-0.02067	-0.01539	-0.01894	-0.01975	-0.02387	-0.02572	-0.02148
Med	-0.00879	-0.01610	-0.01299	-0.01159	-0.01013	-0.01324	-0.01659	-0.01492
T-lomb								
Max	-1.04	-2.79	-3.08	-0.93	-0.47	-0.48	-0.92	-0.61
Min	-2.10	-6.12	-4.52	-3.72	-2.36	-2.00	-1.94	-1.38
Med	-1.56	-3.36	-3.63	-1.48	-0.93	-1.02	-1.31	-1.11
Fix								
Max	-0.00013	-0.00064	-0.00047	-0.00130	0.00080	0.00052	0.00003	0.00025
Min	-0.00042	-0.00120	-0.00115	-0.00185	-0.00084	-0.00155	-0.00241	-0.00270
Med	-0.00034	-0.00099	-0.00099	-0.00168	-0.00002	-0.00007	-0.00070	-0.00054
T-fix								
Max	-0.76	-1.70	-1.43	-2.40	0.76	0.29	0.02	0.09
Min	-1.57	-2.64	-1.99	-2.95	-0.83	-1.39	-1.50	-1.53
Med	-1.30	-2.09	-1.77	-2.71	-0.02	-0.04	-0.31	-0.20
Repo								
Max	-0.00519	0.00430	0.01657	0.02654	0.03005	0.02695	0.10484	0.10634
Min	-0.01400	-0.00309	0.00633	0.01145	0.01971	-0.00859	0.04986	0.05871
Med	-0.00873	-0.00043	0.00871	0.02028	0.02551	0.01180	0.07229	0.07599
T-Repo								
Max	-1.01	0.79	2.67	2.70	2.70	1.08	2.14	3.87
Min	-2.56	-0.55	0.84	1.28	1.65	-0.34	0.91	1.29
Med	-1.41	-0.07	1.13	1.81	2.24	0.43	1.46	1.92
R^2								
Max	0.36	0.52	0.30	0.23	0.12	0.10	0.15	0.17
Min	0.07	0.26	0.14	0.04	-0.03	-0.01	0.05	0.05
Med	0.25	0.38	0.25	0.10	0.02	0.04	0.09	0.10

Notes: The table presents summary statistics of the distribution of estimates for the parameters of 11 multiple regressions for the Fed and 74 regressions for the Bundesbank, obtained by dropping one observation at a time. For each parameter, the maximum, minimum and median values of the estimates are presented.

news from the Fed. The significance of *Funds*, the non significance of *Discfed*, and the higher R^2 on the 1h returns regression are all robust to the sample used, and so are the significance of *Lomb* and the higher R^2 on the 15 m regression for the Bundesbank. However, most of the parameter estimates are quantitatively very sensitive to the inclusion in the sample of particular observations. The range of both the value of the coefficients and the respective t-statistics is quite large for most of the parameters, including those that qualitatively are not affected. For example, the *Lomb* t-statistic on the 15m regression ranges from -2.8 to -6.1, and the *Funds* coefficient on the 3 h regression ranges from 0.035 to 0.050. Even worse, the evidence suggests that some qualitative results may depend on specific observations, like the signs of the coefficients and the non significance of *Discbb* or *Repo*.

2.2.3 Differences in the exchange rate reaction to policy news across sub samples

The dependence of the results on particular observations could be explained by differences in the reaction of the exchange rate to different policy signals, or in different moments of time. In this subsection, several hypotheses relating different behaviour of the exchange rate in response to different policy signals are analysed. First, the hypothesis that the signals from the Bundesbank had a different effect during the troubled period of the ERM crisis is tested. Second, a test of the hypothesis that the effect of the *Funds* news signalled through open market operations are different from the same news signalled by formal statements from the FOMC is performed. The final investigation focus on whether the impact of exchange rate changes differ from the impact of no changes, even if the news content is the same in both cases. The differences in the reaction of the exchange rate in each of these circumstances may be sufficiently large to reduce the power of tests based in the whole sample to close to zero. As may be seen in Figure 2.2, when the data are separated according to some of these sub samples the patterns of the association of the returns and the news become more clear, at least for some of the variables.

The impact of the ERM crisis

The sample used in this chapter includes the period when some European currencies were subject to abnormally high instability, the period leading to the *de facto* collapse of the European exchange rate mechanism (ERM). From the third quarter of 1992 to the third quarter of 1993, the ERM was subject to several speculative attacks that culminated on the widening of the fluctuation bands to 15% in August 1993, which virtually meant the end of the ERM as a fixed exchange rate system. During that period instability surrounding the member currencies was abnormally high, and this instability could have affected the way exchange rates, even those outside the ERM like the DEM/USD, reacted to news. The hypothesis examined is that the DEM/USD may react differently to news from the Bundesbank during the period when there was a risk of a collapse of the ERM, and this restricts the abnormal period to the months around August 1993, when the bands were widened. Although the speculative attacks on ERM currencies started in September 1992, initially these were seen as problems of specific currencies, which could be solved by devaluations of these currencies, or in extreme cases their exit from the ERM.[36] During this period, there is no reason for the DEM/USD to be affected by the attacks, since the problems referred to other currencies (GBP, ITL,...). Only in mid 1993 these attacks started to be seen as a problem of the ERM itself, or of its anchor currency, the DEM; it is then that the ERM problems could affect the DEM/USD (see below for a more detailed explanation). It is difficult to date precisely this period of ERM instability ('ERM crisis', from now on), and the period of May to September 1993 was chosen on somewhat subjective theoretical and empirical grounds.[37]

The test of the 'ERM crisis' hypothesis consisted in estimating regressions similar to equation 2.1, but where each interest rate news variable was replaced by two variables, each one referring to one of the sub-samples, using the dummy '*erm*', which takes the value 1 for the news during the 'ERM crisis' period (May to September 1993), and 0 in the 'normal' period, and the dummy '*nor*' (equal to 1-*erm*). Table 2.4 presents these

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[36] The speculative attacks in September 1992 were 'solved' by the exit of the British pound and the Italian lira from the ERM, and by the devaluation of the Spanish peseta. Other speculative attacks were also solved by devaluation of the currencies involved: in November 1992, devaluation of the peseta and the Portuguese escudo; in February 1993, devaluation of the Irish punt; and in May, new devaluation of the peseta and the escudo. All these speculative attacks were seen as caused by the 'weakness' of the devalued currencies.

[37] This is the periodicity that maximises the estimated fit. It can be motivated theoretically by noting that May 1993 was the month of the last devaluation of 'specific' currencies, and thus the last time the speculative attacks were related to marginal currencies. From this date on, the attacks culminated in the ERM collapse, and thus could be seen as related to the anchor currency, the DEM. Although the widening of the bands occurred in August 1993, it could be argued that the markets needed some time to see if this decision actually delivered stability among ERM currencies (since previous 'solutions' in the ERM did not), before they could decide that the instability was over and thus resume reacting to news the 'normal' way. This explains the need to include one month (September) after the widening of the bands in the ERM crisis period.

results for regressions estimated using all the variables simultaneously, while Table 2.5 presents similar results but for regressions that include only one type of policy signals (to assess the effects on the results of the possible problems of multicolinearity).

Table 2.4 **Effects of Bundesbank's news and the ERM crisis**

Period	*Discnor*	*Lombnor*	*Fixnor*	*Reponor*	*Discerm*	*Lomberm*	*Fixerm*	*Repoerm*	R^2
5 m	-0.00445	-0.01104	-0.00035	-0.00948	0.00054	0.00320	0.00083	-0.00306	0.38
	-1.06	*-1.82*	*-1.12*	*-1.39*	*0.16*	*1.57*	*1.88*	*-0.27*	
15 m	-0.00168	-0.01820	-0.00072	-0.00133	0.01072	0.00002	-0.00041	0.00694	0.63
	-0.52	*-5.60*	*-1.90*	*-0.22*	*5.23*	*0.01*	*-0.51*	*0.33*	
30 m	-0.00296	-0.01308	-0.00067	0.00566	0.00905	-0.00509	-0.00123	0.03278	0.37
	-0.70	*-3.42*	*-2.19*	*0.72*	*2.12*	*-1.34*	*-0.58*	*2.36*	
1 h	0.00156	-0.01807	-0.00142	0.02022	0.00687	0.01784	-0.00091	0.01958	0.31
	0.29	*-3.61*	*-2.62*	*1.63*	*0.77*	*3.21*	*-0.65*	*1.34*	
3 h	-0.00385	-0.01540	0.00105	0.01980	0.01738	0.02501	-0.00195	0.06778	0.34
	-0.41	*-1.96*	*0.92*	*1.69*	*1.43*	*3.32*	*-0.99*	*3.20*	
6 h	0.00201	-0.01800	0.00090	-0.00246	0.02748	0.02216	-0.00106	0.11806	0.23
	0.15	*-1.56*	*0.46*	*-0.08*	*1.65*	*2.21*	*-0.45*	*4.98*	
12 h	0.01399	-0.02300	0.00008	0.05570	0.02715	0.01785	-0.00181	0.20931	0.18
	1.00	*-1.77*	*0.03*	*1.02*	*1.81*	*1.98*	*-0.43*	*3.07*	
24 h	0.01817	-0.01922	-0.00031	0.07314	0.03105	0.01027	0.00081	0.10583	0.13
	1.01	*-1.21*	*-0.10*	*1.70*	*1.83*	*0.99*	*0.23*	*1.21*	
# news	22	25	16	24	8	3	3	5	74

Notes: See Table 2.1. The critical values for the t-tests are 2.00 (1.67) at the 5% (10%) level. The variables with the 'erm' suffix refer to the observations in the period from May to September 1993, the variables with the 'nor' suffix refer to the other observations.

When one allows for different reactions of the exchange rate during the ERM crisis, the impact of Bundesbank's policy news becomes more clearly defined. For the 'normal' periods, the coefficients of *Lomb* are higher in absolute value and have higher significance levels, such that significant impacts (at the 10% level) can be identified up to 12 hours. The size of the coefficients is smaller than the *Funds* coefficients, yet the order of magnitude is not strikingly different, with unexpected announcements of a 1 percentage point increase in *Lomb* appreciating the DEM by almost 2 'pfennigs' (1.3% of the exchange rate). News on the repo tender terms (*Fix*) also have a significant impact on the DEM/USD, but quantitatively this impact is small, with the unexpected announcement of a fixed-rate repo causing a DEM appreciation of around than 0.1 'pfennigs'. The other two policy signals considered do not seem to have any significant impact on the exchange rate. The markets seem to consider that the Lombard rate is the best indicator of the Bundesbank's monetary policy, and the Discount and Repo rates do not have significant additional information.[38]

Table 2.5 **Effects of Bundesbank's news and the ERM crisis (individual regressions)**

Period	*Discnor*	*Discerm*	*Lombnor*	*Lomberm*	*Fixnor*	*Fixerm*	*Reponor*	*Repoerm*
5 m	-0.01152	0.00096	-0.01348	0.00316	-0.00054	0.00063	-0.00948	-0.00306
	-2.23	*0.37*	*-2.52*	*4.41*	*-1.87*	*2.96*	*-1.39*	*-0.27*
15 m	-0.01336	0.01099	-0.01924	0.00718	-0.00097	-0.00175	-0.00133	0.00694
	-2.36	*5.34*	*-7.48*	*1.85*	*-1.96*	*-0.90*	*-0.22*	*0.33*
30 m	-0.01139	0.00832	-0.01479	0.00137	-0.00087	-0.00215	0.00566	0.03278
	-2.45	*1.66*	*-5.37*	*0.21*	*-2.23*	*-0.72*	*0.72*	*2.36*
1 h	-0.01021	0.01277	-0.01752	0.02274	-0.00163	-0.00252	0.02022	0.01958
	-1.43	*1.74*	*-4.54*	*5.86*	*-2.60*	*-1.02*	*1.63*	*1.34*
3 h	-0.01334	0.02608	-0.01724	0.03723	0.00081	-0.00517	0.01980	0.06778
	-1.48	*2.63*	*-2.87*	*5.10*	*0.67*	*-1.20*	*1.69*	*3.20*
6 h	-0.00917	0.03475	-0.01675	0.04052	0.00070	-0.00542	-0.00246	0.11806
	-0.62	*2.85*	*-1.63*	*6.99*	*0.35*	*-1.42*	*-0.08*	*4.98*
12 h	-0.00054	0.03362	-0.01552	0.03635	-0.00003	-0.00595	0.05570	0.20931
	-0.03	*2.90*	*-1.24*	*4.01*	*-0.01*	*-0.94*	*1.02*	*3.07*
24 h	0.00594	0.03359	-0.00959	0.03009	-0.00032	-0.00350	0.07314	0.10583
	0.29	*2.60*	*-0.68*	*3.20*	*-0.10*	*-0.55*	*1.70*	*1.21*
# news	22	8	25	3	16	3	24	5

Notes: See Tables 2.1 and 2.4. The t-statistics critical values are 2.05 (1.70) at the 5% (10%) level, for the *Discbb*, *Lomb* and *Repo* regressions, and 2.11 (1.74) for the *Fix* regression.

The reaction of the exchange rate to Bundesbank policy signals during the ERM crisis was completely different, although these results have to be taken cautiously, since they are based in a very small number of observations. For every rate considered, the signs of the significant coefficients are positive, indicating that unexpected increases in the interest rates caused a DEM depreciation,[39] which is the opposite of what would be expected, and the opposite of what happened during the 'normal' period. One possible explanation for this anomalous behaviour is that the USD was a 'safe haven' during the times of high instability in the ERM. The main cause of ERM instability was the fact that the economic situation in many ERM member countries (in particular France) required

[38] In the case of *Discbb*, note that when the effects of the different rates are considered separately (Table 2.5) one could find a significant effect, with the expected negative sign, at least up to 30 minutes. This result is consistent with the explanation advanced in footnote 31, suggesting that this was caused by the announcement of Discount rate changes simultaneously with Lombard rate changes.

[39] During the 'erm' period there were no interest rate increases by the Bundesbank. Note, however, that if the market is expecting a cut in rates, and the Bundesbank keeps them unchanged, this corresponds to an unexpected increase. It is in this sense that the expression is used in this paragraph.

lower interest rates than the ones the Bundesbank had set. Thus, any increase in German interest rates would increase ERM instability and the risk of the collapse of the system. In this context, it seems natural that risk averse investors would switch their investments from DEM to a non-ERM currency, like the USD, which would not be directly affected by this instability. This transfer of funds from DEM to USD denominated investments would increase the demand of, and appreciate, the USD. This kind of reaction would imply that German rate increases would be associated with USD appreciation, and the coefficients in the regressions would be positive, as it was found in the estimation.[40] Note that it seems that the impact of interest rate changes for the 'crisis' period is higher than in the 'normal' period, either in terms of the size and of the significance level of the coefficients, both for the *Discbb* and *Lomb*. Also, during this period *Repo* has a significant and quantitatively very large impact, which was not found for the 'normal' period. This is more in line with the view that the Repo is the key rate.

Open market operations and official statements from the Fed

Until February 1994, the Fed signalled its Funds target only through open market operations, but since then it announced changes in the Funds target through official statements on the day the decision is taken (see Section 2.1). The hypothesis tested in Table 2.6 is that this change in the announcement procedure is associated with a change in the reaction of the exchange rate. The test consisted of the estimation of a regression for policy news emanating from the Fed, where the differential effect of the news signalled through open market operations is measured by a sub sample variable (*Fundom*) constructed using the dummy '*om*', which takes the value 1 if the *Funds* news are signalled

[40] Some press reports of that time used similar arguments to explain the USD behaviour. During the peak of the speculative attacks that forced the member countries of the ERM to widen the fluctuation bands (29th and 30th July, 1993), the USD (and also the GBP) appreciated against the DEM, even though the Bundesbank failed to cut the Discount rate in 29/7, surprising the market. According to the Financial Times of 30/7/93 and 1/8/93, this happened because these currencies "reaped the benefits of being a safe haven in a crisis" (FT, 30/7/93, p. 35). However, similar explanations could not be found for the other observations during the 'erm' period, even though the reaction of the USD was similar. For example, after the rate cuts of 1/7 and 9/9, the DEM appreciated, and the explanations found in the FT referred to 'profit taking' and 'response to initial overreaction' (even though there was no overreaction in the data).

through open market operations.[41] The results show that *Fundom* is significantly negative for return horizons up to 3 hours, meaning that news signalled through open market operations have a smaller immediate impact on the exchange rate. Note, however, that the significance and the size of the coefficient of *Fundom* are smaller in the longer term horizons, suggesting that the long run the effect is the same whatever the form used for signalling news.

Table 2.6 **Differences in the effects of Fed's news signalled through open-market operations or official statements**

Period	*Discfed*	*Funds*	*Fundom*	R^2
5 m	-0.00155	0.01711	-0.01469	0.64
	-0.93	*3.26*	*-2.61*	
15 m	-0.00230	0.03762	-0.02914	0.86
	-1.53	*5.81*	*-3.99*	
30 m	-0.00726	0.04460	-0.02724	0.67
	-1.88	*4.51*	*-2.03*	
1 h	-0.00692	0.05219	-0.02962	0.83
	-1.71	*9.62*	*-3.40*	
3 h	-0.00992	0.06779	-0.04018	0.74
	-1.60	*4.21*	*-2.18*	
6 h	-0.00035	0.05207	-0.02633	0.56
	-0.05	*2.48*	*-1.09*	
12 h	0.00642	0.04463	-0.01187	0.46
	0.92	*1.88*	*-0.40*	
24 h	0.00855	0.02713	0.03013	0.28
	0.46	*0.82*	*0.69*	
# news	4	9	5	11

Notes: See Table 2.1. The critical values for the t-tests are 2.31 (1.86) at the 5% (10%) level. *Fundom* includes the observations when policy decisions were signalled through open market operations.

This result may be rationalised in the following way. In the long run, there is no reason why different forms of signalling the same news should have different effects on the exchange rate; what drives the exchange rate is the new level of the Funds rate target, and that is independent of the way this level is signalled to the market. However, the adjustment path of the exchange rate to the new equilibrium level will depend of the chosen form of signalling. When an official statement is issued clearly indicating that the Funds rate target has been changed, market agents may only disagree on the new level of the exchange rate consistent with the new Funds rate. But when the news is signalled

[41] The value 0 corresponds to the observations when the news are revealed through official statements.

through open market operations there is another possible source of disagreement, whether a specific open market action denotes a change in the Funds target or not. 'Fed watchers' will quickly identify the new Funds target, but this is likely to add a few hours to the reaction of the exchange rate. Even in the case of official statements, it takes some time (around 3 hours) for a new equilibrium level of the exchange rate to be found. Adding to this the time necessary for the market to reach a consensus on the implications of a certain market operation for the target rate will mean that the new equilibrium level will be reached only after several hours.[42] Note that the relatively small number of observations used in these regressions limit the scope of these conclusions.

Interest rate changes and no changes

Under the definition of news used, an unexpected 25 b.p. rate cut is equivalent to an event in which the central bank keeps rates unchanged when the market was expecting a 25 b.p. increase. However, it is possible that the reaction of the exchange rate to these two events differ. First, because an action (interest rate cut) may provide a better focal point for the markets' view of the policy stance than the absence of action. Second, while an interest rate cut is a *fait accompli*, the absence of action today does not rule out action tomorrow, and so the importance for the future path of interest rates of no change could be smaller than the importance of a change.

Table 2.7 presents the results of the tests of this hypothesis, using sub sample variables constructed using the dummy '*act*', which takes the value 1 if the observation corresponds to an interest rate change. On the Fed regressions, *Fundact* has a positive coefficient for returns up to 6 hours, which is significant only on the very short term returns. It seems that the short term impact of news with action is significantly higher than the impact of news with inaction, but that in the medium run such difference is not significant, a result that is consistent with the hypothesis of the action providing a better focal

[42] Although the results are not clear, it is possible that the exchange rate will only reach the new equilibrium level the following day. Such a result could be the consequence of the market participants only reaching a consensus about the new level of the exchange rate after the Fed action on the following day confirms that it is in fact targeting a new *Funds* rate.

point (that triggers a bigger immediate reaction) than inaction. For the case of the Bundesbank, the results are the opposite. *Discact* and *Lombact* have positive coefficients in almost all the regressions, which imply that the change in the exchange rate is smaller when the Bundesbank changes interest rates than when it keeps them unchanged. However, the coefficients are usually not significant, which suggests that one should not draw any strong conclusions from this exercise.

Table 2.7 **Differences in the effects of news between interest rate changes and no changes**

Period	*Discfed*	*Funds*	*Fundact*	R^2	*Discbb*	*Lomb*	*Fix*	*Repo*	*Discact*	*Lombact*	R^2
5 m	-0.00050	0.00065	0.01194	0.53	-0.00838	-0.01106	-0.00022	-0.00875	0.00775	0.00241	0.28
	-0.37	*0.33*	*2.41*		*-2.20*	*-1.32*	*-0.73*	*-1.43*	*1.55*	*0.23*	
15 m	0.00029	0.00887	0.01756	0.65	0.00340	-0.03385	-0.00076	-0.00038	0.00228	0.01932	0.46
	0.12	*1.65*	*1.94*		*1.11*	*-5.61*	*-1.82*	*-0.06*	*0.47*	*2.44*	
30 m	-0.00501	0.01646	0.01838	0.60	0.00292	-0.03199	-0.00076	0.00876	0.00114	0.02069	0.32
	-1.19	*1.14*	*1.10*		*0.37*	*-3.10*	*-1.44*	*1.13*	*0.13*	*1.87*	
1 h	-0.00410	0.02447	0.01548	0.72	-0.00772	-0.01492	-0.00145	0.02015	0.01532	0.00350	0.14
	-1.09	*2.29*	*1.16*		*-0.36*	*-0.56*	*-2.51*	*1.82*	*0.70*	*0.13*	
3 h	-0.00684	0.02445	0.03001	0.67	-0.01131	-0.02638	0.00046	0.02529	0.02412	0.01752	0.11
	-1.18	*1.92*	*1.65*		*-0.63*	*-1.16*	*0.40*	*2.26*	*1.16*	*0.69*	
6 h	0.00225	0.02815	0.01263	0.51	-0.00609	-0.02748	0.00042	0.01132	0.02685	0.01528	0.10
	0.35	*1.52*	*0.54*		*-0.19*	*-0.87*	*0.25*	*0.41*	*0.77*	*0.45*	
12 h	0.00908	0.04509	-0.01196	0.46	-0.01572	-0.00812	-0.00025	0.07325	0.04484	-0.00960	0.14
	1.50	*1.68*	*-0.38*		*-0.64*	*-0.28*	*-0.12*	*1.49*	*1.67*	*-0.30*	
24 h	0.01103	0.09599	-0.07957	0.47	-0.02035	0.00599	-0.00013	0.07687	0.05343	-0.02322	0.14
	0.66	*3.16*	*-2.12*		*-0.98*	*0.22*	*-0.05*	*1.96*	*2.20*	*-0.77*	
# news	4	9	5	11	21	18	19	29	9	10	74

Notes: See Table 2.4. The variables with the 'act' suffix include the observations when the central banks changed some interest rate. The remaining variables include all observations.

2.2.4 Rationality of expectations and market efficiency

The results in Appendix 2.A suggest that the measure of expectations used for the *Fix* and *Repo* variables might not be appropriate, since they do not meet the restrictions imposed by the rational expectations hypothesis. As for the other variables, although the rational expectations restrictions are verified, this does not mean that they actually are a good measure of the market expectations. In the absence of (better) alternative measures, one can only proceed with these and expect that the results are not significantly affected.

The rationality of expectations may also be assessed in a joint test with the efficient markets hypothesis, as described in section 2.2.1. The results for the first test, of zero average exchange rate change after policy signals, are presented in Table 2.8. The only clear violations of the hypothesis are for the Bundesbank's 'Wednesday' policy signals with news and 'Tuesday' signals without news. These results are probably caused by the non rationality of the expectations for the *Repo* and *Fix* variables (see Appendix 2.A), which are the ones signalled on those occasions. As such, Table 2.8 does not reveal any additional violation of market efficiency.

Tests of the REEM based on equation 2.2 are less favourable for the hypothesis. Although most of the restrictions that the constant and the coefficients associated with the expected values of interest rate changes should not be significantly different from zero are verified, that is not always the case. From Table 2.9, it can be seen that in the regressions for the signals from the Fed, the expectation of Fed Funds rate changes is significant from 15m to 3h, and that in the regressions for the Bundesbank, the constant is significant on the regressions up to 3h, and the coefficients for the expected changes in the Discount and Lombard rates are also significant in three of the regressions. The constant in the Bundesbank regressions is negative, denoting that the DEM tended to appreciate after the Bundesbank issued some policy signal. This result could be interpreted as sign of market inefficiency, but it may more likely be a small sample problem, an indication of a kind of 'peso problem'. The majority of the observations in the sample correspond to a period when the Bundesbank was cutting the interest rates. The markets overestimated the pace of the cuts, and most of the news consisted of expected cuts that did not materialise, thus implying that the reaction of the exchange rate to those policy signals should be an appreciation of the DEM. Does this overestimation of the pace of the cuts mean markets are irrational? Not necessarily. In order to reach any conclusion one would need to know if the markets also overestimated the pace of the Bundesbank's rate cuts in other cycles. Observations from one cycle only might be not enough.

The significance of some of the expectations coefficients is not necessarily an indication of market inefficiency, either. When significant, the coefficients on the expectations have the same sign as the coefficients on news. One possible interpretation of this result is

Table 2.8 **Average exchange rate change after policy signals**

	FED							BUNDESBANK								
		News			*Expected*				*News*				*Expected*			
Period	*All signals*	*All*	*Discfed*	*Funds*	*All*	*OM operations*	*FOMC meetings*	*All signals*	*All*	*Council meetings*	*Tuesday*	*Wednesd*	*All*	*Council meetings*	*Tuesday*	*Wednesd*
5 m	0.00021	0.00095	0.00059	0.00132	-0.00002	-0.00020	0.00011	-0.00016	-0.00031	-0.00020	-0.00006	-0.00052	-0.00010	-0.00010	-0.00010	-0.00011
	0.78	*1.05*	*0.65*	*1.24*	*-0.10*	*-0.70*	*0.36*	*-1.72*	*-1.00*	*-0.32*	*-0.26*	*-2.81*	*-1.86*	*-0.70*	*-1.25*	*-1.19*
15 m	0.00057	0.00311	0.00415	0.00307	-0.00003	-0.00007	0.00000	-0.00023	-0.00046	-0.00065	0.00017	-0.00044	-0.00014	0.00000	-0.00020	-0.00014
	1.12	*2.08*	*1.63*	*1.49*	*-0.08*	*-0.21*	*0.01*	*-1.93*	*-1.27*	*-0.89*	*0.57*	*-1.69*	*-1.53*	*0.00*	*-1.83*	*-0.83*
30 m	0.00062	0.00248	0.00563	0.00248	0.00002	-0.00031	0.00027	-0.00022	-0.00045	-0.00088	0.00040	-0.00024	-0.00013	0.00034	-0.00041	0.00004
	0.95	*1.44*	*2.27*	*0.84*	*0.05*	*-0.80*	*0.44*	*-1.60*	*-1.23*	*-1.21*	*0.77*	*-0.76*	*-1.03*	*0.90*	*-2.50*	*0.20*
1 h	0.00119	0.00364	0.00640	0.00374	0.00042	0.00012	0.00064	-0.00030	-0.00076	-0.00128	-0.00028	-0.00030	-0.00013	0.00028	-0.00061	0.00042
	1.63	*1.42*	*2.59*	*1.19*	*0.84*	*0.18*	*0.89*	*-1.54*	*-1.43*	*-1.21*	*-0.62*	*-0.69*	*-0.73*	*0.89*	*-2.67*	*1.08*
3 h	0.00152	0.00456	0.00876	0.00452	0.00057	0.00025	0.00081	-0.00039	-0.00110	-0.00165	-0.00090	-0.00052	-0.00013	0.00016	-0.00070	0.00063
	1.58	*1.31*	*2.90*	*1.07*	*0.91*	*0.30*	*0.88*	*-1.37*	*-1.66*	*-1.25*	*-1.26*	*-0.92*	*-0.44*	*0.23*	*-1.93*	*0.97*
6 h	0.00114	0.00388	0.00864	0.00412	0.00028	-0.00040	0.00080	-0.00034	-0.00095	-0.00141	-0.00038	-0.00059	-0.00012	0.00105	-0.00092	0.00051
	1.16	*1.14*	*2.28*	*0.99*	*0.39*	*-0.33*	*0.89*	*-0.81*	*-1.00*	*-0.80*	*-0.37*	*-0.54*	*-0.27*	*0.62*	*-1.80*	*0.68*
12 h	0.00129	0.00421	0.00858	0.00425	0.00038	0.00065	0.00017	-0.00044	-0.00067	-0.00174	-0.00082	0.00067	-0.00036	-0.00071	-0.00035	-0.00019
	1.12	*1.07*	*2.66*	*0.88*	*0.43*	*0.48*	*0.14*	*-0.76*	*-0.58*	*-0.89*	*-0.37*	*0.42*	*-0.53*	*-0.38*	*-0.35*	*-0.18*
24 h	0.00139	0.00608	0.01170	0.00386	-0.00009	0.00083	-0.00078	0.00001	-0.00011	-0.00109	-0.00147	0.00154	0.00005	0.00001	0.00008	0.00003
	0.77	*1.10*	*3.17*	*0.59*	*-0.06*	*0.27*	*-0.50*	*0.02*	*-0.09*	*-0.51*	*-0.62*	*0.87*	*0.07*	*0.01*	*0.08*	*0.03*
# obs	46	11	4	9	35	15	20	280	74	35	10	29	206	37	105	64

Notes: The table displays the average exchange rate change after policy signals, for each class of signals and over different periods of time. The numbers in italics are t-statistics under the null that the mean is zero (assuming normality of returns). Underlined values are significantly different from zero at the 5% level.

Table 2.9 Test of the REEM hypothesis

	FED						BUNDESBANK									
Period	*Constant*	*Discfed*	*Funds*	*Exdiscfd*	*Exfunds*	R^2	*Constant*	*Discbb*	*Lomb*	*Fix*	*Repo*	*Exdisc*	*Exlomb*	*Exfix*	*Exrepo*	R^2
5 m	0.00000	-0.00181	0.00966	-0.00285	0.00500	0.30	-0.00019	-0.00012	-0.01306	-0.00021	-0.00706	0.01454	-0.01700	0.00027	0.00045	0.31
	0.02	*-0.66*	*2.49*	*-1.02*	*1.63*		*-2.32*	*-0.03*	*-2.43*	*-0.73*	*-1.11*	*2.05*	*-2.54*	*1.22*	*0.23*	
15 m	0.00001	-0.00161	0.02094	0.00113	0.01082	0.56	-0.00029	0.00565	-0.01847	-0.00087	0.00269	0.00739	-0.00774	0.00010	-0.00269	0.29
	0.03	*-0.59*	*3.61*	*0.31*	*2.69*		*-2.53*	*1.40*	*-4.17*	*-1.90*	*0.49*	*1.00*	*-1.02*	*0.36*	*-1.31*	
30 m	-0.00004	-0.00981	0.03129	-0.00415	0.01632	0.57	-0.00028	0.00430	-0.01419	-0.00070	0.01144	0.00239	0.00331	0.00034	-0.00095	0.16
	-0.10	*-2.08*	*4.13*	*-0.57*	*1.88*		*-1.89*	*0.87*	*-3.13*	*-1.40*	*1.43*	*0.38*	*0.43*	*0.93*	*-0.27*	
1 h	0.00044	-0.00747	0.03525	0.00039	0.01339	0.63	-0.00044	0.00807	-0.01733	-0.00140	0.02436	0.01902	-0.01690	0.00023	-0.00144	0.12
	0.98	*-1.80*	*5.43*	*0.05*	*1.98*		*-2.27*	*1.55*	*-2.64*	*-2.19*	*2.13*	*1.31*	*-1.04*	*0.43*	*-0.44*	
3 h	0.00054	-0.01375	0.04744	-0.00635	0.02291	0.58	-0.00061	0.01282	-0.01888	0.00066	0.03022	0.02713	-0.02395	0.00123	0.00506	0.07
	0.90	*-2.38*	*4.52*	*-0.71*	*2.57*		*-2.03*	*1.28*	*-1.90*	*0.52*	*2.65*	*1.64*	*-1.10*	*1.56*	*0.84*	
6 h	0.00023	-0.00199	0.03775	-0.00029	0.01522	0.43	-0.00038	0.02083	-0.02352	0.00037	0.01314	0.03470	-0.03491	0.00082	0.01231	0.05
	0.32	*-0.26*	*3.09*	*-0.03*	*1.24*		*-0.76*	*1.99*	*-1.90*	*0.20*	*0.62*	*1.46*	*-1.27*	*0.76*	*1.21*	
12 h	0.00052	0.00820	0.03602	0.00328	0.00075	0.33	-0.00082	0.03011	-0.03176	0.00036	0.07981	0.04821	-0.04457	0.00203	0.00680	0.06
	0.55	*0.89*	*2.51*	*0.26*	*0.05*		*-1.23*	*3.32*	*-2.56*	*0.15*	*1.66*	*2.51*	*-2.07*	*0.88*	*0.47*	
24 h	0.00109	0.00768	0.04540	-0.01220	-0.02022	0.25	-0.00010	0.03283	-0.02901	-0.00001	0.07691	0.04986	-0.04519	0.00091	0.00662	0.05
	0.70	*0.44*	*2.16*	*-0.70*	*-0.87*		*-0.14*	*2.99*	*-1.88*	*0.00*	*1.98*	*2.78*	*-2.02*	*0.40*	*0.46*	

Notes: See Table 2.1. This table describes the results of estimation of equation 2.2, for all the relevant Fed's and Bundesbank's policy signals (46 observations for the Fed and 264 for the Bundesbank). The critical values for the t-tests are 2.02 (1.68) for the Fed and 1.97 (1.65) for the Bundesbank, at the 5% (10%) level. The variables with the 'Ex' prefix refer to the expected interest rate changes, the other variables refer to the news (the unexpected changes).

that the measure of expectations used overestimates the actual market expectation (i.e., the actual news are larger than the measure used), which would mean that markets are efficient but one would need a different measure of market expectations. However, another possible explanation which would denote some market inefficiency is that the exchange rate is reacting to the actual change, not the news, i.e., that the market expectations are not incorporated in the exchange rate before the announcement. The results in Table 2.10, of the estimation of equation 2.1, but with the actual interest rate change replacing the news measure, are very similar to the results in Table 2.1, suggesting that one can not rule out that hypothesis. However, distinguishing these two hypothesis in this data set is difficult, because the news and the actual changes are highly correlated (see Appendix 2.A, Table 2.19), thus implying that one will get similar results using either of the two variables. Although the differences are very small, the fit is slightly better when the news variables are used (higher R^2 and t-statistics), and this could be interpreted as an indication that the markets are reacting to the news and not to the actual changes, as the efficient markets hypothesis would imply.

Table 2.10 **Effects of actual interest rate changes on the DEM/USD rate**

	FED			BUNDESBANK				
Period	*Discfed*	*Funds*	*R2*	*Discbb*	*Lomb*	*Fix*	*Repo*	R^2
5 m	-0.00330	0.00795	0.25	0.00147	-0.00896	-0.00025	0.00082	0.16
	-0.99	*2.07*		*0.44*	*-1.81*	*-1.52*	*0.47*	
15 m	-0.00284	0.01774	0.51	0.00579	-0.01434	-0.00075	-0.00021	0.20
	-0.76	*3.62*		*1.61*	*-4.03*	*-2.99*	*-0.11*	
30 m	-0.01097	0.02665	0.49	0.00401	-0.00942	-0.00060	0.00221	0.07
	-2.01	*4.53*		*0.91*	*-2.31*	*-1.99*	*0.67*	
1 h	-0.00943	0.02925	0.50	0.00931	-0.01269	-0.00091	0.00425	0.06
	-1.72	*5.15*		*1.90*	*-2.23*	*-1.88*	*2.09*	
3 h	-0.01654	0.04064	0.49	0.01441	-0.01437	0.00032	0.01181	0.04
	-2.10	*4.40*		*1.58*	*-1.54*	*0.41*	*2.58*	
6 h	-0.00654	0.03054	0.36	0.02242	-0.02133	0.00030	0.01486	0.04
	-0.85	*3.15*		*2.24*	*-1.89*	*0.27*	*2.05*	
12 h	-0.00200	0.02420	0.19	0.03224	-0.02765	0.00067	0.02023	0.04
	-0.24	*2.21*		*3.82*	*-2.98*	*0.35*	*1.57*	
24 h	-0.01566	0.02252	0.03	0.03480	-0.02762	0.00055	0.01520	0.04
	-1.55	*1.66*		*3.39*	*-2.20*	*0.28*	*1.12*	
# changes	4	8	9	10	9	36	44	99

Notes: See Table 2.1. The variables refer to the actual interest rate changes, not to the 'news'. The critical values for the t-tests are 2.37 (1.90) for the Fed, and 1.99 (1.66) for the Bundesbank, at the 5% (10%) level.

2.2.5 The time pattern of the response of the exchange rate to policy news

Figure 2.3 presents the evolution across return periods of the size of the coefficients and respective t-statistics for the main interest rate each central bank, the Funds rate for the Fed and the Lombard rate for the Bundesbank. The data were obtained by running regressions similar to the ones used in the previous sections, but using a finer grid of return periods: the *Funds* results are an extension of Table 2.1, and the Lomb results are similar to Table 2.4. However, the data actually used for Lomb is an extension of Table 2.11, which does not include 3 of the observations used in Table 2.4. These 3 observations correspond to the cases when there was an announcement of some main US macroeconomic indicator after the Bundesbank policy news, whose impact on the exchange rate could distort the time pattern of the effect of *Lomb*.[43]

Table 2.11 **Effects of Bundesbank's news, without observations affected by US macroeconomic announcements**

Period	*Discnor*	*Lombnor*	*Fixnor*	*Reponor*	*Discerm*	*Lomberm*	*Fixerm*	*Repoerm*	R^2
5 m	0.00006	-0.01376	-0.00037	-0.00948	0.00093	0.00323	0.00060	-0.00306	0.39
	0.02	*-2.18*	*-1.23*	*-1.39*	*0.25*	*1.72*	*1.89*	*-0.27*	
15 m	0.00183	-0.01999	-0.00074	-0.00133	0.00903	-0.00015	0.00063	0.00694	0.64
	0.66	*-6.11*	*-1.93*	*-0.22*	*3.57*	*-0.12*	*35.36*	*0.33*	
30 m	0.00141	-0.01593	-0.00069	0.00566	0.00454	-0.00554	0.00153	0.03278	0.39
	0.42	*-4.34*	*-2.22*	*0.72*	*1.48*	*-3.28*	*12.32*	*2.36*	
1 h	0.00452	-0.02211	-0.00141	0.02022	0.00460	0.01762	0.00048	0.01958	0.38
	0.86	*-4.09*	*-2.62*	*1.63*	*0.42*	*3.21*	*1.17*	*1.34*	
3 h	0.00371	-0.02034	0.00102	0.01980	0.01398	0.02467	0.00013	0.06778	0.30
	0.38	*-2.46*	*0.89*	*1.69*	*0.92*	*3.22*	*0.54*	*3.20*	
6 h	0.00358	-0.01808	0.00088	-0.00246	0.02759	0.02217	-0.00113	0.11806	0.20
	0.18	*-1.24*	*0.45*	*-0.08*	*1.43*	*2.28*	*-0.49*	*4.98*	
12 h	0.01246	-0.01982	0.00006	0.05570	0.02303	0.01744	0.00070	0.20931	0.13
	0.57	*-1.26*	*0.03*	*1.02*	*1.26*	*1.87*	*0.15*	*3.07*	
24 h	0.02038	-0.01820	-0.00035	0.07314	0.02582	0.00976	0.00400	0.10583	0.10
	0.76	*-0.94*	*-0.11*	*1.70*	*1.23*	*0.92*	*1.49*	*1.21*	
# news	20	23	14	24	7	2	2	5	71

Notes: See Table 2.4.

[43] In Chapter 3, it is shown that some US macroeconomic data announcements have a significant impact on the DEM/USD exchange rate. To eliminate possible distortions from these announcements, the observations including US macro data announcements inside the 24 hour return period were excluded. The observations excluded were from 2/10/92, when the US Employment Report was announced 30m after the end of the Bundesbank council meeting, from 1/7/93 (NAPM, 3h after meeting) and from 17/2/94 (CPI, 30m after meeting).

The time pattern of the size of the coefficients and significance levels of the key interest rates, exhibits an interesting difference between the exchange rate reactions to news originating from the Fed and the Bundesbank. The evidence suggests that the market reaction to Bundesbank's news is much quicker than the reaction to the Fed's news. The exchange rate adjusts almost immediately to Lombard rate news: after 10 minutes the coefficient is already close to its maximum value. However, the adjustment to Fed Funds news is slower and more gradual. Instead of jumping almost immediately to its maximum value, the size of the coefficient increases gradually; after 10 minutes it is less than half of its maximum level, it takes almost 1 hour to reach two thirds of its maximum level, and the full impact is only felt after 3 hours. Similar differences may be observed for the evolution across time of the t-statistics. This kind of adjustment pattern creates significant profit opportunities, and thus might lead one to question the efficiency of the market. The puzzle is why this only occurs for the Fed news, but not for the Bundesbank news. Two differences between US and German announcements might be originating this result. First, Lombard rate signals are clearer than Fed Funds rate signals. While the Bundesbank clearly states the new level of the Lombard rate ('Lombard rate is 9%', for instance), the Fed only announces changes in the 'degree of reserve pressure'; it requires some interpretation from the 'Fed watchers' to translate this wording into the new target for the Funds rate, and this kind of analysis will probably take some time. Second, Lombard rate policy signals are scheduled, while Funds rate signals are not (at least in most of the sample). The Lombard rate is only changed at the Bundesbank council meeting, and the dates of the meeting are well known; also, most of the times the outcome of the meeting is announced at a press conference, whose precise time has been previously announced. This is not necessarily the case for the Funds signals (at least until February 1994). There are no precise dates when the Funds rate might be changed. Note that this explanation is consistent with the results of Chapter 3, where similar differences in the adjustment pattern to US and German macroeconomic announcements were found: the adjustment to the scheduled (US) announcements is much faster than the adjustment to the unscheduled (German) announcements.

2.3 The Impact of Policy Signals on Exchange Rate Volatility

2.3.1 Methodology

Even if a policy signal does not affect the exchange rate level (because it was expected, for instance) it still might have an impact on the exchange rate volatility. The analysis of the impact of monetary policy signals on exchange rate volatility is based on the estimation of a time series model, inspired on the ARCH methodology. The large number of parameters to estimate (see below), and the large number of observations in the sample (225180) rule out the use of the iterative methods usually applied for the estimation of non-linear time series models. To overcome this problem, an alternative estimation procedure was developed, which requires much less time and computing resources than iterative methods, and still provides consistent estimates, although it might imply some loss of efficiency.[44]

The basic data consist of five-minute returns (R_t'), computed as the first differences of the logarithm of the DEM/USD exchange rate quotes (q_t)[45]

$$R_t' = 100\ (\log q_t - \log q_{t-1}) \qquad 2.3$$

corresponding approximately to the (continuously compounded) percentage nominal return on the USD obtained from period $t-1$ to period t. In the first stage, a small but positive mean, and a small MA term, are filtered from the return series R_t', and the residuals from this model, r_t (the filtered returns), were then used as the basis for the second step of the estimation. Table 2.12 presents the results of the filtering procedure.

Table 2.12 **Estimation of filtered returns**

Variable	*Coefficient*	*Std. Error*	*T-Stat*
Constant	0.00019	0.00016	1.17
MA{1}	-0.07725	0.00364	-21.24

[44] However, with such a large number of observations in the sample, efficiency should not be a serious concern.

[45] See Appendix 2.B for a description of q_t.

The second stage consists of modelling r_t as a GARCH(1,1) process. A substantial body of literature has now accumulated showing that the behaviour of foreign exchange rates can be reasonably described under Engle's (1982) Autoregressive Conditional Heteroscedasticity (ARCH) framework. In particular, some derivation of Bollerslev's (1986) GARCH(1,1) model has been widely used to model the behaviour of foreign exchange rates.[46] Applying the general specification of GARCH(1,1) to describe the behaviour of the filtered 5 minute returns on the DEM/USD exchange rate, r_t, yields

$$r_t \,/\, \psi_{t-1} \sim N(0, h_t) \qquad 2.4$$

$$h_t = G_t + \alpha r_{t-1}^2 + \beta h_{t-1} \qquad 2.5$$

where G_t is some function of exogenous variables. The GARCH(1,1) model can be expressed as an ARMA(1,1) in squared returns (Bollerslev, 1986, p. 310)

$$r_t^2 = G_t + (\alpha+\beta)\, r_{t-1}^2 - \beta v_{t-1} + v_t \qquad 2.6$$

where

$$v_t = r_t^2 - h_t = (\eta_t^2 - 1)\, h_t$$

and

$$\eta_t \sim i.i.d.\ N(0,1)$$

Notice that v_t is a Martingale difference and can be thought of as a white-noise sequence. Thus equation 2.6 can be used to estimate the model with standard time-series techniques (Engle, 1995, p.xiii). Since any ARMA process can be approximated by an AR(p) model, with p sufficiently large (Harvey, 1993, p. 133), equation 2.6 can be rewritten as

$$r_t^2 \;=\; G_t + \sum_{i=1}^{p} \phi_i r_{t-i}^2 + v_t \qquad 2.7$$

Applying OLS to equation 2.7 will yield biased estimates of the coefficients. Also, given the heteroscedasticity present in v_t, inference using OLS standard deviations would not be valid. However, OLS estimators are consistent. Furthermore, computing the covariance matrix allowing for heteroscedasticity as in White (1980) will yield asymptotically valid tests of hypothesis about the coefficients (Hamilton, 1994, p. 215-220).

Estimating the model in squared returns form is generally inefficient and the original

[46] For references, see Bollerslev, Chou and Kroner (1992, p.37).

GARCH specification is usually preferred. However, the fact that there are 225180 observations in the sample is simultaneously a motive and a justification for estimating the model in the form of equation 2.7. The motive is the impracticable computational costs of estimating a model with more than 150 parameters (as described below) and such a large number of observations, using any kind of iterative process. An autoregression makes the model easier to specify and estimate. The justification is that with such a large number of observations efficiency should not be an important problem. Also, the large number of observations provides the justification for applying asymptotic results that allow for the estimation of some variant of equation 2.7 using OLS.

In the estimations performed p was chosen to be 30, an arbitrarily large number. The function of exogenous variables G_t has two main sets of terms (apart from the constant κ), policy signals (and their lags) A_t, and intra-day seasonal terms S_t,

$$G_t = \kappa + S_t + A_t \qquad 2.8$$

The policy signals, and their lags, included in the models are described in Appendix 2.B. Intra-day seasonality was modelled using a set of deterministic trigonometric components (as in Payne, 1996), with some additional dummies to account for specific spikes in volatility that the smooth seasonal cannot cope with, and accounting for the daylight savings time problem.[47] The daylight savings time problem implies that there are 3 different sets of seasonal terms, according to the period of the year:[48] S^W during Winter time, S^S during Summer time and S^P during the (pooled) transition periods, such that

[47] The time stamp on Reuters' quotes and news data is expressed in terms of GMT. The volatility patterns are associated with the trading activity in the main financial centres. Daylight savings time changes will change the local time relative to GMT, and thus the intra-day volatility pattern in reference to GMT. This implies that estimation of the seasonal pattern must accommodate different patterns for different periods of the year.

[48] Daylight savings time changes occurred in Germany (and other European countries) in the last weekend of March and September. In the US, changes occurred in the first weekend of April and last weekend of October. (Japan did not have daylight savings time changes.) These changes define 4 different seasonal patterns according to the possible combinations of local time relative to GMT in US and Europe: between the last weekends of October and March, both the US and Europe are on Winter time; from the first weekend in April, to the last weekend in September, both the US and Europe are in Summer time; between the last weekends of September and October, the US is still in Summer time, but Europe is already in Winter time; and in the week before the first weekend in April, the US is still in Winter time but Europe is already in Summer time. Given that the transition periods only last for 5 weeks (1+4), they were pooled, and only one set of seasonal parameters was estimated for the two periods.

$$S_t = S^W{}_t + S^S{}_t + S^P{}_t \qquad 2.9$$

The basic structure of these sets of seasonal terms is similar. For example, S^W is of the form

$$S_t^W = \sum_{l=1}^{\lambda}\left(\gamma_l \cos\frac{2l\pi}{288}n_t^W + \gamma_l^* \sin\frac{2l\pi}{288}n_t^W\right) + \sum_{i=1}^{m}\delta_i D_{it}^W \qquad 2.10$$

where $n^W{}_t$ takes the value (from 1 to 288) of the corresponding number of the intra-day 5 minute interval, if t is between the last weekend of October and the last weekend of March, and takes the value 0 if t corresponds to a different period in the year. After experimenting different values for λ (between 4 and 12), λ was chosen to be 6, since this number of parameters provided an estimated seasonal that fitted reasonable well the sample average volatility. Two sets of dummy variables were considered, the first one accounting for a spike in volatility at the opening of the Tokyo market (intervals 1 and 2), and the other corresponding to the 15 minutes after the time of the announcement of the majority of the US macroeconomic data, 8:30 EST (intervals 163 to 165 in Winter and 151 to 153 in the other periods).[49]

2.3.2 Empirical results for the whole sample

Initially, the time series model was estimated using all observations for each of the policy signals described in Appendix 2.B: for the Fed, the open market operations (*Fedom*), and the official statements either at the end of the FOMC meeting (*Fedmb* and *Fedma*, depending on whether it was before or after January 1994) or in other occasions (*Fedst*); and for the Bundesbank, the statements at the end of the council meetings (*Bbmeet*), and the announcement of the repo tender terms (*Bbtues*) and results (*Bbwedn*). Table 2.13 presents the results of the estimation of the model using leads and lags covering the period from 15m before up to 30m after the policy signal. The evidence suggests that policy signals have a significant impact in exchange rate volatility, since for most of the

[49] See Payne (1996) for an analysis of the effects of US macroeconomic announcements on DEM/USD volatility.

policy signals the coefficients for all lags are jointly significant.

The expected immediate effect of a policy signal is an increase in volatility. Market agents will use the information incorporated in the signal to update their beliefs, and consequently their desired portfolio positions. The subsequent trading necessary to achieve the desired portfolio positions will induce an increase in volatility. The evidence in Table 2.13 is consistent with this hypothesis. The sum of the coefficients across all lags is positive for all policy signals (except *Fedmb*) and significantly different from zero in most of them. The total increase in volatility, as measured by the long term multiplier of the policy signal variable, is quite large, compared to the average level of volatility in days without policy signals. For instance, for *Fedma* the total increase in volatility is 0.402, a figure 176 times larger than the normal level of volatility at the comparable time of day. Corresponding figures for *Bbmeet* are 0.115 and 75.

Table 2.13 **Effect of policy signals on DEM/USD volatility**

Policy Signal	FED				BUNDESBANK		
Lag	*Fedst*	*Fedmb*	*Fedma*	*Fedom*	*Bbmeet*	*Bbtues*	*Bbwedn*
t-15m	-0.00642	-0.00065	0.02403	-0.00140	0.00040	0.00080	-0.00072
	-2.41	*-1.08*	*1.06*	*-0.97*	*0.39*	*1.30*	*-2.26*
t-10m	-0.00444	-0.00088	0.00836	0.00037	0.00387	0.00054	-0.00015
	-1.96	*-3.70*	*0.87*	*0.18*	*1.87*	*1.06*	*-0.28*
t-5m	-0.00593	-0.00093	0.00540	0.00896	0.00269	0.00256	0.00131
	-2.32	*-3.11*	*0.84*	*1.40*	*2.11*	*1.12*	*0.96*
t	**0.02824**	**0.00189**	**0.01335**	**0.00032**	**0.02481**	**-0.00001**	**0.00067**
	1.13	***0.62***	***1.45***	***0.15***	***2.02***	***-0.03***	***1.10***
t+5m	0.02139	-0.00048	0.04023	-0.00111	0.01319	-0.00011	-0.00026
	4.12	*-0.72*	*1.51*	*-1.03*	*3.31*	*-0.23*	*-0.48*
t+10m	-0.00504	-0.00084	0.01654	0.00403	0.00509	-0.00053	0.00021
	-1.42	*-2.81*	*1.40*	*0.86*	*2.17*	*-1.58*	*0.47*
t+15m	-0.00527	0.00081	0.06071	0.01441	0.00460	-0.00040	0.00029
	-2.41	*0.71*	*1.57*	*1.51*	*1.92*	*-1.19*	*0.46*
t+20m	-0.00524	-0.00029	0.02237	0.00189	0.00517	0.00060	-0.00068
	-3.85	*-0.71*	*1.11*	*0.46*	*1.65*	*1.01*	*-2.45*
t+25m	0.04688	-0.00147	-0.00296	0.00028	0.00058	0.00009	0.00095
	1.46	*-2.33*	*-0.95*	*0.16*	*0.72*	*0.23*	*0.67*
t+30m	0.00886	-0.00093	0.03217	-0.00262	0.00255	0.00080	0.00072
	1.96	*-3.36*	*1.10*	*-4.66*	*1.31*	*1.47*	*0.75*
χ (10)	61.5	44.2	14.9	29.4	33.4	11.1	15.1
Sum of all lags	0.07303	-0.00378	0.22021	0.02512	0.06294	0.00432	0.00235
	1.75	*-1.06*	*3.33*	*1.83*	*4.36*	*1.60*	*0.89*
Total effect	0.13167	-0.00690	0.40228	0.04596	0.11550	0.00799	0.00423

Table 2.13 (continued)

Autoregressive terms								
1-7		0.04114	0.02396	0.01534	0.01401	0.01587	0.01064	0.01057
		1.46	*1.44*	*1.44*	*1.44*	*1.52*	*1.36*	*1.52*
8-14		0.01086	0.01136	0.00906	0.00801	0.00687	0.00735	0.00727
		3.40	*2.41*	*2.92*	*1.31*	*1.52*	*1.74*	*1.48*
15-21		0.00484	0.00649	0.00674	0.01027	0.00479	0.00406	0.00582
		1.30	*1.32*	*1.34*	*3.16*	*1.22*	*1.22*	*1.23*
22-28		0.00505	0.00468	0.00423	0.00482	0.00343	0.00429	0.00919
		1.29	*1.24*	*1.25*	*1.44*	*1.44*	*1.39*	*1.94*
29-30		0.00648	0.00728				**Constant**	0.00136
		1.35	*1.27*					*21.00*
Seasonal terms								
Trig terms			1	2	3	4	5	6
Winter	cos		-0.00083	-0.00023	0.00062	-0.00007	0.00023	0.00000
			-11.51	*-5.56*	*9.15*	*-0.80*	*3.10*	*0.00*
	sin		-0.00060	0.00064	-0.00004	0.00014	-0.00005	-0.00003
			-7.82	*7.10*	*-0.56*	*3.00*	*-0.79*	*-0.42*
Summer	cos		-0.00088	-0.00004	0.00045	-0.00016	0.00009	-0.00008
			-10.74	*-1.20*	*6.61*	*-1.76*	*1.19*	*-2.14*
	sin		-0.00036	0.00056	-0.00045	0.00035	0.00006	0.00005
			-5.28	*5.78*	*-5.93*	*8.67*	*0.92*	*0.55*
Transition	cos		-0.00101	-0.00009	0.00076	-0.00021	-0.00008	-0.00011
			-7.95	*-1.24*	*6.06*	*-1.30*	*-0.61*	*-1.39*
	sin		-0.00058	0.00072	-0.00042	0.00033	0.00019	0.00009
			-4.46	*4.50*	*-3.28*	*3.83*	*1.62*	*0.54*
Dummies				*Tokyo*		*US macro announcements*		
Winter				0.00070	0.00117	0.00478	0.00987	0.00307
				1.56	*2.06*	*2.75*	*3.32*	*1.25*
Summer				0.00086	0.00117	0.00762	0.01136	0.00274
				2.69	*3.43*	*3.10*	*2.69*	*2.58*
Transition				0.00040	0.00017	0.01552	0.00453	0.00211
				1.22	*0.50*	*1.05*	*1.51*	*1.02*

Notes: The table presents the estimated coefficients for the time series model of volatility, using 30 autoregressive terms, and for the seasonal, λ=6 and dummies for the Tokyo opening and US macro announcements. Values in italics are asymptotic t-statistics. $\chi(10)$ are Wald statistics for the null hypothesis that the coefficients for all the 10 lags are zero. The critical values for this test are 18.3 (16.0) at the 5% (10%) level. The 'total effect' corresponds to the long term multiplier of the policy signal, given by the sum of the coefficients for all lags divided by 1 minus the sum of all autoregressive terms.

The estimated reaction of the exchange rate suggests that for the foreign exchange market the relevant policy signals are *Bbmeet* for the Bundesbank and *Fedma* for the Fed. For these signals, the sum of the coefficients across all lags is significantly positive at the 1% level. Other policy signals from the Fed (*Fedst* and *Fedom*) also have a significantly positive impact on volatility, at the 5% level. The results for the Bundesbank's signals are consistent with the evidence in section 2.2, where it was found that the Lombard rate was the key German interest rate. Exchange rate volatility was affected by those signals revealing information related to the fortnightly council meetings (*Bbmeet*), when decisions regarding the Lombard rate were taken, but did not seem to be affected by signals regarding the Repo rate (*Bbtues* and *Bbwedn*). Again, this is not consistent with the official rhetoric of the Bundesbank (Deutsche Bundesbank, 1994) that stresses that the Repo rate is the key rate in German monetary policy (see discussion in Section 2.2). The results for the Fed highlight the differences in the announcement policy before and after February 1994 described in subsection 2.1.2. The statements issued at the end of the FOMC meetings before that date (*Fedmb*) do not cause a significant increase in volatility; if anything, they reduce it, although this effect is not significantly different from zero. On the contrary, those statements after February 1994 (*Fedma*) cause large increases in volatility. Before that date, it was the Fed's open market operations (*Fedom*) that provided the markets with the relevant monetary policy information, judging from the exchange rate reaction.

One common feature of the policy signals that have the largest impacts on volatility is the fact that they refer to official statements of the central banks, not to open market operations. The market-based signals (*Fedom* and *Bbwed*) have a much lower impact on volatility, as may be seen in Figure 2.4. The most interesting result refers to the differences between *Fedom* and *Fedma*. These two policy signals convey to the market information about the same interest rate, the Fed Funds target. In 1992 and 1993 the Fed used open market operations (*Fedom*) to signal changes in that target, but in February 1994 adopted the practice of making official statements (*Fedma*) to announce those changes. Given that these two variables convey the same type of information, the reaction of the exchange rate should be similar, but this is not what was found. The impact on volatility of *Fedma* is 9 times larger than the impact of *Fedom*. This result suggests that different announcement procedures will have different implications for foreign exchange market instability. An official statement captures the attention of market agents more effectively than a market operation. The clearer official statement forces all market participants to immediately update their beliefs, and immediately trade on the new beliefs; whilst the market operation is only slowly revealed to the market, and thus the updating process is more gradual, causing a much smaller increase in volatility.

Figure 2.4 may also be used to analyse the impact on volatility across time, for each policy signal. The largest effects are immediate; for most of the signals, the largest coefficients are for lags *t* to *t+15m*. These coefficients tend to be individually significantly different from zero, and are big relative to the normal volatility levels. For instance, for *Fedma* the volatility response at lag *t+15m* is 28 times the normal level of volatility at the comparable time of day. The volatility response to *Bbmeet* at lag *t* is 15 times the normal level of volatility. However, the significance of the coefficients disappears in 20 minutes, at most. Although the autoregressive structure of the model implies that the increase in volatility is rather 'long lived' (in an high frequency setting), after 20 minutes the size of these effects is small. For the two variables above (*Fedma* and *Bbmeet*), after 1 hour volatility is only 110% and 40% higher than normal, respectively.

The variables *Fedst*, *Fedmb* and *Bbmeet* have significant coefficients on the period before the actual signal is released. However, for *Fedst* and *Fedmb* these coefficients are negative, while for *Bbmeet* they are positive. Negative coefficients suggest that the agents stop trading while waiting for the policy signal to be released. Although neither of the two signals is scheduled, it is possible that a few minutes beforehand the market may know that the Fed is going to issue a statement, and agents might not want to trade before they know the outcome of the statement. A different reaction is found for *Bbmeet*, with volatility increasing before the actual announcement time. This result suggests that some market agents may have faster access to the information from the Bundesbank, and start trading on it before Reuters' actually reports it. However, the relatively small size of the coefficients suggest that this is not widespread.

2.3.3 Differences in the impact on volatility across sub sets of policy signals

In this subsection, differences in the effect on volatility across sub samples are explored. The first division of the sample is between signals whose contents had been anticipated by the market (expected signals) and those that do not conform with the market expectations (unexpected signals). The second division is between signals that reveal that the central bank has acted to change some interest rate (action signals), and signals that reveal that interest rates are kept unchanged (inaction signals).

Expected and unexpected signals

Table 2.14 presents the results of the estimation of the time series model, dividing the policy signals between expected and unexpected. Expected signals were defined as those with news equal to zero. The evidence suggests that most of the impact of policy signals on volatility originates in the unexpected signals. All the unexpected policy signals have coefficients that are jointly significant, while for the expected signals this only occurs for *Fedom* and *Fedmt*.[50] The long term effect of unexpected signals is significantly positive (except for *Bbtues*), but significant increases in volatility caused by expected signals can only be found for *Bbmeet*. Even in this case, the impact on volatility of the expected signals is 7 times smaller than the impact of unexpected signals. The differences in the reaction of the exchange rate to these two classes of signals are evident when one compares Figures 2.5 and 2.6. The effects of expected signals in Figure 2.6 are dwarfed by the effects of unexpected signals in Figure 2.5.

If the excess volatility associated with policy signals is caused by agents trading on revised beliefs, then the impact on volatility of unexpected signals should be higher than that of expected signals. Unexpected signals will induce the market as a whole to revise their beliefs, and the associated trading could lead to large increases in volatility. As long as there is some heterogeneity in beliefs, even expected signals will induce some agents to revise their beliefs (those whose expectations differed from the market's), but the impact of those agents trading should be smaller than for the unexpected signals. The positive but small values for the sum of the coefficients for the expected signals support this view.

Isolating the policy signals that are responsible for the bulk of the increase in volatility allows for a more precise characterisation of this effect. When one considers only the unexpected policy signals, three major differences arise relative to the results of the

[50] Due to the small number of observations involved, the 3 types of signals consisting of official statements by the Fed (*Fedmb*, *Fedma* and *Fedst*) were aggregated in one single variable, *Fedmt*.

Table 2.14 **Impact on volatility of expected and unexpected signals**

Policy Signal	FED		BUNDESBANK		
Lag	*Fedmt*	*Fedom*	*Bbmeet*	*Bbtues*	*Bbwedn*
Unexpected					
t-15m	0.03011	-0.00365	0.00218	-0.00102	0.00003
	1.00	*-1.62*	*0.62*	*-2.82*	*0.04*
t-10m	0.01058	-0.00471	0.00330	0.00273	0.00454
	0.83	*-3.90*	*1.50*	*0.91*	*1.25*
t-5m	0.00493	0.03559	0.00416	0.00023	0.01186
	0.56	*1.72*	*1.65*	*0.19*	*1.07*
t	**0.01346**	**0.00130**	**0.07908**	**-0.00051**	**0.00239**
	1.33	***0.25***	***1.91***	***-0.52***	***0.88***
t+5m	0.06191	0.00283	0.03376	-0.00156	-0.00179
	1.94	*1.01*	*3.49*	*-4.10*	*-3.32*
t+10m	-0.00542	0.01687	0.01377	0.00108	0.00350
	-2.25	*1.00*	*1.94*	*0.74*	*1.11*
t+15m	0.07255	0.05485	0.01388	-0.00040	0.00026
	1.44	*1.75*	*1.88*	*-0.62*	*0.21*
t+20m	0.02756	0.00974	0.00590	0.00368	-0.00094
	1.04	*0.63*	*1.57*	*0.96*	*-1.93*
t+25m	0.01197	0.00557	0.00227	0.00004	-0.00024
	0.79	*0.90*	*0.96*	*0.11*	*-0.29*
t+30m	0.04435	-0.00362	0.00883	-0.00020	0.00326
	1.17	*-2.11*	*1.38*	*-0.28*	*0.81*
χ (10)	18.7	33.7	31.5	27.2	19.9
Sum of all lags	0.27199	0.11476	0.16712	0.00407	0.02287
	3.20	*2.54*	*3.71*	*0.74*	*1.73*
Total effect	0.49344	0.20820	0.30485	0.00737	0.04196
Expected					
t-15m	-0.00060	-0.00064	-0.00032	0.00096	-0.00080
	-1.16	*-0.37*	*-1.09*	*1.44*	*-2.34*
t-10m	-0.00099	0.00208	0.00406	0.00033	-0.00070
	-4.01	*0.81*	*1.48*	*0.69*	*-2.14*
t-5m	-0.00067	0.00010	0.00210	0.00278	0.00005
	-2.20	*0.05*	*1.44*	*1.11*	*0.08*
t	**0.00562**	**0.00001**	**0.00392**	**0.00004**	**0.00047**
	1.26	***0.01***	***1.71***	***0.08***	***0.81***
t+5m	-0.00074	-0.00241	0.00528	0.00003	-0.00005
	-1.28	*-2.78*	*1.52*	*0.05*	*-0.09*
t+10m	0.00705	-0.00024	0.00175	-0.00069	-0.00017
	1.41	*-0.15*	*1.21*	*-2.03*	*-0.55*
t+15m	0.00264	0.00093	0.00105	-0.00040	0.00031
	1.12	*0.49*	*0.73*	*-1.09*	*0.45*
t+20m	-0.00008	-0.00070	0.00489	0.00031	-0.00063
	-0.16	*-0.71*	*1.20*	*0.59*	*-2.08*
t+25m	-0.00129	-0.00146	-0.00006	0.00010	0.00111
	-1.67	*-1.88*	*-0.11*	*0.24*	*0.69*
t+30m	-0.00030	-0.00228	0.00015	0.00091	0.00043
	-0.54	*-5.84*	*0.16*	*1.54*	*0.45*
χ (10)	29.6	44.7	14.3	11.7	15.3
Sum of all lags	0.01064	-0.00460	0.02281	0.00437	0.00003
	1.47	*-0.85*	*3.22*	*1.51*	*0.01*
Total effect	0.01934	-0.00818	0.04164	0.00804	-0.00006

Table 2.14 (continued)

Autoregressive Terms								
1-7		0.04079	0.02366	0.01503	0.01397	0.01583	0.01041	0.01038
		1.45	*1.44*	*1.43*	*1.44*	*1.52*	*1.36*	*1.52*
8-14		0.01082	0.01144	0.00885	0.00803	0.00649	0.00721	0.00747
		3.42	*2.40*	*2.98*	*1.32*	*1.52*	*1.75*	*1.48*
15-21		0.00470	0.00644	0.00672	0.01028	0.00475	0.00405	0.00578
		1.30	*1.32*	*1.34*	*3.16*	*1.22*	*1.22*	*1.23*
22-28		0.00507	0.00467	0.00425	0.00482	0.00342	0.00428	0.00916
		1.29	*1.24*	*1.25*	*1.44*	*1.44*	*1.39*	*1.94*
29-30		0.00652	0.00720				**Constant**	0.00137
		1.35	*1.26*					*21.19*
Seasonal Terms								
Trig terms			*1*	*2*	*3*	*4*	*5*	*6*
Winter	cos		-0.00083	-0.00023	0.00061	-0.00007	0.00023	0.00001
			-11.49	*-5.73*	*9.10*	*-0.78*	*3.13*	*0.20*
	sin		-0.00061	0.00064	-0.00003	0.00014	-0.00004	-0.00004
			-7.93	*7.04*	*-0.47*	*3.02*	*-0.64*	*-0.52*
Summer	cos		-0.00087	-0.00005	0.00045	-0.00015	0.00010	-0.00008
			-10.73	*-1.42*	*6.57*	*-1.70*	*1.22*	*-2.16*
	sin		-0.00036	0.00054	-0.00043	0.00034	0.00007	0.00003
			-5.27	*5.64*	*-5.68*	*8.52*	*1.12*	*0.33*
Transition	cos		-0.00103	-0.00010	0.00077	-0.00017	-0.00006	-0.00014
			-8.11	*-1.36*	*6.14*	*-1.06*	*-0.43*	*-1.80*
	sin		-0.00057	0.00073	-0.00038	0.00032	0.00017	0.00004
			-4.41	*4.53*	*-2.97*	*3.79*	*1.44*	*0.23*
Dummies			*Tokyo*			*US macro announcements*		
Winter			0.00069	0.00116		0.00480	0.00998	0.00327
			1.55	*2.05*		*2.77*	*3.37*	*1.33*
Summer			0.00086	0.00117		0.00760	0.01142	0.00279
			2.68	*3.43*		*3.09*	*2.70*	*2.63*
Transition			0.00039	0.00017		0.01556	0.00451	0.00220
			1.19	*0.50*		*1.05*	*1.50*	*1.06*

Notes: See Table 2.13.

previous section. First, the signals regarding the Bundesbank's Repo rate (*Bbwedn*) now have a significant positive impact on volatility, although this is still quantitatively small. This suggests that the foreign exchange market did not ignore the Repo rate, although its importance was marginal relative to the Lombard rate. Second, the increase in volatility is even larger than previously estimated (as one would expect given that the expected signals only add noise to the estimation), with *Fedmt* and *Bbmeet* causing increases of 220 and 108 times the normal volatility levels, respectively. Finally, although the differences between the effects of the Fed's market operations (*Fedom*) and statement

(*Fedmt*) signals are less pronounced than in the previous section,[51] there is still a clearly larger impact of the latter.

Interest rate changes and no changes

Similar results arise when the sample is divided between action signals (those reporting interest rate changes) and inaction signals (those reflecting unchanged rates), as reported in Table 2.15. Action signals have a much higher impact on volatility than inaction signals, as may be distinctly observed in Figure 2.7, and this impact for the inaction signals is only significant for *Bbmeet*. The reason why the effect in volatility of action signals might be higher than the effect of inaction signals is that the action of changing interest rates may provide a better focal point for the updating of beliefs than the absence of action. The interest rate change is the confirmation of an action that was not certain, even if it was expected. If expectations were heterogeneous, there would be some traders with expectations different than the average and for those the action causes a revision of their beliefs, and thus a change in their optimum portfolio. They will then trade to achieve this new optimum portfolio, and this trading generates volatility. With no interest rate change, there is still the possibility that it will be changed in the next opportunity. This renders the convergence of beliefs only partial, and thus the revision of portfolios will also be only partial, requiring a smaller amount of trading, and thus lower volatility.

Note that there is a strong correlation between unexpected signals and interest rate changes, so the differences in Table 2.15 could be a consequence of the differences between expected and unexpected signals and not caused by different reactions of the exchange rate to action or inaction by the central bank. The model can not be estimated using a classification of the policy signals according to both criteria simultaneously, because this would produce too few observations in two categories, 'unexpected inac-

[51] Note that the results are not directly comparable, since the definition of the variables is different in the two tables. In Table 2.13 the observations corresponding to *Fedmt* were divided into three variables, *Fedst*, *Fedma* and *Fedmb*.

Table 2.15 **Impact on volatility of interest rate changes and no changes**

POLICY SIGNAL	FED		BUNDESBANK		
Lag	*Fedmt*	*Fedom*	*Bbmeet*	*Bbtues*	*Bbwedn*
Rate change					
t-15m	0.02552	-0.00219	0.00482	0.00079	-0.00071
	0.98	*-2.00*	*0.77*	*1.29*	*-2.24*
t-10m	0.00882	-0.00506	0.00515	0.00053	-0.00014
	0.80	*-2.99*	*1.34*	*1.05*	*-0.27*
t-5m	0.00423	0.03725	0.00688	0.00256	0.00132
	0.56	*1.27*	*1.60*	*1.12*	*0.97*
t	**0.01250**	**0.00487**	**0.09813**	**-0.00001**	**0.00068**
	1.44	***0.64***	***1.46***	***-0.03***	***1.12***
t+5m	0.05250	0.00038	0.04300	-0.00011	-0.00024
	1.83	*0.11*	*2.69*	*-0.22*	*-0.46*
t+10m	0.00774	-0.00288	0.02305	-0.00053	0.00023
	0.68	*-2.01*	*1.99*	*-1.58*	*0.50*
t+15m	0.06188	0.01121	0.02579	-0.00040	0.00031
	1.40	*1.08*	*2.11*	*-1.18*	*0.48*
t+20m	0.02316	0.02454	0.01039	0.00060	-0.00066
	1.00	*1.12*	*1.64*	*1.01*	*-2.40*
t+25m	0.01108	0.00705	0.00019	0.00010	0.00096
	0.85	*1.01*	*0.06*	*0.24*	*0.67*
t+30m	0.03923	-0.00479	0.00534	0.00081	0.00073
	1.20	*-2.32*	*1.30*	*1.49*	*0.76*
χ (10)	12.8	27.6	25.9	11.1	14.9
Sum of all lags	0.24666	0.07039	0.22274	0.00434	0.00246
	3.28	*1.77*	*3.07*	*1.61*	*0.93*
Total effect	0.44786	0.12807	0.40697	0.00797	0.00443
No rate change					
t-15m	-0.00051	-0.00126	-0.00044		
	-0.97	*-0.75*	*-1.70*		
t-10m	-0.00094	0.00133	0.00360		
	-3.70	*0.57*	*1.54*		
t-5m	-0.00069	0.00397	0.00190		
	-2.16	*0.88*	*1.51*		
t	**0.00557**	**-0.00048**	**0.01157**		
	1.19	***-0.22***	***1.75***		
t+5m	-0.00055	-0.00137	0.00780		
	-0.92	*-1.25*	*2.42*		
t+10m	0.00287	0.00524	0.00184		
	0.82	*0.96*	*1.32*		
t+15m	0.00290	0.01497	0.00078		
	1.18	*1.35*	*0.63*		
t+20m	0.00010	-0.00210	0.00422		
	0.19	*-1.53*	*1.21*		
t+25m	-0.00164	-0.00091	0.00064		
	-2.92	*-0.59*	*0.87*		
t+30m	-0.00076	-0.00224	0.00205		
	-2.10	*-4.98*	*0.95*		
χ (10)	32.1	33.6	22.1		
Sum of all lags	0.00635	0.01716	0.03396		
	0.98	*1.24*	*3.72*		
Total effect	0.01159	0.03127	0.06199		

Table 2.15 (continued)

Autoregressive Terms								
1-7		0.04072	0.02363	0.01507	0.01399	0.01586	0.01051	0.01051
		1.45	*1.44*	*1.44*	*1.44*	*1.52*	*1.36*	*1.52*
8-14		0.01084	0.01146	0.00891	0.00797	0.00655	0.00722	0.00745
		3.41	*2.40*	*2.96*	*1.31*	*1.52*	*1.75*	*1.48*
15-21		0.00472	0.00642	0.00670	0.01027	0.00476	0.00406	0.00581
		1.30	*1.32*	*1.34*	*3.16*	*1.22*	*1.22*	*1.23*
22-28		0.00508	0.00470	0.00426	0.00484	0.00341	0.00431	0.00919
		1.29	*1.24*	*1.25*	*1.44*	*1.44*	*1.39*	*1.94*
29-30		0.00649	0.00719				**Constant**	0.00137
		1.35	*1.26*					*21.19*
Seasonal terms								
Trig terms			*1*	*2*	*3*	*4*	*5*	*6*
Winter	cos		-0.00084	-0.00022	0.00061	-0.00006	0.00022	0.00001
			-11.65	*-5.48*	*9.04*	*-0.68*	*2.99*	*0.27*
	sin		-0.00060	0.00064	-0.00004	0.00014	-0.00005	-0.00004
			-7.86	*7.06*	*-0.50*	*3.01*	*-0.75*	*-0.43*
Summer	cos		-0.00087	-0.00005	0.00045	-0.00016	0.00009	-0.00008
			-10.66	*-1.45*	*6.64*	*-1.75*	*1.19*	*-2.13*
	sin		-0.00036	0.00055	-0.00043	0.00034	0.00007	0.00004
			-5.25	*5.69*	*-5.74*	*8.45*	*1.11*	*0.41*
Transition	cos		-0.00102	-0.00010	0.00075	-0.00019	-0.00008	-0.00012
			-8.06	*-1.39*	*6.01*	*-1.20*	*-0.55*	*-1.53*
	sin		-0.00059	0.00071	-0.00040	0.00032	0.00019	0.00006
			-4.59	*4.44*	*-3.09*	*3.80*	*1.63*	*0.37*
Dummies			*Tokyo*			*US macro announcements*		
Winter			0.00069	0.00117		0.00480	0.00994	0.00321
			1.55	*2.05*		*2.77*	*3.35*	*1.30*
Summer			0.00086	0.00117		0.00753	0.01139	0.00280
			2.67	*3.42*		*3.07*	*2.69*	*2.64*
Transition			0.00041	0.00018		0.01541	0.00438	0.00217
			1.25	*0.55*		*1.04*	*1.45*	*1.05*

Notes: See Table 2.13.

tion' and 'expected action'. Table 2.16 presents the results of an (not very successful) attempt to overcome this problem, by pooling all Fed signals together and analysing only the difference between unexpected action and inaction, just for these *Fed* signals and for *Bbmeet*. Even though these results may be not very robust, since both 'unexpected inaction' categories have less than 10 observations, they suggest that an 'unexpected action' does indeed have a larger impact on volatility than 'unexpected inaction'. For both *Fed* and *Bbmeet*, the total increase in volatility is more than double for the former than for the latter.

Table 2.16 **Impact on volatility of unexpected rate changes and no changes**

POLICY SIGNAL	FED		BUNDESBANK		
Lag			Bbmeet		
Unexpected	Change	No change	Change	No change	
t-15m	0.02556	-0.00411	0.00482	-0.00107	
	0.98	*-1.55*	*0.77*	*-5.65*	
t-10m	0.00754	-0.00317	0.00516	0.00101	
	0.67	*-3.04*	*1.34*	*1.10*	
t-5m	0.01876	0.01906	0.00689	0.00081	
	1.19	*1.24*	*1.60*	*0.65*	
t	0.01393	-0.00254	0.09813	0.05578	
	1.54	*-1.46*	*1.46*	*1.40*	
t+5m	0.05344	0.00291	0.04301	0.02247	
	1.88	*1.16*	*2.69*	*3.41*	
t+10m	-0.00535	0.02232	0.02306	0.00244	
	-2.54	*1.10*	*1.99*	*0.59*	
t+15m	0.06686	0.06040	0.02580	-0.00066	
	1.54	*1.57*	*2.11*	*-0.65*	
t+20m	0.03397	-0.00590	0.01040	0.00042	
	1.42	*-1.52*	*1.65*	*0.25*	
t+25m	0.00996	0.00751	0.00020	0.00478	
	0.76	*1.04*	*0.07*	*1.43*	
t+30m	0.03707	-0.00287	0.00536	0.01306	
	1.12	*-1.56*	*1.31*	*1.00*	
χ (10)	22.9	26.7	25.9	52.3	
Sum of all lags	0.26173	0.09361	0.22282	0.09903	
	3.46	*1.98*	*3.07*	*2.32*	
Total effect	0.47441	0.16926	0.40618	0.18008	
Expected	Fed		Bbmeet	Bbtues	Bbwedn
t-15m	-0.00061		-0.00033	0.00079	-0.00071
	-0.76		*-1.12*	*1.29*	*-2.22*
t-10m	0.00033		0.00405	0.00053	-0.00013
	0.29		*1.48*	*1.05*	*-0.26*
t-5m	-0.00033		0.00209	0.00256	0.00132
	-0.37		*1.43*	*1.12*	*0.97*
t	0.00322		0.00392	-0.00001	0.00068
	1.16		*1.71*	*-0.02*	*1.13*
t+5m	-0.00145		0.00527	-0.00011	-0.00024
	-2.82		*1.52*	*-0.22*	*-0.45*
t+10m	0.00393		0.00175	-0.00053	0.00023
	1.32		*1.20*	*-1.57*	*0.52*
t+15m	0.00191		0.00104	-0.00039	0.00031
	1.21		*0.72*	*-1.17*	*0.49*
t+20m	-0.00034		0.00488	0.00061	-0.00066
	-0.66		*1.20*	*1.02*	*-2.38*
t+25m	-0.00136		-0.00007	0.00010	0.00097
	-2.46		*-0.12*	*0.25*	*0.68*
t+30m	-0.00115		0.00015	0.00081	0.00074
	-2.90		*0.16*	*1.50*	*0.77*
χ (10)	25.1		14.3	11.1	14.8
Sum of all lags	0.00415		0.02274	0.00436	0.00252
	0.86		*3.21*	*1.62*	*0.95*
Total effect	0.00762		0.04145	0.00800	0.00451

Table 2.16 (continued)

Autoregressive Terms								
1-7		0.04067	0.02354	0.01500	0.01396	0.01586	0.01044	0.01036
		1.45	*1.44*	*1.43*	*1.44*	*1.52*	*1.36*	*1.52*
8-14		0.01078	0.01146	0.00891	0.00801	0.00652	0.00715	0.00747
		3.44	*2.40*	*2.96*	*1.32*	*1.52*	*1.75*	*1.48*
15-21		0.00472	0.00645	0.00667	0.01023	0.00476	0.00399	0.00575
		1.30	*1.32*	*1.34*	*3.18*	*1.22*	*1.21*	*1.23*
22-28		0.00509	0.00460	0.00428	0.00481	0.00336	0.00434	0.00907
		1.29	*1.24*	*1.26*	*1.44*	*1.44*	*1.39*	*1.94*
29-30		0.00644	0.00727				**Constant**	0.00137
		1.35	*1.27*					*21.25*
Seasonal terms								
Trig terms			1	2	3	4	5	6
Winter	cos		-0.00084	-0.00023	0.00060	-0.00006	0.00022	0.00002
			-11.61	*-5.68*	*9.05*	*-0.72*	*3.08*	*0.32*
	sin		-0.00061	0.00063	-0.00003	0.00014	-0.00004	-0.00004
			-7.94	*7.01*	*-0.46*	*3.07*	*-0.67*	*-0.49*
Summer	cos		-0.00087	-0.00005	0.00044	-0.00015	0.00010	-0.00009
			-10.65	*-1.43*	*6.50*	*-1.67*	*1.28*	*-2.32*
	sin		-0.00036	0.00054	-0.00043	0.00034	0.00006	0.00003
			-5.23	*5.59*	*-5.66*	*8.63*	*1.03*	*0.33*
Transition	cos		-0.00102	-0.00010	0.00075	-0.00018	-0.00007	-0.00013
			-8.09	*-1.36*	*6.04*	*-1.14*	*-0.48*	*-1.70*
	sin		-0.00059	0.00071	-0.00039	0.00032	0.00018	0.00005
			-4.52	*4.44*	*-3.02*	*3.82*	*1.57*	*0.30*
Dummies			*Tokyo*			*US macro announcements*		
Winter			0.00069	0.00116		0.00481	0.00998	0.00328
			1.54	*2.05*		*2.78*	*3.37*	*1.33*
Summer			0.00086	0.00117		0.00753	0.01139	0.00280
			2.68	*3.43*		*3.07*	*2.69*	*2.63*
Transition			0.00041	0.00018		0.01546	0.00439	0.00218
			1.24	*0.54*		*1.04*	*1.45*	*1.05*

Notes: See Table 2.13.

2.4 Conclusions

The evidence provided in this chapter, based on high frequency data on the DEM/USD exchange rate, suggests that news about monetary policy have a strong impact on exchange rates. Large and significant changes in the exchange rate level and increases in its volatility were found to be associated with some specific information releases regarding US and German monetary policy. From the point of view of the foreign exchange market, the key indicators of the monetary policy stance were the Fed Funds rate for the US and the Lombard rate for Germany. Unexpected 1 percentage point increases in these rates were found to cause a statistically significant appreciation of the domestic currency of around 3% and 1.3%, respectively. Also, exchange rate volatility increased more than 100 times when the central banks released information regarding these key interest rates. Such large high frequency effects create the scope for significant capital gains or losses in holding currency. Changes in expectations about future monetary policy would appear to be one of the main factors (if not the main factor) driving exchange rates, even when no information from the central banks is being released.[52]

The effect of monetary policy news on the DEM/USD varies across time. The same piece of news might have a different impact in the exchange rate at different moments in time, in some cases even implying opposite reactions. One such case was found to be the reaction of the exchange rate to Bundesbank policy news during the ERM crisis, in the Summer of 1993. While in the rest of the sample unexpected increases in the German interest rates caused a DEM appreciation, during that period the effect of the same news was a DEM depreciation, most likely because the USD played the role of a safe haven during these troubled periods.

The exchange rate reaction was also found to differ according to the channel used to release the information to the market. For the Fed, news signalled through open market operations were found to have a smaller immediate impact on the exchange rate level, and were associated with smaller increases in volatility, than news announced through official statements, even though the long run effect in the level of the exchange rate is the same whatever the form used for signalling news. On the other side, the market reaction to Bundesbank's news is much quicker than the reaction to the Fed's news, probably because the signals from the Bundesbank are scheduled and the ones from the Fed are not, and because the Bundesbank relies more on official statements and less on market operations than the Fed. The impact on volatility was also found to be much smaller

[52] This topic is not covered in this chapter, but some evidence supporting this hypothesis is provided in Chapter 3, where it is shown that the effect on the DEM/USD of some German macroeconomic data releases was higher when these releases were likely to influence policy decisions by the Bundesbank.

(and not significant) when the policy signals contained only information that was expected.

If central banks are concerned with high volatility in the foreign exchange market, the results in this chapter suggest two possible solutions to reduce it. The first is to make more use of market operations to reveal information about monetary policy, instead of relying on official statements. However, the recent trend in many central banks (namely the Fed) has been in the other direction, i.e., more use of official statements. These moves are usually justified by the need to increase transparency and accountability in monetary policy. If these principles are thought to be sufficiently important to justify that official statements remain the main channel for monetary policy information revelation, then the central bank may use a second solution to reduce exchange rate volatility. Since expected signals do not increase volatility significantly, this alternative implies providing markets with sufficient information such that the outcome of the monetary policy committees may be widely anticipated by market agents. However, this information has to be sufficiently noisy such that each piece of information does not contain a significant amount of news.

Appendix 2.A: Market Expectations

2.A.1 Sources of the expectations data

FED

Discount (*Discfed*) and Fed *Funds* rate: the market expectation is the median of forecasts from a MMS International survey; the survey is conducted every Friday, and leading practitioners and academics are asked to forecast the Discount and Federal Funds interest rates for the end of the current and next two week reserve maintenance periods; for each Fed signal, the forecast for the end of the current period, made on the previous Friday was used.

BUNDESBANK

Discount (*Discbb*) and Lombard (*Lomb*) rate: the market expectation series were constructed from the information provided in the Financial Times' 'Currencies and Money Markets Report' and 'European stock markets - Frankfurt' sections, on the day of the announcement; the FT's description of market sentiment on the day before each council meeting was taken to be the market expectation; when this description was qualitative, it was transformed into a quantitative expectation according to the following criteria:

- amount of change: when not explicitly stated in the FT, it was assumed to be 25 b.p. (the minimum change observed in the sample period);
- likelihood of rate changes: when the FT report denoted no consensus in the market, the expected rate change was adjusted as follows - if the market was split on the likelihood of change, the expected change was reduced by 50%; if only a few dealers expected change, or if most thought changes were possible but unlikely, the expected change was reduced by 80%.[53]

[53] For example, if the report said 'opinion was divided on whether the Bundesbank will cut rates' it was assumed that the expected cut was of 25 b.p., but since opinion was divided it was reduced by 50%. Thus, the market expectation was taken to be of a cut of 12.5 b.p. on both the Discount and Lombard rates.

Repo terms (fixed/variable-rate) (*Fix*): the market expectation was taken to be the one reported in the Financial Times' 'Currencies and Money Markets Report' and 'European stock markets - Frankfurt' sections, on the day of the announcement (Tuesday or council meeting day).

Repo results (*Repo* rate): median of forecasts, MMS International survey; the survey is usually conducted on the Tuesday before the repo tender, after the tender terms have been announced; thus, this source of data is only relevant when the Wednesday announcement is a policy signal, i.e., for the case of variable-rate tenders. No expectations were available for the fixed rate tenders.

2.A.2 Rationality of the market expectations

Table 2.17 describes some of the properties of the 'news' series. Under rational expectations, the forecast errors (i.e., the 'news') should be uncorrelated and have mean zero, and these properties do not seem to be violated by any of the series used. The mean is smaller than two standard deviations for all series. None of the sample autocorrelations up to four lags are significantly different from zero, either individually or jointly as described by the Ljung-Box Q statistic, thus suggesting that the series are white noise.

Another form of testing the rationality of expectations is by regressing the actual interest rate changes (x_t) on the expectation about those changes (x^e_t),

$$x_t = \alpha + \beta\, x_t^e + \varepsilon_t \qquad 2.11$$

Under rational expectations, there should be no systematic bias, and thus the expected values for the parameters on equation 2.11 are α=0 and β=1. The evidence on Table 2.18 suggests that these restrictions are not violated for the Fed's rates, nor for the Bundesbank's *Discbb* and *Lomb* rates, but casts some doubt on the rationality of the expectations for the *Fix* and *Repo* series. Since in most of the sample period the trend in the *Repo* was downward, it seems that the market was systematically expecting that the Bundesbank would lower the Repo rate more than it actually did. This bias could either

Table 2.17 **Properties of the 'news' series**

	FED		BUNDESBANK			
	Discfed	*Funds*	*Discbb*	*Lomb*	*Fix*	*Repo*
# signals	46	46	72	72	182	80
Mean	0.0163	0.0055	-0.0021	-0.0146	0.0275	0.0036
Std. deviation of mean	0.0197	0.0198	0.0168	0.0157	0.0239	0.0022
Autocorrelations						
1	-0.02	-0.08	-0.02	0.06	0.10	0.00
2	0.15	0.08	-0.19	-0.02	-0.11	0.03
3	-0.01	-0.08	-0.01	0.08	-0.01	0.09
4	0.00	0.08	-0.12	-0.03	-0.01	-0.04
($2 T^{-1/2}$)	0.29	0.29	0.24	0.24	0.15	0.22
Ljung-Box Q-Statistics						
Q(1)	0.01	0.30	0.03	0.30	1.80	0.00
Q(2)	1.07	0.60	2.69	0.35	4.20	0.07
Q(3)	1.08	0.90	2.70	0.79	4.21	0.69
Q(4)	1.08	1.24	3.83	0.86	4.22	0.81

Notes: The statistics in the table were computed using all the policy signals relevant for the variable in question; e.g., for the *Discbb* variable the signals used were all the Bundesbank council meeting signals. ($2 T^{-1/2}$) is an approximation for the critical value for rejecting the null that an individual autocorrelation coefficient is zero. The critical values for the Q statistics at the 5% significance level are 3.8, 6.0, 7.8 and 9.5, for 1 to 4 degrees of freedom, respectively.

be caused by non rationality in the market agents' expectations formation process, or by poor quality of the expectations series used, that do not accurately reflect the market's expectation. It is assumed throughout the chapter that the series used is a good measure of market expectations, but nevertheless the robustness of the results based on these series is put into question.

Table 2.18 **Regression of actual on expected interest rate changes**

	Constant	*t: α=0*	*Expected*	*t: β=1*	R^2	*DW*
<u>FED</u>						
Discfed	0.018	0.91	0.821	-0.52	0.39	2.04
Funds	0.006	0.29	0.988	-0.04	0.42	2.15
<u>BUNDESBANK</u>						
Discbb	-0.016	-1.06	0.680	-0.97	0.18	2.16
Lomb	-0.024	-1.46	0.717	-1.29	0.16	2.00
Fix	0.074	<u>3.45</u>	0.744	<u>-3.10</u>	0.47	1.67
Repo	0.005	<u>2.28</u>	1.062	0.66	0.89	1.99

Notes: Underlined entries denote rejection of the null at the 5% significance level.

Further evidence supporting the rationality of the expectations series used may be found on Table 2.19. Under rational expectations the 'news' must be uncorrelated with any available information at the time of the expectations formation, including the expectation itself. The low correlation coefficients between the expectation and the news seem to support that restriction.

Table 2.19 **Correlation coefficients between the actual, expected and 'news' on interest rate changes**

	FED		BUNDESBANK			
Correlations	*Discfed*	*Funds*	*Discbb*	*Lomb*	*Fix*	*Repo*
Expected/news	-0.17	-0.01	-0.20	-0.12	-0.28	0.08
Expected/actual	0.63	0.65	0.48	0.45	0.71	0.95
News/actual	0.66	0.75	0.77	0.83	0.48	0.39

A different question is how well the markets predict central bank actions. The low R^2 in Table 2.18 and the high correlation coefficients between actual changes and news (in Table 2.19), for most of the series, suggest that central banks have regularly deceived the market, at least during the sample period. According to the expectations series used, the market has correctly predicted (i.e., both the timing and the amount) only 1 out of 4 *Discfed* and 2 out of 9 *Funds* changes. The picture is similar for the Bundesbank rate changes, with only 1 out 10 *Discfed* and 1 out of 8 *Lomb* rate changes being correctly predicted. The market seems to be able to better predict the *Repo* rate, since not only the correlation coefficient is higher but also the market had a higher proportion of correct predictions (12 out of 44).

Appendix 2.B: Data

Exchange Rate Quotes

The exchange rate data were originally received as an irregularly spaced, continuous-time set of DEM/USD quotations with time stamps, published on the screens of Reuters' information system, for the period 1/1/92 to 31/12/94. The properties and limitations of this type of data are described in Goodhart (1989a), Müller *et al.* (1990) and Goodhart and O'Hara (1997). The data were then converted to an equally spaced, calendar time-series by imposing each five minute observation grid, taking the last quotation in a five minute period as effective. Weekends, defined as the period from 21:00 on Friday to 21:00 on Sunday (GMT), were excluded because during that period quote activity is sparse and not significant (see Andersen and Bollerslev, 1997). Finally, the average of bid and ask quotations was taken as the basic quotation variable (q_t).

Policy Signals

The official publications of the two central banks (Deutsche Bundesbank Monthly Report and Federal Reserve Bulletin) provided the basic information on the type of signals and their usual date (and sometimes time). Then, a data set consisting of reports on the Reuters Money Market Headline News screen, with the corresponding date and time stamp, provided by Olsen & Associates, was used to determine the exact date and time of the signal. It was assumed that the time of a policy signal was the time of its announcement on Reuters screens. The policy signals considered in the analysis (see Section 2.1 for details) were, for the Bundesbank:

- *Bbmeet*: the news conference or press release at the end of the council meetings;
- *Bbtues*: the announcement of the repo tender terms;
- *Bbwedn*: the announcement of the repo tender results;

and for the Fed:

- *Fedom*: the daily open market operations, but only when some policy signalling might occur, mainly in the days after FOMC meetings;
- *Fomcb*: the end of FOMC meetings, in 1992 and 1993;
- *Fomca*: statements at the end of FOMC meetings, in 1994;
- *Fedst*: press releases announcing rate changes, not at the end of FOMC meetings.

Table 2.20 provides a brief description of the policy signals, their usual date and time, and the number of observations in the sample. The full data set may be obtained from the author.

Table 2.20 **Monetary policy signals**

POLICY SIGNAL	*Day (usual)*	*Local Time (approx.)*	*# of signals*
BUNDESBANK			
Bbmeet	Alternate Thursdays	Mid day	72
Bbtues	Tuesday	9:00 am	115
Bbwedn	Wednesday	10:00 am	93
FEDERAL RESERVE			
Fedom	Every day *	11:30 am	20
Fomcb	8 times a year	Mid day	16
Fomca	8 times a year	Mid day	8
Fedst	Any		2

* the open market operations considered refer only to the days when some policy signalling might occur, mainly in the days after FOMC meetings.

'News' Events

A 'news' event is a policy signal with a non-zero information content. The 'news' content of policy signal of type i at period t, $x^n_{i,t}$ is given by $x^n_{i,t} = x_{i,t} - x^e_{i,t}$, where $x_{i,t}$ is the actual action and $x^e_{i,t}$ is the measure of the market expectation regarding that action, as described in Appendix 2.A. Almost all the actions are expressed in terms of an interest rate change, the exception being the announcement by the Bundesbank of the repo tender terms, which was defined as a dummy variable taking the value 1 if a fixed-rate repo is announced. Table 2.21 provides summary statistics for the news events included in the sample. The complete set of 'news' events may be obtained from the author. The definition of the variables is:

- *Discfed*: news on the Fed's Discount rate;
- *Funds*: news on the Fed Funds rate;
- *Discbb*: news on the Bundesbank's Discount rate;
- *Lomb*: news on the Bundesbank's Lombard rate;
- *Fix*: news on the repo tender terms announcement; a value of 1 means that a fixed-rate tender was announced when a variable-rate tender was expected; vice-versa

for a value of -1;

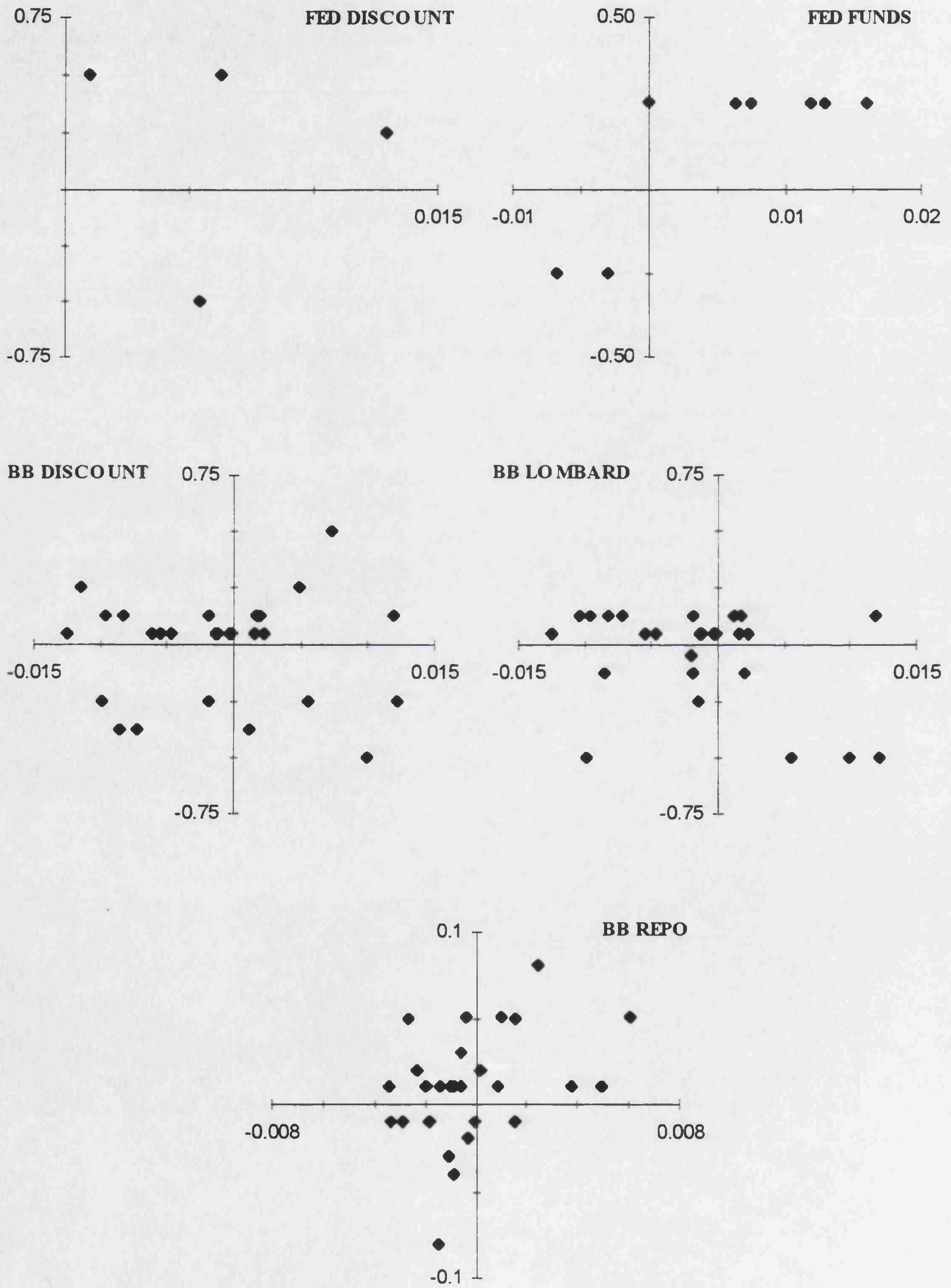
- *Repo*: news on the Repo rate (on *Bbwedn* signals only).

Table 2.21 **'News' events - summary statistics**

	# of news events					*Average absolute*
	Total	*joint*	*Maximum*	*Minimum*	*Average*	*news*
FED						
Discfed	4	2	0.5	-0.5	0.1875	0.43
Funds	10	2	0.25	-0.5	0.0253	0.28
BUNDESBANK						
Discbb	30	25	0.5	-0.5	0.0075	0.19
Lomb	28	25	0.125	-0.5	-0.0375	0.15
Fix	19	7	1	-1	0.2632	1
Repo	29	0	0.08	-0.08	0.0100	0.03

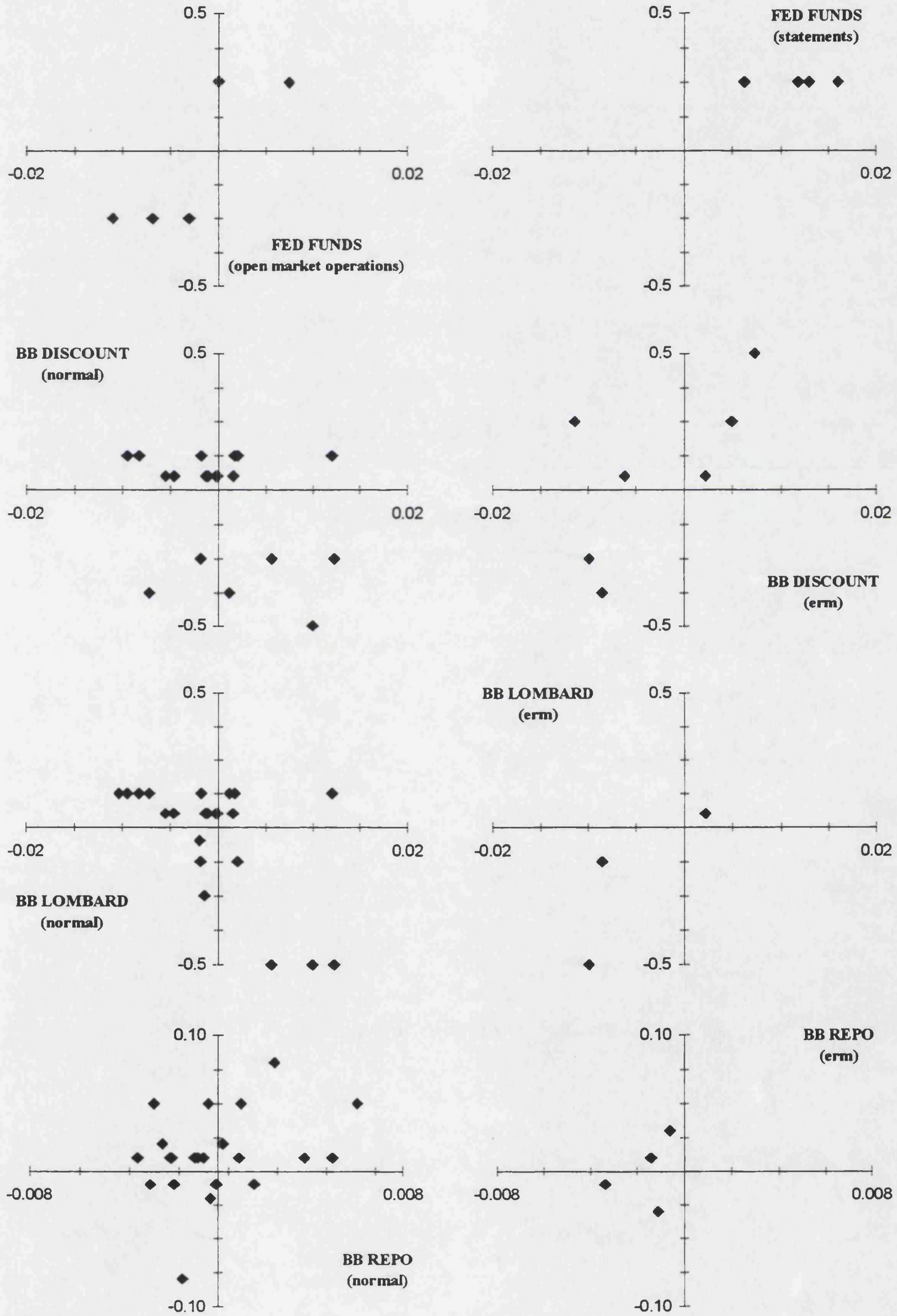
NEWS EVENTS PER TYPE OF POLICY SIGNAL	FED		BUNDESBANK	
	Fedom	4	*Bbmeet*	35
	Fomcb	0	*Bbtues*	10
	Fomca	6	*Bbwedn*	29
	Fedst	2		

Figure 2.1: Plots of interest rate news and 1 h DEM/USD returns (full sample)



Notes: Interest rate news are measured in the vertical axis, in percentage points. The horizontal axis measures exchange rate returns.

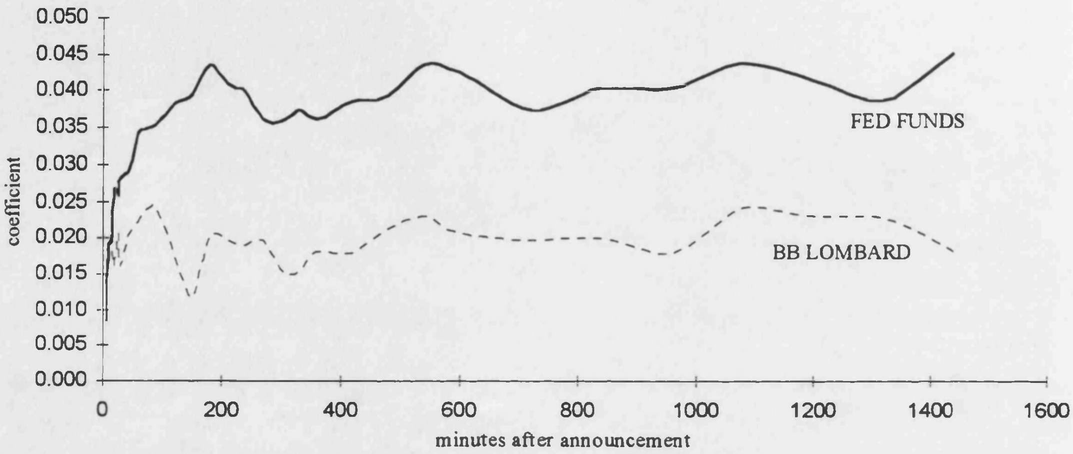
Figure 2.2: Plots of interest rate news and 1 h DEM/USD returns (sub samples)



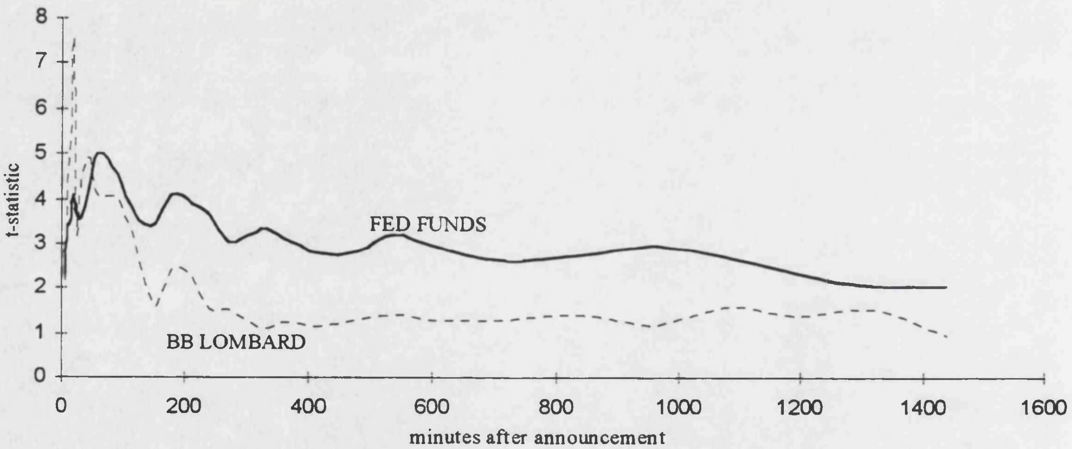
Notes: See Figure 2.1.

Figure 2.3: Time pattern of the exchange rate reaction

Evolution of the size of the coefficient across return periods

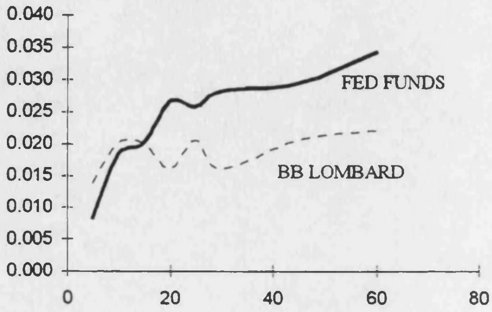


Evolution of the t-statistic across return periods



Detail of the first 60 minutes

Coefficient



T-statistic

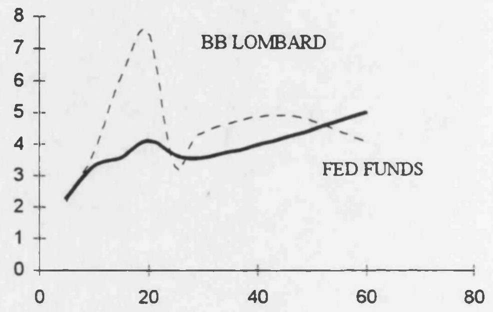
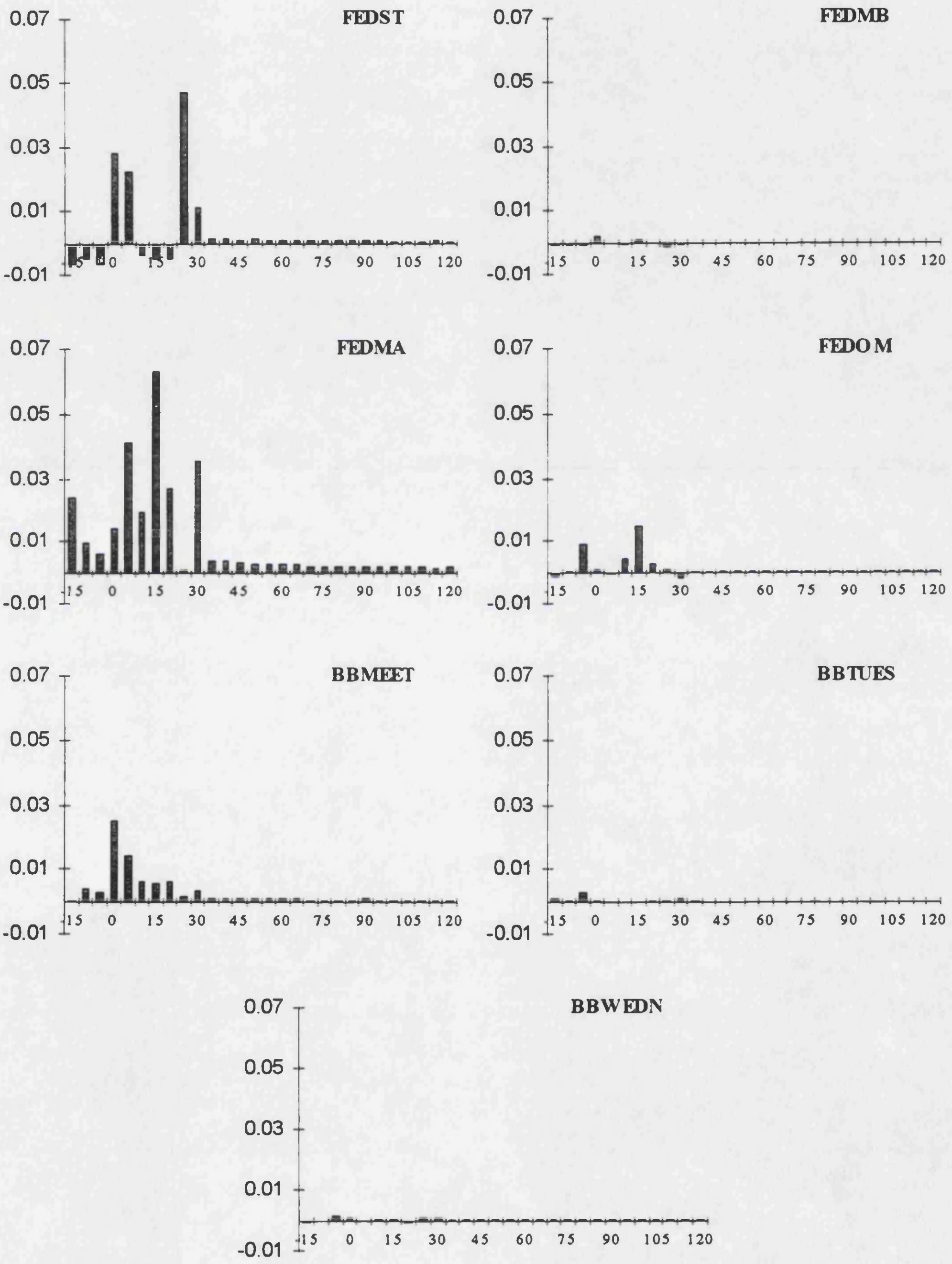
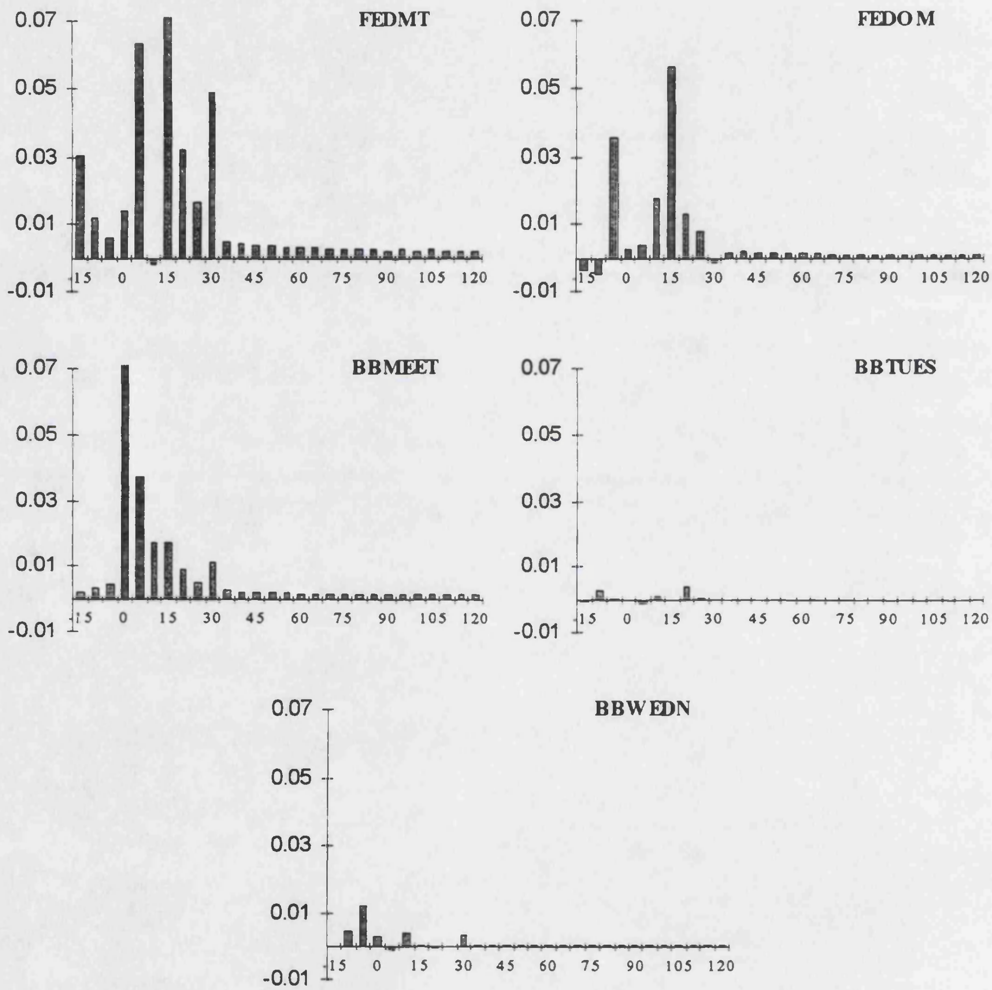


Figure 2.4: Impact of policy signals on volatility across time



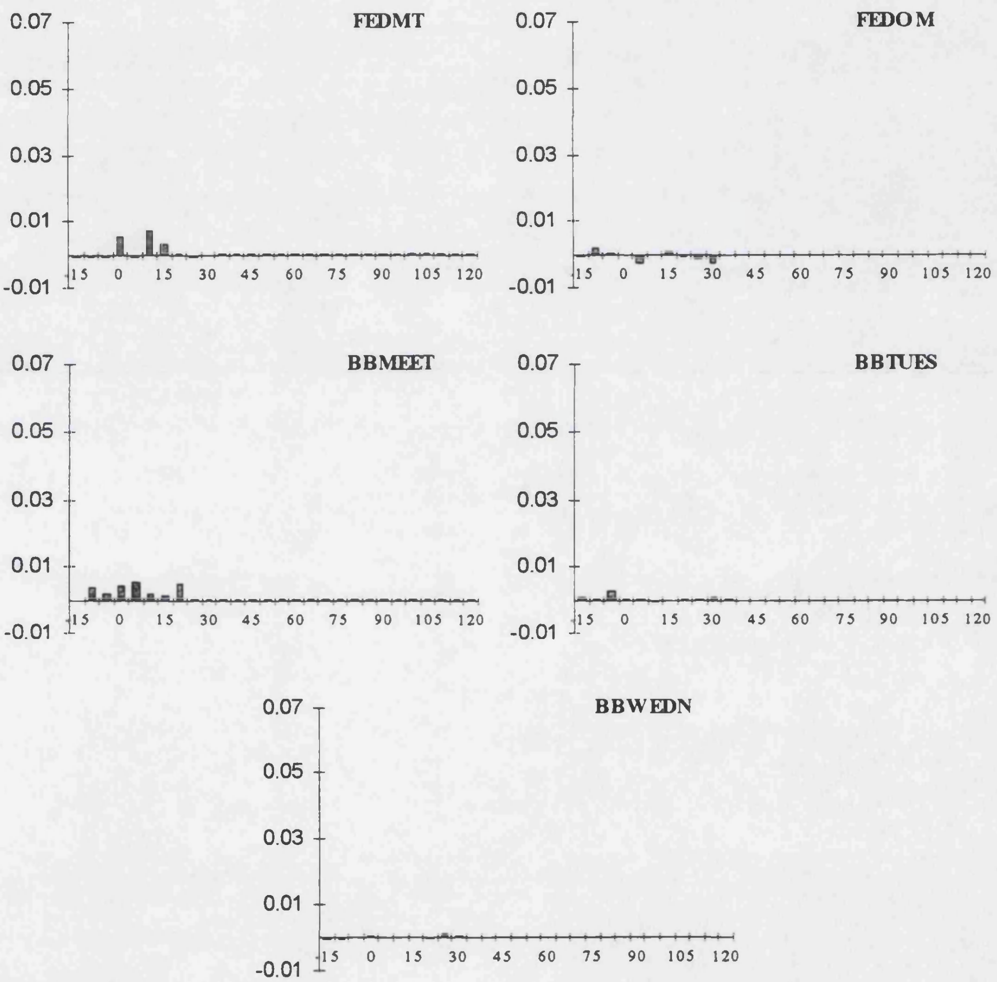
Notes: The horizontal axis measures the time relative to the signal release, in minutes. The vertical axis measures the change in volatility at each interval.

Figure 2.5: Impact of unexpected policy signals on volatility across time



Notes: See Figure 2.4.

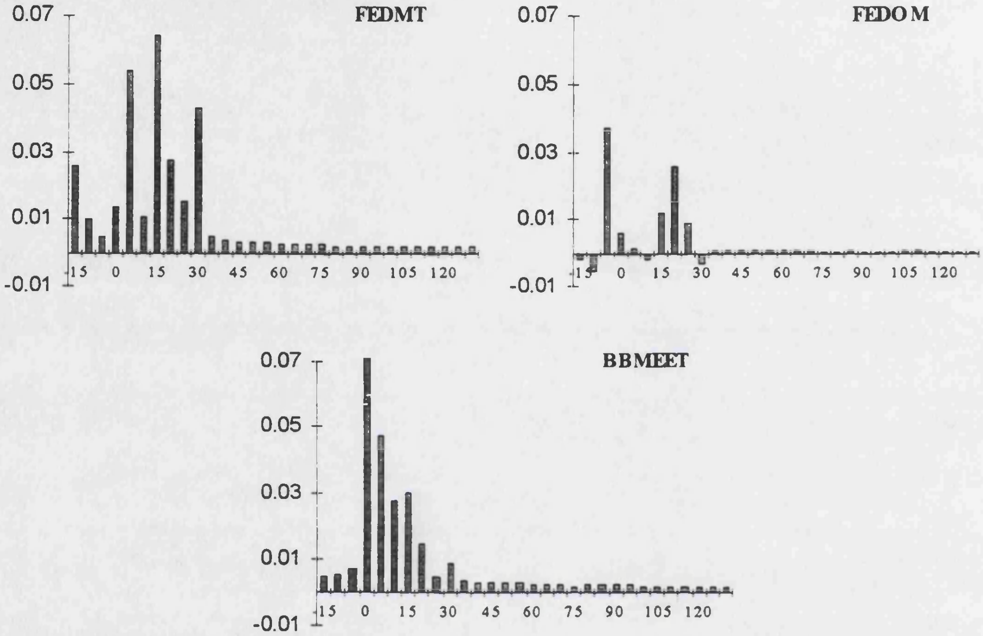
Figure 2.6: Impact of expected policy signals on volatility across time



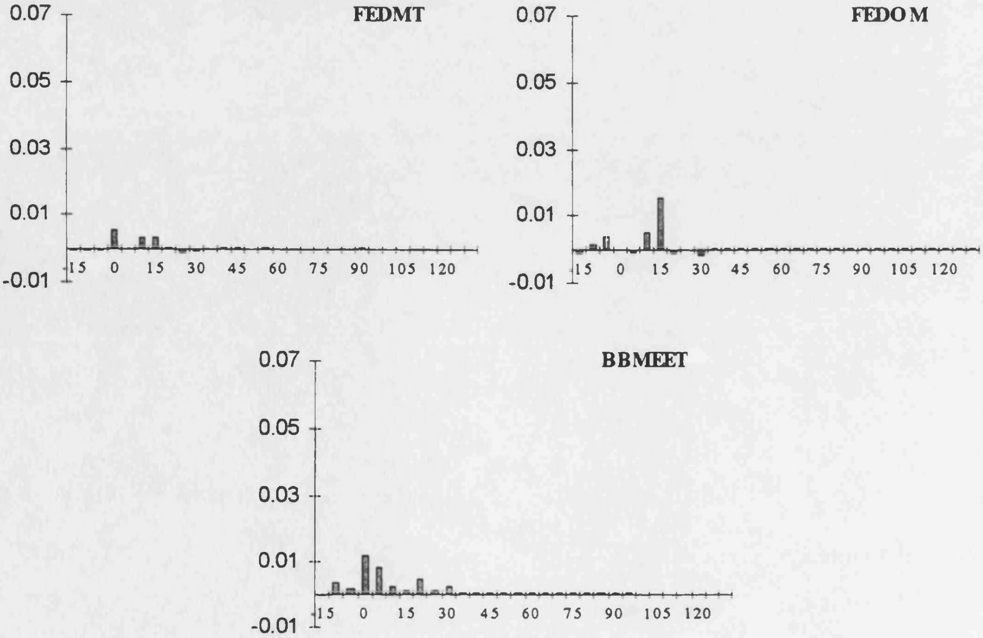
Notes: See Figure 2.4.

Figure 2.7: Impact of action and inaction signals on volatility across time

Action signals



Inaction signals



Notes: See Figure 2.4.

Chapter 3

The Effects of Macroeconomic 'News' on High Frequency Exchange Rate Behaviour

3.1 Introduction

This chapter studies the high-frequency reaction of the DEM/USD exchange rate to macroeconomic information emanating from Germany and the US. Specifically, we utilise exchange rate data covering the period 1/1/92 to 31/12/94, sampled at a five minute frequency, to investigate how the major monthly macroeconomic releases from these two countries impact the DEM/USD. The information contained in announcements over this three year period is extracted via a set of market expectation series supplied by Money Market Services International (MMS). Our analysis improves on previous work in this area in two main respects. First, our study is conducted using very high-frequency data, whereas most earlier work has used exchange rate data sampled at a frequency of a number of hours or more. This allows us to construct a very precise characterisation of the reaction of the exchange rate to macroeconomic information. Second, this is, to our knowledge, the first study which includes German data releases. Most work in this area has focused on US (and to a lesser extent Japanese) macroeconomic announcements.

The major issue under examination is whether one can trace systematic effects of economic 'news' on the evolution of the exchange rate. The direction in which 'news' will move the exchange rate is, however, a priori uncertain. It will depend on the market's belief about both the model of exchange rate determination and the manner in which monetary authorities will respond to new information. Take an unexpected increase in US real activity, for example. A Monetarist model of exchange rate determination would imply that the dollar should appreciate as domestic money demand rises, whilst a Keynesian model would predict the opposite due to increased import demand by US citizens. These two mechanisms do not, however, factor in the possibility of a reaction to 'news' by the US monetary authority. Assuming the Fed to have a preference for low inflation, they should raise short term interest rates in order to cool the inflationary pressures in the economy, implying US dollar appreciation. We label this latter mechanism the 'reaction function' effect. Which of the above mechanisms pertain to the determination of the DEM/USD and which dominates will determine the sign of the exchange rate response to 'news'.[1]

The impact of macroeconomic 'news' on exchange rates has previously been the subject of extensive research, but most of the work has concentrated solely on announcements of US economic data. Research based on several USD exchange rates sampled at a daily frequency (Hardouvelis, 1988, Aggarwal and Schirm, 1992, Harris and Zabka, 1995, Edison, 1997) finds significant positive relationships between dollar appreciation and US M1 and non-farm employment (and in some cases also the merchandise trade balance) news, but no impact from any other macroeconomic news. Other papers utilising spot quotations from the opening and closing of the main regional foreign exchange (FX) markets (these being North America, the Pacific, Tokyo and Europe), reach similar conclusions. Hakkio and Pearce (1985), Ito and Roley (1987), Hogan, Melvin, and Roberts (1991) and Hogan and Melvin (1994) demonstrate that USD exchange rates respond quite rapidly to US money supply and trade balance surprises, but not to other types of US news. Ito and Roley (1987) also find that the JPY/USD does not respond to

[1] See Hoffman and Schlagenhauf (1985) for a more complete treatment of the alternative theories of exchange rate determination and an empirical test of these theories.

macroeconomic news from Japan. Hence, a general result from these studies is that few economic announcements have systematic impacts on exchange rates when rates are sampled at relatively coarse frequencies. We conjecture that other announcements may have discernible impacts on exchange rates when examined in a higher frequency setting, with the disappearance of the effects at lower frequencies due to their being drowned in subsequent exchange rate fluctuations. By examining the impact of US and German news on exchange rate changes measured over different time horizons (from 5 minutes to 12 hours post-announcement), we are able to test this conjecture.[2]

We extend our analysis by also considering a number of other issues. Following Hakkio and Pearce (1985) we examine the efficiency of the intra-day FX market via the traditional equation linking exchange rate changes to anticipated and unanticipated macroeconomic data. We also examine the temporal stability of our results, since most of the previous literature finds that there are significant structural breaks in the response of exchange rates to news (usually associated with shifts in the Fed's policy).

Lastly, the use of German announcement data allows us to address two further interesting questions. This is due to the fact that, unlike US announcements, German releases do not have pre-set and pre-advertised release dates and times. Hence first we can examine how pre-scheduling of announcements affects the impact of 'news' on the DEM/USD by comparing the dynamic responses to US and German data. A hypothesis relevant here is that the response to scheduled announcements is completed more quickly than that associated with a non-scheduled release. Using the German data we can also examine how the proximity of the announcement to other events, specifically the bi-weekly Bundesbank council meeting, affects the reaction of the exchange rate. We hypothesise that announcements which occur closer to Bundesbank council meetings

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[2] Previous research on the reaction of exchange rate volatility to economic announcements (Ederington and Lee, 1993, Payne, 1996, and the study described in Chapter 2 of this thesis) has shown that large increases in volatility are apparent at the times of these announcements, but this lasts only a few minutes. Using high frequency data from the foreign currency futures market, Ederington and Lee (1995) also demonstrate that transaction prices react very swiftly (i.e., within a couple of minutes) to the announcement of US economic data. This evidence suggests that the impact of macroeconomic announcements may be identified best using exchange rate returns over periods of a few minutes.

have a larger exchange rate impact due to the belief that they will carry more weight in Bundesbank policy deliberations.

The structure of the chapter is as follows. Section 3.2 describes our data and methodology. We then turn to a discussion of our empirical findings, first for US news, Section 3.3, and then German news, Section 3.4. We have a Section reporting some comparative results, Section 3.5, and the chapter closes with some concluding remarks in Section 3.6.

3.2 Data and Methodology

3.2.1 The data

Our exchange rate data covers the period 1/1/92-31/12/94. The data were originally received as an irregularly spaced, continuous-time set of DEM/USD quotations, published on the screens of Reuters' information system. We then converted the data to an equally spaced, calendar time-series by imposing a five minute observation grid, taking the last quotation in a five minute period as effective. Finally, the average of bid and ask quotations was taken as our basic quotation variable.

The other portion of our data set consists of US and German macroeconomic announcements covering the same period, plus a market expectation series for each type of announcement obtained from MMS.[3] The US macroeconomic announcements object of our 'news' analysis are the Employment Report, the Trade Report, and the Producer Price Index (PPI), Consumer Price Index (CPI), Retail Sales, Durable Goods Orders, Consumer Confidence, Leading Indicators, the NAPM survey, and the Industrial Pro-

[3] To determine the time of the German announcements, a data set consisting of news headlines published on the screens of Reuters' information systems, with the corresponding date and time stamp, was also used.

duction and Capacity Utilisation announcements. For Germany, the series used are the CPI, Industrial Output, Money (M3), Industrial Orders, PPI, Retail Sales, the Trade Balance, Unemployment rate and the Wholesale Price Index (WPI). Appendix 3.A provides a list of the definitions of these announcements along with their usual release timing and the identifiers assigned to each series. Since all of these announcements are monthly, for each series we have a maximum of 36 observations, although irregularity in some of the releases and missing expectations data reduce the number of available observations in some cases (see Appendix 3.A).

The MMS expectations we employ are calculated as the median from a survey of forecasts made by leading practitioners and academics. The surveys cover between 30 and 40 respondents and are conducted on the Friday immediately preceding each announcement.[4] These data allow us to separate the series relevant to each type of announcement into an unexpected and expected portion. In line with efficient markets theory, only the unexpected part of an announcement should have any impact on the DEM/USD, the expected portion having already been impounded into quotations. The adequacy of the MMS expectations series is an issue which has been examined in previous work. Utilising a simple test of rational expectations our analysis of these data suggested that, overall, the MMS expectations series are unbiased.[5] Some indications of systematic biases in expectations were present but these were relatively scarce. Hence, whilst other authors have cast doubt on the rationality of the MMS expectations series (notably Aggarwal, Mohanty, and Song, 1995) our pre-testing supports the use of these data, in line with the results of Pearce and Roley (1985).

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[4] This implies that there is at most a seven day lag between the survey and corresponding announcement. Note that this is true for both the scheduled US announcements and the unscheduled German releases.

[5] In order to save space the tests of rational expectations are omitted. The testing methodology was, in most cases, a simple regression of forecasts on realised values. For those series where the forecasts and announced data proved to be I(1), a cointegrating representation was estimated via the Engle-Granger two-step procedure. Results are available from the authors upon request.

3.2.2 Methodology

Define q_t to be our 5 minute quotation series for the DEM/USD. Define $x_{i,t}$ to be the actual announced value for series i at moment t, $x^e_{i,t}$ to be the correspondent expected value from the MMS data, and $x^n_{i,t} = x_{i,t} - x^e_{i,t}$ the unexpected part of the announcement. The basic equation which underlies most of our empirical analysis, equation 3.1, is derived from the REEM (rational expectations efficient markets hypothesis),

$$R_{i,t+k} = \beta x^n_{i,t} + \varepsilon_{i,t} \qquad 3.1$$

where $R_{i,t+k}$ is defined as $q_{t+k} - q_t$ and $\varepsilon_{i,t}$ is an error term. Equation 3.1 relates the change in the DEM/USD in the k minutes immediately following an announcement to the unexpected portion of that announcement (the 'news'), as implied by the structural exchange rate model in 'news' form described in Chapter 1, subsection 1.1.1. Impacts from the 'news' contained in announcements on the evolution of the DEM/USD will show up as significant coefficients on the unexpected portion of the release.

To test for the existence of systematic effects of each type of 'news' on the DEM/USD, we estimate equation 3.1 for each series i, and test the difference of β from zero.[6] Note that, as argued in Section 3.1, the signs of the coefficients are a priori uncertain, depending on which of the fundamental or reaction function responses dominates for a given release. We employ the return in the fifteen minutes immediately post-announcement as the dependent variable (i.e., we took k=15m), the fifteen minute window chosen with reference to earlier studies (Ederington and Lee, 1993 and 1995, and Payne, 1996) which suggest that the major impacts on both prices and volatility occur within a fifteen minute span post-announcement. These tests are described in subsections 3.3.1 and 3.4.1.

Note that estimations of the above equation are not strict time-series regressions as the observations are not temporally consecutive. An observation for a given series is added

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[6] All the tests in this chapter were computed using heteroscedasticity-consistent standard errors for the OLS estimates, as in White (1980). In most cases the effect of this adjustment was very marginal and in no case was the qualitative nature of the results altered.

at every point when a new release of data occurs and the associated return is then constructed. This implies that, as we focus on monthly macroeconomic announcements observed over a three year period, our estimations of equation 3.1 will be based on at most 36 observations of a given US or German macroeconomic release. Furthermore, in order to validate the specification of equation 3.1 we also performed an explicit test of market efficiency, by estimating an unrestricted version that equation, which included a constant term and the expected part of the announcement, $x^e_{i,t}$, as regressor. Departures from efficiency were very slight for both the US and German releases and hence, in order to save space, the results are omitted.[7]

Our next estimations concern the persistence of the impact from announcements on the DEM/USD. If the 'news' contained in these macroeconomic data is considered 'fundamental' for the determination of the DEM/USD exchange rate then there should not only be a significant impact in the fifteen minutes post-release, but also, for example, in the twelve hours immediately after announcements. This is tested in subsections 3.3.2 and 3.4.2 by varying the window over which the return variable is calculated, i.e., estimating equations similar to equation 3.2, but with k assuming values from 5 minutes to 12 hours.

In the exercises above, we have assumed that the response to macroeconomic 'news' is invariant over our sample. In subsections 3.3.3 and 3.4.3 we test this hypothesis explicitly. To this end we employ three dummy variables: the first taking the value unity only in the first year of our sample and zero otherwise, the second being unity in the second year of the sample and zero everywhere else and the final dummy taking the value unity in the last sample year only. These dummies were then interacted with the forecast error series, giving three regressors in the basic 'news' impact regressions, $x92^n_{i,t}$, $x93^n_{i,t}$ and $x94^n_{i,t}$. Hence, our structural stability test consisted of the estimation of equation 3.2 for

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7 The market efficiency tests performed are similar to those described in Chapter 2, subsection 2.3.4, which are based on equation 2.2. The results for these tests are available from the authors upon request. We further examined whether there was any systematic impact of each announcement on the exchange rate in the minutes before the official announcement time. The results derived were largely insignificant, implying a lack of information leakage and validating our use of the Reuters reporting time as the time when German announcements hit the market.

each series *i*,

$$R_{i,t+k} = \beta_2\ x92^n_{i,t} + \beta_3\ x93^n_{i,t} + \beta_4\ x94^n_{i,t} + \varepsilon_{i,t} \qquad 3.2$$

Significant differences in the estimated coefficients from this regression will indicate that the exchange rate response to 'news' is not invariant across our sample. This is formally tested by computing a Wald statistic that has a $\chi^2(2)$ distribution under the null hypothesis $\beta_2=\beta_3=\beta_4$.

3.3 Analysis of US Macroeconomic Announcements

In this section we present the results from testing the impact of US data releases on the DEM/USD rate. As detailed in subsection 3.2.1, our analysis concentrates on the following monthly US data: the statistics contained in the Employment Report (Payroll Employment and Unemployment rate), and the Mercantile Trade Report (Trade Balance), and the figures for PPI, CPI, Retail Sales, Durable Goods, Consumer Confidence, Leading Indicators, the NAPM survey and the Industrial Production/Capacity Utilisation announcement.[8]

3.3.1 The impact of 'news'

The first question we address in our empirical analysis of the US data is do markets react systematically to good (and bad) news about the state of the economy? Given the list of announcements above, one would expect the coefficients on the forecast error series for all real activity indicators to have the same sign aside from that on the unemployment

[8] Note that in our empirical analysis of individual announcements we can decompose the Employment Report responses into the effects due to its two principal components, the Unemployment rate and Payroll employment via their forecast errors. For the analysis of this pair of announcements, and for the simultaneously released Industrial Production and Capacity Utilisation figures, we use a multiple regression version of equation 3.1.

series. The actual sign which the coefficients take will depend on which of the fundamental or reaction effects outlined in Section 3.1 dominate. A priori, the signs of the price indices and their relationship with those of the real indicators is unknown. The results from estimations of equation 3.1 are given in Table 3.1.[9]

Table 3.1 **The impact of US announcements on DEM/USD returns**

Series	*Coefficient*	*T-stat*	R^2	*Scaled*
Payroll Employment	0.00004	5.77	0.44	0.00310
Durable Goods	0.00090	5.39	0.44	0.00170
NAPM	0.00087	4.94	0.35	0.00140
Retail Sales	0.00385	3.48	0.23	0.00160
Trade Balance	0.00110	3.41	0.24	0.00130
Consumer Confidence	0.00030	2.74	0.20	0.00130
Unemployment rate	-0.00730	-1.77	0.44	-0.00100
CPI	0.00450	1.48	0.06	0.00046
PPI	0.00290	1.29	0.04	0.00057
Industrial Production	0.00280	0.76	0.03	0.00037
Capacity Utilization	0.00046	0.28	0.03	0.00010
Leading Indicators	0.00060	0.25	0.01	0.00007

Notes: The table presents estimates of equation 3.1. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. The second column displays the estimated coefficients on the forecast error series. T-values relating to the hypothesis that the coefficients are zero are given in third column. The critical values for the t-values are 2.04 at 5% and 1.70 at 10%. The final column displays the product of the coefficient with the average absolute forecast error.

A first point to note is that the coefficients on all indicators have the sign predicted by the reaction function response to news. Unexpected Retail Sales growth, for example, entails an appreciation in the dollar whereas unexpected Unemployment shocks have the opposite effect. The coefficients on announcements of real activity also conform with a Monetarist model of exchange rates. However, there is marginal evidence that price shocks tend to cause dollar appreciations also, an effect which is inconsistent with the Monetarist model. Hence our preferred interpretation of these results is that the response of exchange rates to macroeconomic 'news' is indicative of expected Federal Reserve reactions in domestic money markets.

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9 The results presented here and throughout the chapter are based on separate estimations of equation 3.1 for each announcement, except for those mentioned in the previous footnote. We also estimated a multiple regression version of equation 3.1 which yielded the 'news' impacts for all US or German announcements simultaneously. The results from the multiple regression formulation were qualitatively and quantitatively very similar to those presented here.

Moving to the inference on these coefficients, the *t*-values demonstrate that most are significant at, at least, 10%. Exceptions to this are the coefficients associated with PPI, CPI, Leading Indicators, Industrial Production and Capacity Utilisation figures. Whilst one might expect these results for the final three of this group, due to their being fairly unimportant indicators, the lack of impact from the price series is a notable result.[10] In the final column of Table 3.1 we give a common scale to the results by forming the product of the estimated coefficient and the average absolute forecast error. These figures yield a ranking of announcements, in terms of the mean impact on the DEM/USD, as follows. The Payroll Employment data is clearly most influential, entailing in excess of a 30 b.p. revision on average. There is then a group of indicators, comprising the Unemployment Rate, Trade Balance, Retail Sales, Durable Goods, Consumer Confidence and the NAPM survey, which give, on average, at least a 10 b.p. impulse to the DEM/USD. A low impact group of indicators includes the PPI, CPI, Leading Indicators, Industrial Production and Capacity Utilisation. The dominance of the Employment Report statistics links with the comments in Harris and Zabka (1995) who expound the view that they are regarded as the key indicator of US performance by the markets. Also, the strong influence of the Trade Balance on exchange rates is unsurprising.

3.3.2 How important is this 'news' in the longer run?

In this subsection we test the persistence of the effect of 'news' on the exchange rate by examining the impact of the unanticipated information on exchange rate changes measured over intervals of various length from the announcement instant. Table 3.2 presents the results from estimation of equation 3.1 using returns from 5 minutes to 12 hours, while Figure 3.1 plots the average of the scaled impact of the 'news' effects, and Figure 3.2 the average value for the t-statistic, over the different post-announcement horizons.

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[10] Closer examination of the PPI data reveals that a single observation, associated with the release of the September 1994 figure, greatly influences the results. Removal of this observation yields a regression coefficient on PPI forecast errors of 0.0044 with a *t*-value of 2.20. Hence, the earlier assertion, that the exchange rate reaction to the price series is inconsistent with a Monetarist model, is strengthened.

Table 3.2 **The persistence of the effect of US 'news' on the DEM/USD**

Series	*5m*	*15m*	*30m*	*45m*	*1h*	*1.5h*	*2h*	*2.5h*	*3h*	*6h*	*12h*
Consumer Conf	*0.8*	*2.9*	*2.7*	*2.9*	*3.6*	*3.4*	*4.2*	*4.1*	*4.1*	*3.1*	*4.4*
CPI	*29.0*	45.0	-16.0	-24.0	-8.8	-20.0	-51.0	-66.0	-58.0	32.0	28.0
Capacity Util	1.6	4.6	2.8	16.0	11.0	-2.1	-19.0	-24.0	-21.0	-30.0	-12.0
Durable Goods	*6.5*	*9.1*	*8.3*	*7.5*	*7.7*	*8.9*	5.3	4.3	6.8	4.3	6.0
Industrial Prod	5.8	29.0	-2.1	-18.0	-14.7	-1.5	-2.3	34.0	43.0	123.5	*178.3*
Leading Indic	*24.0*	*5.8*	4.9	-4.8	51.0	15.0	2.0	*100.0*	*127.0*	59.7	*135.0*
NAPM	*4.4*	*8.7*	*8.7*	*5.6*	*8.0*	4.8	2.5	-0.6	2.9	1.2	0.8
Payroll Emp	0.1	*0.4*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.6*	*0.6*	*0.6*	*0.5*
PPI	4.2	29.0	21.0	12.0	21.0	-4.3	-22.0	-32.0	-36.0	-29.0	-8.8
Retail Sales	11.0	*39.0*	*28.0*	22.0	22.0	24.0	24.0	33.0	21.0	10.0	34.0
Trade Balance	*7.8*	*11.0*	*9.7*	*12.0*	*14.0*	*12.0*	*13.0*	4.8	5.5	1.8	-2.2
Unemployment	-26.0	*-73.0*	*-85.0*	-57.0	-58.0	-27.0	-10.0	29.0	12.0	-1.0	-30.0

Notes: The table presents estimates of equation 3.1 for differing post-announcement return intervals. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. Each cell gives the slope coefficient, multiplied by 10^4, from a linear regression of the return over the period displayed in the first row of the given column on the forecast errors from the series in the first cell of the given row. Coefficients in italics underlined are significantly different from zero at a 5% level.

As Table 3.2 demonstrates, the general picture that emerges is that the impact of these macroeconomic releases on the DEM/USD is a very short run phenomenon. Examining first the group of seven announcements which were found to be fairly influential in the previous subsection,[11] the following results emerge. An encouraging result is that of the 77 regressions over differing horizons, more or less all yield a correctly signed coefficient (only 4 of the 77 coefficients are 'wrongly' signed).[12] The pattern of significance, however, is not strong. In general the impacts are significant only until around 2 hours after release, after which, it seems, the effect of unanticipated macroeconomic information is drowned in the subsequent random fluctuations of the exchange rate. The only exceptions to this picture are the patterns for the Payroll Employment and Consumer Confidence figures. These retain significance until the 12 hour horizon, confirming the earlier results and, with regard to the former, in line with the earlier remarks that these figures are by far the most influential in the market.

The persistence patterns associated with the less important announcements are, unsur-

[11] These being the Employment Report statistics, and the Trade Balance, Retail Sales, Consumer Confidence, Durable Goods and NAPM figures.

[12] By 'correctly' signed we mean that the signs of the coefficients agree with those from Table 3.1 and our inference that exchange rates follow a 'reaction function' response to 'news'.

prisingly, even less impressive. Only 29 of the 55 estimated coefficients are correctly signed and there is no consistent impact of 'news' on returns from any of the individual announcements.

Hence our results suggest that, aside from the Payroll Employment and Consumer Confidence figures, one can trace very little long-term effect of 'news' on quotations. This indicates that the very short-term reaction to 'news' is drowned very rapidly in subsequent 'noise'.

3.3.3 Structural stability

Finally we perform the structural stability tests described in subsection 3.2.2. In examining these results, presented in Table 3.3, we again split the announcements into two groups, the first consisting of those series with significant results from the basic 'news' regression and the second containing all other series. With regard to the first group, all coefficients are of the sign implied by the reaction function response to news, in line with the results of Table 3.1. A regularity in the results, excepting the Unemployment rate and Consumer Confidence coefficients, is that the absolute value and significance of the coefficients declines over the three years, suggesting a greater impact of these news variables in 1992 relative to 1994. This diminution of the size of the coefficients is significant for the Retail Sales and Trade data and especially marked for the Durable Goods news. A possible explanation for this is the fact that global FX markets were far more turbulent in 1992, perhaps leading to greater emphasis being placed on macroeconomic announcements than in the relatively quiet times of 1994. Overall, for these six announcements there are strong patterns in significance and sign which confirm their, at least short-term, importance in FX markets.

The picture for the latter group is quite different. Only the coefficients associated with the CPI figures are all of the sign predicted by the reaction function response. Results for the Leading Indicators, Industrial Production and Capacity Utilisation news, in particular, are very erratic. One point to note is the correct sign and significance of the

PPI news in 1992 and 1993, with coefficients that are significantly greater than their 1994 counterpart (see also footnote 10). Hence, in line with our earlier results, there is robust evidence that news associated with the Unemployment rate, Payroll Employment, Trade Balance, Retail Sales, Durable Goods, Consumer Confidence and the NAPM survey have a strong short-term impact on the DEM/USD spot rate. The direction of these impacts corresponds to a 'reaction function' response to 'news'.

Table 3.3 **Structural stability tests - US announcements**

Series	*1992*	*1993*	*1994*	$\chi^2(2)$
Consumer Confidence	0.00025	0.00052	0.00005	<u>*14.02*</u>
	1.01	*4.71*	*0.91*	
Durable Goods	0.00144	0.00095	0.00019	<u>*21.87*</u>
	5.32	*4.64*	*1.47*	
NAPM	0.00103	0.00071	0.00034	2.26
	5.49	*2.08*	*0.73*	
Payroll Employment	0.00005	0.00003	0.00002	3.88
	5.49	*3.8*	*2.12*	
Retail Sales	0.00737	0.00327	0.00303	<u>*8.96*</u>
	1.68	*1.72*	*4.19*	
Trade Balance	0.00221	0.00129	0.00020	<u>*7.62*</u>
	3.86	*3.75*	*0.43*	
Unemployment rate	-0.00939	-0.00371	-0.00720	0.45
	-1.40	*-0.67*	*-1.18*	
CPI	0.00855	0.00145	0.00494	1.37
	1.01	*0.58*	*2.02*	
Capacity Utilisation	-0.00674	0.00150	-0.01100	<u>*6.45*</u>
	-1.07	*1.81*	*-1.96*	
Industrial Production	0.02075	-0.00423	0.00897	<u>*12.31*</u>
	2.34	*-3.05*	*1.56*	
Leading Indicators	-0.00314	0.00663	-0.00469	<u>*15.88*</u>
	-1.07	*3.61*	*-1.79*	
PPI	0.00960	0.00593	-0.00182	5.10
	1.97	*2.67*	*-0.55*	

Notes: The table presents estimates of equation 3.2. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. The columns with number headings give the coefficients on the series created from interacting the forecast error series with that year's dummy. T-values relevant to the test that the coefficient on the forecast error is zero in a given year are given in italics. The final column gives a Chi-squared test statistic relevant to the hypothesis that the regression slope is identical in each of the three sample years. The Chi-squared statistic has two degrees of freedom and a 5% critical value of 5.99. Chi-square values in italics underlined denote the null is rejected at the 5% level.

3.4 Analysis of German Macroeconomic Announcements

In this section we present the results obtained for the German macroeconomic announcements. Our analysis concentrates on the following monthly German macroeconomic series: CPI, Industrial Production, M3, Manufacturing Orders, PPI, Retail Sales, Trade Balance, Unemployment, and WPI.

3.4.1 The impact of 'news'

The results from estimations of equation 3.1 for the German announcements are given in Table 3.4. Note that a positive coefficient in these regressions implies that a positive surprise in the announcement is associated with a depreciation of the DEM (i.e., the USD appreciates). Of the 9 series analysed, only 3 (Unemployment, Industrial Production and CPI) have a significant impact at the 10% level. The R^2 is small in all the regressions, including those with significant coefficients. These results suggest that German macroeconomic announcements have low explanatory power for exchange rate changes in the 15 minutes after their release.

Table 3.4 **The impact of German announcements on DEM/USD returns**

Series	*Coefficient*	*T-stat*	R^2	*Scaled*
Unemployment	-0.00003	-3.06	0.16	-0.00029
Industrial Production	-0.00023	-2.07	0.05	-0.00034
CPI	0.00261	2.00	0.08	0.00020
Retail Sales	-0.00006	-1.35	0.01	-0.00018
Manufacturing Orders	0.00006	1.15	0.01	0.00010
PPI	-0.00113	-0.81	-0.08	-0.00014
M3	-0.00017	-0.75	-0.19	-0.00022
Trade Balance	-0.00004	-0.41	0.01	-0.00008
WPI	0.00017	0.35	-0.01	0.00005

Notes: The table presents estimates of equation 3.1. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. The second column displays the estimated coefficients on the forecast error series. T-values relating to the hypothesis that the coefficients are zero are given in the third column. The critical values for the t-values are 2.04 at 5% and 1.70 at 10%. The final column displays the product of the coefficient with the average absolute forecast error.

As in the previous analysis of US data, in the final column of Table 3.4 we give a common scale to the results by forming the product of the estimated coefficient and the average absolute forecast error. These figures show that Industrial Production and Unemployment are the series causing the largest response (each announcement entails a 3 b.p. revision, on average), followed by M3, CPI and Retail Sales (which entail a 2 b.p. revision, on average). Comparison with the relevant figures from the US results indicates that, at this point, it seems that the effects of German 'news' on DEM/USD evolution is very slight.

The impact of 'news' and Bundesbank council meetings

Previous work on the reaction of DEM/USD exchange rate volatility to central bank actions, described in Chapter 2, has shown that the DEM/USD exchange rate is very sensitive to statements issued after Bundesbank council meetings. These results suggest the possibility that Bundesbank decisions, and expectations about those decisions, are the key German factor driving the DEM/USD exchange rate. If this is true, then the importance of German macroeconomic announcements should be a function of the extent to which they can influence the outcome of the Bundesbank council meetings. Our hypothesis is that this is a function of the period of time between the release and the meeting: if an announcement is made just after a Bundesbank council meeting (long before the next) the markets will not pay much attention to it; the Bundesbank will not act on that information for two weeks,[13] and during that period new information may arrive that could be more relevant for their decision.

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[13] The Bundesbank meets every other Thursday, with some exceptions: it did not meet over the Christmas or Easter holidays or at the beginning of August. Hence there was a 3 or 4 week interval between meetings at those times. Also, on the 4 times when the Thursday was a public holiday, the meeting was held on the Wednesday (3 times), or the Friday (once). As such, there is a weekly regularity to Bundesbank meetings. The macroeconomic data are announced monthly, but there is no precise monthly regularity to these announcements. The combination of these two facts implies that for a particular series, the proximity to the next Bundesbank meeting varies considerably across announcements. Overall the average number of days to the next Bundesbank meeting is 7.9, with a standard deviation of 5.7, and these results hold roughly for each individual series. Note that in order not to have a number of days to the next announcement equal to zero, we included both the day of the announcement and the day of the meeting in the difference. Thus a figure of 1 means the announcement occurred on the day of a Bundesbank meeting, and each meeting is 15 days before the next.

This hypothesis implies that an announcement will be more important the closer it is to the next Bundesbank council meeting, so we weighted our observations according to this. The test consisted of running regressions similar to the ones used in Table 3.4 but with each observation weighted by the inverse of the number of days to the next meeting, i.e., we ran cross-section regressions of the form

$$r_{i,t+k} = \delta z^n_{i,t} + \varepsilon_{i,t} \qquad 3.3$$

where $r_t = R_t/d$, $z^n_{i,t} = x^n_{i,t}/d$, and d is the number of days to the next Bundesbank council meeting (including the day of the announcement).

The results for these regressions, presented in Table 3.5, support our hypothesis, since there is an increase in the significance of the coefficient on 'news' (and in the R^2) for most of the announcements (the only exceptions being WPI and Manufacturing Orders). When the proximity to Bundesbank council meetings is considered, 6 of our 9 series have coefficients significant at the 10% level. The scaled impact is, on average, doubled and at least for M3, Unemployment, Industrial Production and PPI, the R^2 is relatively high. These results suggest that, in contrast to those in Table 3.4, the German macroeconomic announcements may indeed have an important impact on the behaviour of the exchange rate, at least over the short term.

Table 3.5 **The impact of German announcements on DEM/USD returns weighted by proximity to the next Bundesbank council meeting**

Series	*Coefficient*	*T-stat*	R^2	*Scaled*
M3	-0.00046	-5.02	0.35	-0.00060
Unemployment	-0.00002	-3.43	0.29	-0.00027
Industrial Production	-0.00029	-2.80	0.24	-0.00043
CPI	0.00540	2.72	0.08	0.00042
PPI	-0.00358	-2.00	0.33	-0.00044
Retail Sales	-0.00007	-1.84	0.03	-0.00020
Trade Balance	-0.00014	-1.30	0.05	-0.00025
WPI	0.00012	0.23	-0.03	0.00003
Manufacturing Orders	0.00000	0.08	0.00	0.00001

Notes: The table presents estimates of equation 3.3. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. The second column displays the estimated coefficients on the forecast error series. T-values relating to the hypothesis that the coefficients are zero are given in the third column. The critical values for the t-values are 2.04 at 5% and 1.70 at 10%. The final column displays the product of the coefficient with the average absolute forecast error.

The interpretation of the sign of the coefficients

As described in Section 3.1, the sign of the coefficient on 'news' depends on the market's belief about both the appropriate model of exchange rate determination and the likely reaction of the monetary authorities. Here we try to identify those beliefs based on the results presented in Tables 3.4 and 3.5. Note that the signs of the coefficients are the same in both tables (although the significance of the coefficients changes when we weight by the proximity to Bundesbank council meetings): negative for Industrial Production, M3, PPI, Retail Sales, Trade Balance and Unemployment (i.e., a positive surprise in these announcements causes a DEM appreciation), positive for CPI, Manufacturing Orders and WPI.[14] As explained below, these results suggest that the markets believe the DEM behaves according to a model where international capital flows dominate trade flows, i.e., the key variable for exchange rate determination is the interest rate differential, and where the monetary authorities set interest rates according to their expectations of future inflation (and eventually growth).

The negative sign on M3 is not consistent with the direct effects of any of the 'fundamentals' models, but is consistent with a 'reaction function' interpretation: faced with higher than expected monetary growth, the Bundesbank will raise interest rates to reduce M3 growth; higher interest rates will cause an appreciation of the DEM. The signs on Industrial Production, PPI and Retail Sales are also consistent with a 'reaction function' interpretation:[15] higher than expected producer prices or real activity may be seen as indicators of future inflation; to curb these inflationary pressures, the Bundesbank will raise interest rates, causing an appreciation of the DEM. However, the signs on CPI and Unemployment are not consistent with a 'reaction function' interpretation, whilst they are consistent with the Keynesian model: lower unemployment will increase consumer spending and increase imports; higher domestic prices should also increase im-

[14] In the following analysis, we will ignore the variables that do not have significant coefficients in Tables 3.4 and 3.5, i.e., Manufacturing Orders, Trade Balance and WPI.

[15] Note that the negative sign on these three variables is not consistent with the direct effects of a Keynesian model, but the signs on Industrial Production and Retail Sales (although not on PPI) are consistent with the direct effects in the Monetarist model.

ports and reduce exports; in both cases, the balance of payments will deteriorate, causing a depreciation of the DEM.

The Bundesbank is usually described as a 'money targeting' central bank. Each year the Bundesbank council sets a (band) target for M3 growth, and monetary policy actions are justified with reference to the attainment of this target. A strict interpretation of this framework would imply that the Bundesbank should only react to unexpected changes in M3, and not to any other information. However, some authors claim that in practice the Bundesbank does not follow money targets strictly. Von Hagen (1995) claims that the Bundesbank follows an inflation target framework, with expected future inflation being the main factor driving policy actions, and M3 growth just an (important) indicator of future inflation. Clarida and Gertler (1996) estimate a policy reaction function for the Bundesbank, and conclude that German monetary policy is conditioned on inflationary pressures and the state of real economy, but since the Bundesbank behaves in a forward-looking manner, it only reacts to future (consumer price) inflation and growth. In particular, they show that the Bundesbank reacts first of all to M3 shocks, but also to past growth as measured by Industrial Production, or to past commodity price shocks, but they do not react to past consumer price inflation. Although the variables used by Clarida and Gertler (1996) do not match exactly the variables used in this chapter, their results suggest that the Bundesbank should react to unexpected changes in M3, Industrial Production, Retail Sales (as indicators of current and future growth), or PPI (as proxy for commodity prices), but not to unexpected changes in CPI or Unemployment.[16] Our results are consistent with this.

This interpretation is also consistent with the results of the weighting procedure. Scaling by the proximity to the next Bundesbank council meeting will only make a significant difference if the market believes that the Bundesbank will react to the information released, i.e., if the reaction effect is dominant. The significance and magnitude of the

[16] Note that Clarida and Gertler (1996) do not include an unemployment variable in their study. However, current unemployment may be seen more as a consequence of low growth in the past, than as an indicator of future growth, i.e., it is more a backward-looking variable that should not enter the reaction function of a forward-looking central bank.

coefficients (and also the R^2) for M3, Industrial Production, PPI, and Retail Sales are all increased, the biggest increase being for M3, the main variable in the Bundesbank's reaction function (according to Clarida and Gertler, 1996). However, although there is some increase in the significance of both coefficients, the effects seem to be quantitatively smaller for the CPI and Unemployment and some measures of importance actually deteriorate (the size of the coefficient for Unemployment and the R^2 for CPI). These results suggest that M3, Industrial Production, PPI, and Retail Sales affect the DEM/USD exchange rate through their effects on Bundesbank policy decisions, whereas the effects of CPI and Unemployment may be felt through other channels.

Since the 'reaction function' effect dominates for the majority of the variables, it seems that expectations about future interest rates are the main factor driving the DEM/USD reaction to German macroeconomic news. The effect of backward-looking variables (like the CPI and Unemployment) suggest that the markets see the DEM behaving according to a model in which the elasticity of the exchange rate to the current account is small relative to the elasticity of the exchange rate to interest rate differentials.

3.4.2 The 'long run' effects of German announcements

In this subsection, we extend our analysis to assess if and how the effect of German macroeconomic announcements is felt over longer periods of time. Table 3.6 presents the results from estimation of equation 3.1 (the 'original' data) using returns over different periods of time, from 5 minutes to 12 hours, while Table 3.7 presents similar results for regressions of the type of equation 3.4 (the 'weighted' data). Figure 3.3 plots the average of the scaled impact of the 'news' effects, and Figure 3.4 the average value for the t-statistic, over the different post-announcement horizons.

For periods longer than the 15 minute interval already considered, the significance levels of the forecast error variables tend to be lower, although for the 'weighted' data the significance levels are relatively high even after 3 hours. For the 'original' data only PPI

Table 3.6 **The persistence of the effect of German 'news' on DEM/USD returns ('original' data)**

Series	*5m*	*15m*	*30m*	*45m*	*1h*	*1.5h*	*2h*	*2.5h*	*3h*	*6h*	*12h*
CPI	1.0	*26.1*	2.3	14.9	7.3	19.2	10.1	15.9	23.0	75.1	-12.3
Industrial Prod	-0.8	<u>*-2.3*</u>	-0.5	-0.4	-1.2	-3.5	-2.2	-2.9	-4.6	-4.1	-8.0
M3	0.8	-1.7	-1.4	-0.8	-2.0	-2.1	-2.9	-2.1	-4.2	<u>*-5.9*</u>	-5.2
Manuf Orders	*0.7*	0.6	1.0	1.2	*2.1*	0.5	0.4	-1.2	1.4	4.0	2.7
PPI	-0.5	-11.3	*-34.3*	-34.3	<u>*-67.2*</u>	<u>*-78.6*</u>	<u>*-117.5*</u>	<u>*-145.9*</u>	<u>*-150.0*</u>	-84.0	-102.7
Retail Sales	-0.2	-0.6	-0.8	-0.4	-0.3	-0.2	-0.4	-0.4	*-1.7*	2.1	2.8
Trade Balance	0.3	-0.4	1.0	-1.8	-0.8	-3.4	*-4.1*	-1.6	-3.1	-1.7	-1.3
Unemployment	-0.1	<u>*-0.3*</u>	<u>*-0.3*</u>	-0.2	-0.2	-0.1	-0.2	-0.2	0.0	-0.4	-0.9
WPI	-0.6	1.7	-6.2	-2.8	0.4	-6.0	4.7	-9.7	-0.3	-0.7	-10.1

Notes: The table presents estimates of equation 3.1 for differing post-announcement return intervals. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. Each cell gives the slope coefficient, multiplied by 10^4, from a linear regression of the return over the period displayed in the first row of the given column on the series of forecast errors from the series in the first cell of the given row. Coefficients in italics (underlined) are significantly different from zero at a 10% (5%) level.

has consistently significant coefficients up to 3 hours, and of the 3 series identified as significant in Table 3.4, only Unemployment extends its significance to the 30 minute interval. For the 'weighted' data the significant effects extend up to 6 hours for some series. However, the full impact of the announcement (measured by the highest value of the coefficient) is, on average, only felt after 3 hours, for the 'original' and 'weighted' data, although the pattern is more clearly defined for the latter. The relatively long period that the market takes to adjust is probably associated with the fact that the German announcements are not scheduled. This also explains the relatively small scaled

Table 3.7 **The persistence of the effect of German 'news' on DEM/USD returns ('weighted' data)**

Series	*5m*	*15m*	*30m*	*45m*	*1h*	*1.5h*	*2h*	*2.5h*	*3h*	*6h*	*12h*
CPI	*43.7*	<u>*54.0*</u>	57.4	*81.2*	97.8	*90.3*	113.2	<u>*161.3*</u>	<u>*200.3*</u>	142.3	82.4
Indust Prod	-1.1	<u>*-2.9*</u>	<u>*-2.5*</u>	<u>*-2.2*</u>	<u>*-3.7*</u>	-6.6	-3.2	-6.2	-7.7	1.5	-15.0
M3	-1.0	<u>*-4.6*</u>	-4.9	<u>*-5.1*</u>	-8.5	<u>*-9.9*</u>	<u>*-9.5*</u>	<u>*-9.9*</u>	<u>*-9.5*</u>	<u>*-9.9*</u>	-2.3
Manuf Orders	0.0	0.0	-0.6	-1.0	0.9	-1.2	-0.4	<u>*-2.7*</u>	<u>*-3.9*</u>	<u>*-12.4*</u>	-7.5
PPI	-2.7	-35.8	-20.7	*-24.4*	<u>*-38.0*</u>	<u>*-46.7*</u>	<u>*-88.6*</u>	-71.9	-69.7	136.2	216.7
Retail Sales	*-0.7*	*-0.7*	0.1	0.8	0.3	0.0	-1.1	-0.8	-2.2	0.5	1.6
Trade Bal	0.1	-1.4	2.2	<u>*-2.6*</u>	-1.0	-3.3	-3.9	<u>*-3.5*</u>	<u>*-8.9*</u>	-1.0	-7.1
Unemploym	0.0	<u>*-0.2*</u>	-0.2	-0.2	-0.1	0.0	-0.1	0.0	0.1	0.0	0.3
WPI	3.7	1.2	-1.6	-4.3	1.2	-2.5	-0.1	-7.1	-5.8	-34.4	-0.1

Notes: The table presents estimates of equation 3.3 for differing post-announcement return intervals. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. Each cell gives the slope coefficient, multiplied by 10^4, from a linear regression of the return over the period displayed in the first row of the given column on the series of forecast errors from the series in the first cell of the given row. Coefficients in italics (underlined) are significantly different from zero at a 10% (5%) level.

effect found in subsection 3.4.1. If one takes the 3 hour instead of the 15 minute return, then the impact of German announcements on the DEM/USD exchange rate becomes higher, as shown in Table 3.8. For the 'original' data, the scaled response reaches an exceptional 19 b.p. for PPI, but is lower than 7 b.p. for the other series. For most of the series, the scaled response is even higher for the 'weighted' data, reaching 16 b.p. for Trade and CPI, 12 b.p. for M3 and 11 b.p. for Industrial Production.

Table 3.8 **The impact of German announcements on DEM/USD 3 hour returns**

Series	*Original*		*Weighted*	
	Coefficient	*Scaled*	*Coefficient*	*Scaled*
Trade Balance	-0.00031	0.00055	-0.00089	0.00159
	-0.88		*-2.85*	
CPI	0.00230	0.00018	0.02003	0.00156
	0.45		*2.25*	
M3	-0.00042	0.00054	-0.00095	0.00123
	-1.11		*-3.13*	
Industrial Production	-0.00046	0.00067	-0.00077	0.00112
	-1.45		*-0.82*	
PPI	-0.01500	0.00186	-0.00697	0.00087
	-2.46		*-1.27*	
Manufacturing Orders	0.00014	0.00025	-0.00039	0.00067
	0.43		*-2.33*	
Retail Sales	-0.00017	0.00050	-0.00022	0.00066
	-1.84		*-1.28*	
WPI	-0.00003	0.00001	-0.00058	0.00016
	-0.02		*-0.33*	
Unemployment	0.00000	0.00004	0.00001	0.00015
	-0.15		*0.29*	

Notes: The table presents estimates of equations 3.1 and 3.3. Each regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering 1/1/92 to 31/12/94. The second and fourth columns display the estimated coefficients on the forecast error series. T-values relating to the hypothesis that the coefficients are zero are given in italics. The critical values for the t-values are 2.04 at 5% and 1.70 at 10%. The third and fifth columns display the product of the coefficient with the average absolute forecast error.

3.4.3 Structural stability

The results of the structural stability tests for both the 'original' and 'weighted' German data are presented in Table 3.9. The main feature of the results in Table 3.9 is the consistency of the signs of the coefficients across time. For all the series with significant coefficients in Tables 3.4 and 3.5, the signs of the coefficients in the weighted data regressions are the same in all 3 years. However, the size of the coefficient varies across the sample, and in several cases the differences across periods are statistically significant. Given the small number of observations in each subsample (12), it is not surprising that the significance levels vary considerably across years. The consistency of the signs of the coefficients strongly suggests that the results are not spurious, and that there is strong evidence that some German macroeconomic announcements have a significant (although small) impact on the DEM/USD exchange rate.

Table 3.9 **Structural stability tests - German announcements**

Series	*Original Data*				*Weighted Data*			
	1992	*1993*	*1994*	$\chi^2(2)$	*1992*	*1993*	*1994*	$\chi^2(2)$
CPI	0.00136	0.00736	0.00150	4.00	0.00197	0.00855	0.00604	5.60
	0.96	*2.65*	*0.96*		*1.22*	*1.69*	*7.78*	
Indust Prod	-0.00013	-0.00027	-0.00035	2.80	-0.00023	-0.00047	-0.00050	*8.58*
	-1.90	*-0.70*	*-3.26*		*-3.08*	*-1.01*	*-9.66*	
M3	-0.00131	0.00036	-0.00034	*7.83*	-0.00131	-0.00071	-0.00036	*21.04*
	-2.47	*1.10*	*-5.53*		*-0.68*	*-10.60*	*-9.17*	
PPI	-0.00206	-0.00252	0.00027	1.05	-0.00545	-0.00472	-0.00106	*17.32*
	-0.72	*-0.72*	*0.25*		*-5.75*	*-0.96*	*-2.17*	
Retail Sales	-0.00013	-0.00001	-0.00003	1.70	-0.00013	-0.00004	-0.00010	1.26
	-1.75	*-0.16*	*-0.77*		*-1.58*	*-0.83*	*-1.29*	
Unemploym	-0.00003	-0.00004	0.00000	*6.33*	-0.00002	-0.00003	-0.00001	1.44
	-2.44	*-3.33*	*-0.16*		*-4.67*	*-1.61*	*-1.09*	
Manuf Orders	0.00015	0.00001	0.00006	1.00	0.00006	0.00000	-0.00028	2.35
	1.04	*0.18*	*0.42*		*1.45*	*0.08*	*-1.07*	
Trade Bal	0.00015	-0.00020	-0.00003	3.46	0.00014	-0.00033	-0.00022	*7.84*
	0.77	*-2.33*	*-0.27*		*0.88*	*-6.43*	*-2.37*	
WPI	-0.00065	0.00171	0.00003	*6.37*	-0.00097	0.00168	-0.00014	*9.88*
	-1.27	*2.18*	*0.05*		*-2.31*	*2.29*	*-0.18*	

Notes: The table presents estimates of equation 3.2. Each announcement regression is based on a sample of at most 36 forecast errors and associated exchange rate changes, covering the period 1/1/92 to 31/12/94. The columns with number headings give the coefficients on the series created from interacting the forecast error series with that year's dummy. T-values relevant to the test that the coefficient on the forecast error is zero in a given year are given in italics. The columns headed $\chi^2(2)$ give a Chi-squared test statistic relevant to the hypothesis that the regression slope is identical in each of the three sample years. The Chi-squared statistic has two degrees of freedom and a 5% critical value of 5.99. Chi-square values in italics underlined denote the null is rejected at the 5% level.

3.5 Are the Impacts of German and US Announcements Similar?

In this section we compare the results obtained for the German and US announcements and try to extract some general conclusions. The main feature of the results is that the FX markets' primary concern is with the future likely reaction of the monetary authorities, both in Germany and the US. The results for Germany are somewhat mixed, since they suggest that the exchange rate reacts to news on CPI and Unemployment according to the Keynesian model, but the effects of other variables follow the 'reaction function' hypothesis. However, the quantitative effects of the latter variables dominate the effects of the former, which lead us to prefer the reaction function hypothesis as the main force driving the DEM/USD reaction to German macroeconomic news. The reaction of the DEM/USD exchange rate to US macroeconomic announcements is less ambiguous as all series have the sign predicted by the reaction function hypothesis, with the announcements with the largest and most significant impact on the USD being related to the real economy, in particular with employment.

In both countries the implied reaction function has, however, some curious and interesting features. In Germany, for example, the Bundesbank has been usually described as basing its policy on monetary targets, whereas von Hagen (1995) and Clarida and Gertler (1996) have recently argued that the Bundesbank seldom complies with its M3 targets, and actually reacts to divergences of inflation and output from their desired values using a modified Taylor (1993) rule. Our results suggest that the FX market does not believe that the Bundesbank will only react to monetary shocks, but that it will also react to other macroeconomic variables. However, the market still sees the Bundesbank reacting primarily to monetary surprises. Does the former result mean that the market places more belief in the Bundesbank's rhetoric than is actually justified?

By contrast, in the US the FX market primarily reacts to unexpected shocks emanating from the real economy. How does this square with the greater weight which central banks, including the Fed, are supposedly now giving to the primacy of price stability as an objective? One, perhaps slightly cynical, answer is that the switch to awarding price stability much greater weight as an objective has been much more pronounced in central bank rhetoric than in their actions; there is an emerging academic literature (Taylor, 1993, Goodhart, 1996, Muscatelli and Tirelli, 1996, and Chapter 5 in this thesis), documenting how much continuity there has been in central bank actions in recent years, and how little these have altered in response to supposed regime changes, e.g., independence, inflation targets, etc. A kindlier interpretation is that the FX market's stronger reaction to (US) data on real shocks (than on price shocks) is that real shocks provide a better guide to future inflationary pressures than do price shocks (which may be more backwards looking).[17]

If the main determinant of the FX market's response to news is their view of how the authorities will react to such news, as we suggest here, these effects are likely to shift over time. Specifically, changes in the policy priorities of monetary authorities and the market's perceptions of those priorities will imply that the coefficients derived from our 'news' regressions will alter over time. The results from our structural stability regressions corroborate the above intuition. These results also suggest one reason why stable relationships between FX rates and economic 'news' have been hard to uncover. Moreover, as detailed earlier, most economic news items can be interpreted in different ways. A stronger real economy can, under the Keynesian model, be regarded as bad news for the exchange rate, since imports and future inflation will rise, but good news if the authorities react by raising domestic interest rates. We find that the reaction function effect tends to dominate but this does not imply that all market participants favour a reaction function interpretation. If some follow a Keynesian model, this will also weaken the discernible impact of 'news' on exchange rates.

Although most of the macroeconomic announcements considered in this chapter have a

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[17] One should also note that our sample period (1992-94) is mostly a period of low inflation and accelerating growth in the US. In such circumstances, primacy of price stability may be consistent with the Fed focusing on growth indicators: if inflation is thought to be under control, then the Fed will react mostly to the state of the real economy.

significant (short term) impact on the DEM/USD exchange rate, this impact might be seen as quantitatively small. For the series with the largest impact, the US Payroll Employment figures, the exchange rate change caused by the average announcement is 31 b.p., a mere 0.2% change. Apparently, the DEM/USD is driven more by US than German announcements, since the impact of the former is much larger, even taking the results of the weighted regressions for Germany. For the series with significant coefficients, the average revisions after 15 minutes caused by the US announcements are between 10 and 17 b.p., whereas for the German announcements the average revisions are between 2 and 6 b.p. However, this difference could be caused by the different time pattern of response for the US and German announcements:[18] if instead of taking the 15 minute returns, one compares the periods with the maximum average revisions, then the impact for most of the significant German series is of similar magnitude to those for the US series.

One of the major differences between US and German announcements of economic data is that the US data are announced at regular pre-arranged times, fixed to the minute, whereas German releases are unscheduled and irregular. Prearranged announcements are likely to encourage contingency planning beforehand, in terms of consultation with support staff, economists and technical analysts. In contrast, the variation of German announcement times will potentially discourage concentrated pre-planning of reactions. Hence it is plausible that there will be longer lags in the exchange rate assimilating German information, relative to that from the US.

Our results support this view. As shown in Figures 3.1 and 3.3, the maximum impact (as measured by the average scaled response across announcements) is reached after 15 minutes for the US announcements, but only after 3 hours for the German announcements. Note, however, that the evidence in Figures 3.2 and 3.4 suggests that the significance levels are maximum at the 15 minute period, for both the German and US an-

[18] As is described below, the maximum impact (measured by the size of the coefficient) of the German announcements is only reflected in the DEM/USD after 3 hours, whereas the maximum impact of the US announcements is felt after 15 minutes.

nouncements.[19] Hence, market reaction can be seen to be concentrated in a short post-announcement period for the US, with the response to German 'news' being far more protracted. Like the German data, the majority of public news, e.g., on political events, market developments, arrives at unexpected times. The timing differences found between responses to the US and German announcements suggest that the response of exchange rates to these events is likely to be somewhat slower than earlier studies which concentrate on scheduled US announcements have suggested, and hence there may be some profit opportunities available to those agents that are able to respond more quickly to such unpredictable events.

A priori, one might have thought that the data we examine incorporates a significant number of releases which are 'fundamental' to the DEM/USD. However, although there is a clear effect on very high frequency DEM/USD returns from most of our 'news' series, their influence on lower frequency returns is surprisingly weak. On average, US 'news' is only significant for at most a couple of hours. German 'news' releases retain significance for a marginally longer period after which subsequent exchange rate fluctuations drown their effects. Hence, our results suggest that, whilst announcements have a significant impact on short-run DEM/USD determination, they cannot be considered the key factor driving exchange rates.

3.6 Conclusions

In this chapter we have studied the impact of macroeconomic news on exchange rates, using high frequency data for the DEM/USD. As described in the previous section, the overall picture is one of a strong, quick impact of macroeconomic 'news', with the exchange rate reflecting the anticipated policy reaction by the monetary authorities to the piece of news just released. However, this impact may be seen as quantitatively small, and the overall effect of the macroeconomic news on lower frequency exchange rate changes decays quite rapidly towards insignificance.

[19] This vindicates our use of the 15 minute exchange rate change as the basis for our analysis.

Although the main features of the 'news' effects are common to German and US announcements, there are some peculiarities and interesting features in the former group. First, the 'news' from German announcements tend to be incorporated in the exchange rate more slowly than the 'news' emanating from the US, due to differences in timing arrangements. Second, the impact on the exchange rate is, on average, quantitatively smaller for the German announcements. Finally, the effect of German announcements depends on the proximity to the next Bundesbank council meeting: when the observations were weighted by this proximity, the impact of the variables seen to be entering the Bundesbank's reaction function (especially M3) was significantly increased.

We have argued above that the most sensible explanation of the set of coefficients showing the markets' response to unexpected news is that these are, primarily, driven by their interpretation of the monetary authorities' reactions. Those reactions, when triggered, affect short-term money market interest rates. Consequently the finding of a dominant response from a reaction function model would seem to suggest that exchange rates would in turn predominantly respond to unexpected changes in such interest rates. This is consistent with the results of the study presented in Chapter 2.

Appendix 3.A: US and German Macroeconomic Data

Table 3.10 US macroeconomic announcements

Identifier	*Announcement type*	*Reported as*	*Time*	*Week*	*Obs.*
Consumer Conf	Consumer Confidence	level	10:00EST	4	36
CPI	Consumer Price Index	m/m % change	8:30EST	2/3	36
Capacity Util	Capacity Utilisation	%	9:15EST	3	36
Durable Goods	Durable Goods Orders	m/m % change	8:30EST	4	36
Industrial Prod	Industrial Production	m/m % change	9:15EST	3	36
Leading Indic	Index of Leading Indicators	m/m % change	8:30EST	1	35
NAPM	US N.A.P.M. survey	% level	10:00EST	1	36
Payroll Emp	Nonfarm Payrolls	thousands	8:30EST	1	36
PPI	Producer Price Index	m/m % change	8:30EST	2	36
Retail Sales	Advance Retail Sales	m/m % change	8:30EST	2	36
Trade Balance	Merchandise Trade Balance	$ billions	8:30EST	3	33
Unemployment	Civilian Unemployment rate	m/m % change	8:30EST	1	36

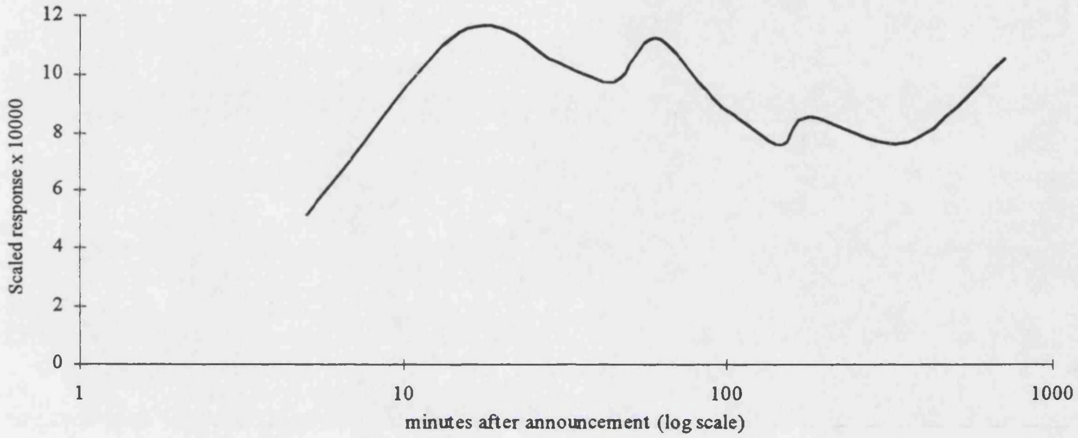
Table 3.11 German macroeconomic announcements

Identifier	*Announcement type*	*Reported as*	*Week*	*Obs.*
CPI	Consumer Prices, prelimin. release	m/m % change	4	36
Indust Prod	Industrial Production	m/m % change	1	35
M3	Money Stock M3, monthly average	% change from previous year Q4	4	33
Manuf Orders	Manufacturing Orders	m/m % change	2	35
PPI	Producer Prices	m/m % change	4	33
Retail Sales	Retail Sales, volume	y/y % change	3	34
Trade Bal	Trade Balance	DEM billions		29
Unemploym	Number of unemployed, s/a	m/m change, thousands	1	35
WPI	Wholesale Price index	m/m % change	3	35

NOTES:

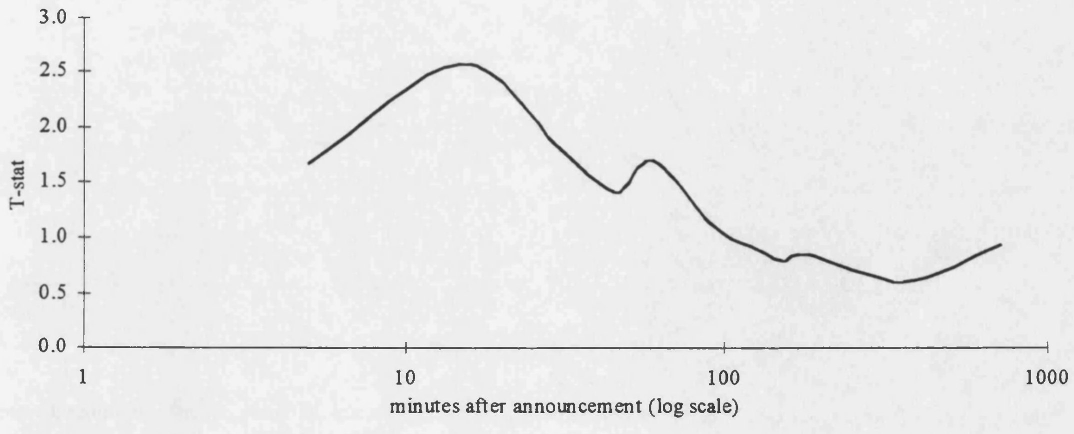
- week refers to the usual trading week of each month within which the given announcement is usually released, e.g., the US PPI figures are generally published in the second trading week of the month;
- the German data refer only to Western Germany (Federal Republic of Germany before the unification), except for M3 and Trade Balance which refer to unified Germany;
- the timing of the German announcements is not regular, but they usually occur between 7:00 and 13:00 GMT; in the absence of other sources of information, we take the time of a German announcement to be the time of its report by Reuters' news service; since the majority of the market participants receive their information through Reuters' or similar news services, it is reasonable to assume that the time of the Reuters' report is the time the information reaches the market; this would not be true if the other news services reported the announcement before Reuters', but given the periodicity of our data (5 minutes) it is not likely that this is a serious problem;
- the regularity in the week of the month of the German releases is not precise; there is no regularity for the Trade Balance announcements, due to the fact that during our sample period the German Federal Statistics Office was implementing the transition from Western German to unified German data; until the end of 1992 the emphasis was on data for Western Germany only, although data for unified Germany was also published, but with some delay; from January 1993, the emphasis shifted to unified Germany data, which was the first to be announced; this shift led to irregular data releases;
- we have a maximum of 36 observations for each announcement series; however, as the publication of the US Mercantile Trade figure was discontinued in late 1994 there are only 33 data points for this announcement and within this 3 year span there are only 35 US Leading Indicators announcements; also, irregularity in the German Trade releases (there are only 35 Trade releases in our data period) and some missing expectations data reduce the number of usable observations for most of the German series.

Figure 3.1: The persistence of the effect of US 'news' on the DEM/USD: average scaled response



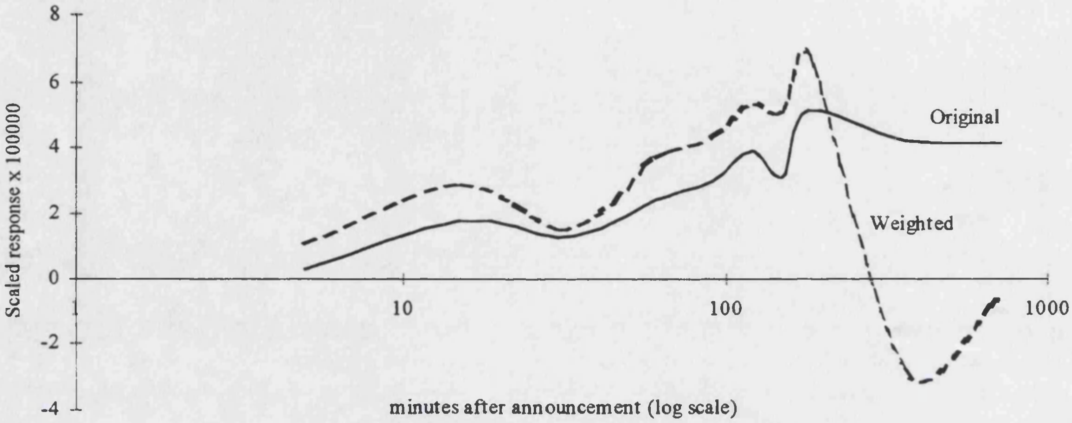
Notes: The graph plots the average across all announcements of the scaled response (the absolute value of the product of the regression coefficient on 'news' and the mean absolute forecast error) for different return horizons.

Figure 3.2: The persistence of the effect of US 'news' on the DEM/USD: average t-statistic



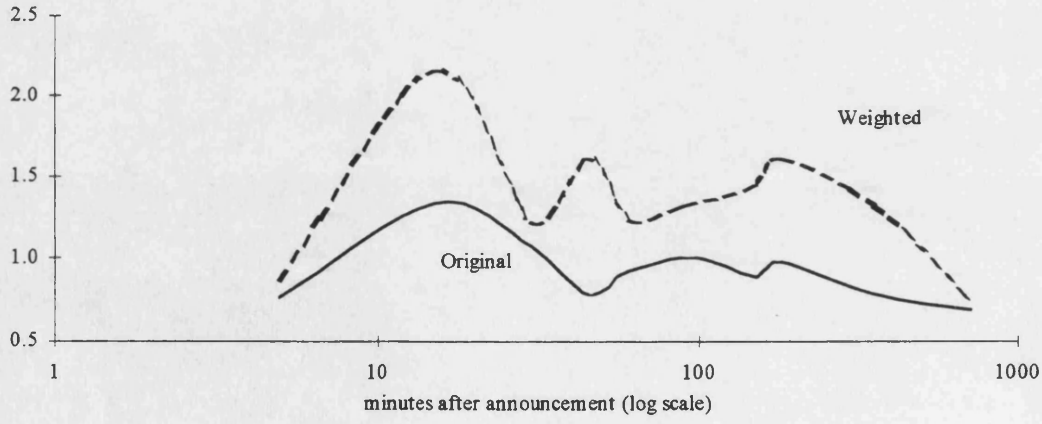
Notes: The graph plots the average across all announcements of the T-statistic on the coefficient on news' for different return horizons.

Figure 3.3: The persistence of the effect of German 'news' on the DEM/USD: average scaled response



Notes: The graph plots the average across all announcements of the scaled response (the absolute value of the product of the regression coefficient on 'news' and the mean absolute forecast error) for different return horizons.

Figure 3.4: The persistence of the effect of German 'news' on the DEM/USD: average t-statistic



Notes: The graph plots the average across all announcements of the T-statistic on the coefficient on news' for different return horizons.

Chapter 4

Monetary Policy in Developing Countries: Objectives and Independence

This chapter examines the monetary policy framework in 44 developing countries that appear to be reasonably representative of central banks in developing countries as a whole. The majority of the previous work on monetary policy objectives was motivated by the history and circumstances of central banks in the developed countries (e.g., Fischer, 1994, Goodhart, 1994), or focused on specific (or small groups of) developing countries. Central banks in the developing countries tend to face a different set of economic problems and conditions, that changes substantially the nature of the monetary policy choices. The purpose of this chapter is to provide an overview of the objectives of monetary policy in a wide sample of developing countries. The chapter also discusses the conflicts that may arise when central banks pursue several objectives, and how the legal status of the central bank affects policy outcomes.[1]

[1] This chapter is based on a study on central banking in developing countries sponsored by the Bank of England. The results of this study were presented in the Bank of England's Symposium on Central Banking in Developing Countries on 9 June 1995, and published in Fry, Goodhart, and Almeida (1996). Only the results that are relevant for this thesis are presented in this chapter, and some of the topics are only mentioned briefly here. Extensive discussions of the latter may be found in Fry, Goodhart, and Almeida (1996).

The chapter starts with a description of the data sources and of the countries included in the sample analysed. The choice of countries to include in this study was not random, and in Section 4.1 we try to assess whether our sample is nevertheless representative of the population of developing countries. In Section 4.2 we note that the primary objective of central banks, in both developing and developed countries, has generally moved towards the attainment of price stability. Considering that growth is negatively associated with inflation (Barro, 1995, Gregorio, 1996, Fischer, 1994) and inflation is disliked for its own sake, the achievement of price stability would seem, subject to the transitional costs of getting there, self-evidently desirable. Since inflation is a monetary phenomenon, as we document once more, and central banks should be able to control monetary conditions, why is inflation still so high in so many countries?

One reason may be that central banks have been pursuing other objectives. In Section 4.3 we point out that short-sighted governments have in many cases effectively used their central bank as an alternative source of revenue, and that external constraints may affect the ability of central banks to conduct monetary policy. We then analyse the role of the central bank in promoting the development and stability of the financial system, in Section 4.4. In Section 4.5, we explore whether the differing constitutional status of central banks has made a significant difference to their behaviour, especially with respect to their relative inflation performance. The subject matter of this section falls mainly within the rapidly expanding field of central bank independence and covers much the same ground as Cukierman (1992, chs. 18–23), Cukierman, Webb, and Neyapti (1992), Cukierman *et al.* (1993) and Gregorio (1996). Section 4.6 provides some concluding remarks.

4.1 Sample Countries and Data Sources

This study relies on several sources of information. Most of the quantitative work is based on data from the *International Financial Statistics* and the World Bank's *Socio-*

economic Time-series Access and Retrieval System: World Tables. In addition to publicly available data from the *IFS* and *World Tables*, we supplemented the factual basis for this chapter through responses to a questionnaire on a variety of central banking topics sent to a sample of central banks. The questionnaire is reproduced in Appendix 4.A, and the countries to which it was sent are listed in Table 4.1.[2] These countries, referred to hereafter as the BoE group, were not randomly selected, but consisted of those whose governors had been invited to the Bank of England's Symposium on Central Banking in Developing Countries on 9 June 1995. For this reason, the group consists predominantly of Commonwealth countries and under-represents Francophone and East Asian countries.

Table 4.1 **Sample countries - the BoE Group**

Africa	*Asia*	*Middle East and Europe*	*Western Hemisphere*
Botswana	Bangladesh	Cyprus	Argentina
Gambia	Brunei	Israel	Chile
Ghana	Fiji	Jordan	Bahamas
Kenya	Hong Kong	Kuwait	Barbados
Lesotho	India	Malta	Belize
Malawi	Malaysia	Saudi Arabia	Guyana
Mauritius	Pakistan	United Arab Emirates	Jamaica
Namibia	Papua New Guinea		Mexico
Nigeria	Singapore		St. Lucia
Sierra Leone	Solomon Islands		Trinidad & Tobago
South Africa	Sri Lanka		
Swaziland			
Tanzania			
Uganda			
Zambia			
Zimbabwe			

Nevertheless, the BoE group possesses most of the features that characterise the developing country population as a whole. Table 4.2 compares some salient variables across

[2] The questionnaire partially reproduced in Appendix 4.A was the basis for the study published in Fry, Goodhart, and Almeida (1996). The questionnaire included some questions that are not presented in Appendix 4.A, because they refer to topics that are outside the scope of this chapter. The aggregated raw data on which our analysis is based can be obtained from the authors. However, the individual questionnaire responses are confidential and could be released only with each central bank's agreement. Although the Eastern Caribbean Central Bank is located on St. Kitts, we use St. Lucia in our quantitative analysis because it is the largest country served by this central bank. Unfortunately, data deficiencies prevented the inclusion of Brunei in the quantitative analysis presented here.

developing and OECD countries.[3] The sample consists of 122 developing countries and 20 OECD countries, all countries for which reasonably comprehensive data sets are available from *IFS* and *World Tables*.[4] The 122 developing countries are split into two groups: a control group of 79 countries and 43 countries of the BoE group.[5]

Table 4.2 **Some macroeconomic and monetary characteristics of developing and OECD countries**

Variable	*Developing Countries (122)*	*Control Group (79)*	*BoE Group (43)*	*OECD Countries (20)*
YG	2.9	2.7	3.3	2.5
INF	29.4	27.7	32.2	7.3
M/Y	38.9	35.7	44.2	67.6
H/M	40.3	44.2	33.2	13.7
R/D	28.6	33.8	19.1	5.7
CBCG	85.0	84.9	85.1	45.3
CGDC	21.2	21.0	21.6	15.9
GS/Y	-5.9	-6.4	-5.0	-3.8
GR/Y	25.2	24.2	26.8	32.8
DT/Y	68.6	69.3	67.2	n.a.
PCY	$1,149	$1,000	$1,440	$21,083

Notes: the table refers to the average of annual values for the period 1979-1993, in percent, except when indicated. Key: *YG*, Trend growth rate in GDP at constant prices; *INF*, Consumer price inflation; *M/Y*, Money (M2)/GNP; *H/M*, Reserve money/M2; *R/D*, Bank reserves/Bank deposits; *CBCG*, Central bank net credit to government/Net domestic credit to government; *CGDC*, Net domestic credit to government/Aggregate domestic credit; *GS/Y*, Government deficit (–)/GDP; *GR/Y*, Government revenue/GDP; *DT/Y*, Foreign debt/GDP; *PCY*, 1992 per capita income in US dollars (exchange rate based, geometric averages).

[3] The 20 OECD countries used for comparison throughout this chapter are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and United States.

[4] Data for Hong Kong were obtained from local sources and Asian Development Bank, *Key Indicators of Developing Asian and Pacific Countries* (annual).

[5] The countries in the control group, which consists of all other developing countries for which a reasonably complete data set is available, are Afghanistan, Algeria, Antigua and Barbuda, Aruba, Bahrain, Benin, Bhutan, Bolivia, Brazil, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, China, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Gabon, Greece, Grenada, Guatemala, Guinea-Bissau, Haiti, Honduras, Indonesia, Iran, Korea, Lebanon, Liberia, Libya, Madagascar, Maldives, Mali, Mauritania, Morocco, Mozambique, Myanmar, Nepal, Netherlands Antilles, Nicaragua, Niger, Oman, Panama, Paraguay, Peru, Philippines, Portugal, Qatar, Rwanda, St. Kitts and Nevis, St. Vincent and the Grenadines, Senegal, Seychelles, Somalia, Sudan, Suriname, Syria, Thailand, Togo, Tonga, Tunisia, Turkey, Uruguay, Vanuatu, Venezuela, Western Samoa and Zaire.

Table 4.2 shows that developing countries present features that clearly distinguish their financial systems from OECD countries. For instance, the ratio of money (M2) to GNP (*M/Y*) in developing countries is barely above one-half of the money/income ratio in OECD countries. Also, the data in Table 4.2 suggest that central banks dominate their financial systems to a considerably greater extent in developing countries than they do in the OECD countries. Specifically, the ratio of central bank liabilities in the form of reserve money (currency in circulation plus bank deposits at the central bank) to M2 (*H/M*) is almost three times higher in developing countries than in the OECD countries, and the ratio of bank reserves to bank deposits (*R/D*) is five times higher in developing countries than in the OECD countries.

While Table 4.2 demonstrates that developing countries differ from OECD countries in some important respects, it also suggests the BoE group does not diverge greatly from the developing country population as a whole, at least in terms of the variables considered. For example in the period 1979-1993, in both the BoE group and all other developing countries:

- inflation (*INF*) averaged 30 percent;
- the ratio of M2 to income (*M/Y*) averaged 40 percent;
- the ratio of reserve money to M2 (*H/M*) averaged 40 percent;
- the ratio of bank reserves to deposits (*R/D*) averaged 25 percent;
- Government deficits averaged 6 percent of GDP (*–GS/Y*);
- foreign debt averaged 70 percent of GDP (*DT/Y*).

In other words, the BoE group appears to represent developing countries reasonably well. We hope, therefore, that our findings from this group apply more broadly to developing countries in general. Nevertheless, the BoE group is far from homogeneous, another accurate reflection of developing countries as a whole. Average rates of economic growth over the period 1979–1993 range from –2.3 percent in Guyana to 10.2 percent in Botswana. Inflation averaged 0.7 percent in Saudi Arabia compared with 556 percent in Argentina. Per capita income comparisons also reveal large disparities.

4.2 Price Stability in the BoE Group

4.2.1 Inflation and growth

In the 1960s, much of the economics profession accepted the finding that a trade-off existed between inflation and growth. In the 1970s, more sophisticated expectations-augmented Phillips curves became popular. Far from there being any exploitable trade-off in the medium and longer term between inflation and higher output levels, the accepted view now is that in the longer term this relationship is negative, i.e., more inflation is associated with lower growth (Barro, 1995, Gregorio, 1996, Fischer, 1994). Negative sloping long-run expectations-augmented Phillips curve relationships between inflation and growth have been found, particularly in developing countries (Fry, 1995, ch. 10). This negative relationship between inflation and growth is also what simple bivariate regressions, cross-section and pooled time series, indicate for the BoE group in both long and short runs, even though the average inflation-average growth rate relationship portrayed in Figure 4.1 does not seem to exhibit any clear pattern.[6]

We analysed the relationship between economic growth and nominal variables (inflation, M1, and M2), by regressing average output growth both against average CPI inflation and the average growth rates of M1 and M2 (measured in percentage points). To assess the robustness of the results presented in Table 4.3,[7] these averages were computed over different periods: a 15-year period (1979-1993); the last five years of that period (1989-1993); and using annual data for 1991, the latest year for which a complete data set was available.

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6 Figures 4.1 and 4.3 exclude Argentina because it is an extreme outlier.

7 The data in Table 4.3 are again exclusive of Argentina, because this country is an anomaly in this respect since it combines an extremely high inflation rate with a moderate rate of growth. If Argentina was included with the other countries in Table 4.3, all the coefficients would become less negative, and none would then be significant. The Argentina case clearly weakens the claim that inflation reduces growth, but the experience of this country may be considered an outlier and sui generis.

Table 4.3 **Regression of nominal variables on growth**

Explanatory Variable	*Dependent variable: average GDP growth in* 1979–1993	1989–1993	1991
CPI Inflation	–0.023	–0.050	–0.059
	–1.17	*–2.72*	*–2.82*
M1	–0.018	–0.084	–0.027
	–0.76	*–2.52*	*–1.52*
M2	–0.005	–0.015	–0.034
	–0.30	*–1.14*	*–1.47*

Notes: the table presents the coefficient and t-value (in italics) of a regression of the nominal variable on real GDP growth; a constant term was used in all regressions but is not presented here to save space.

The negative relationship appears to be slightly stronger in the short run, in part because of outliers, notably Zambia and Sierra Leone, both with low growth and high inflation. Partly to remove cases of (incipient) hyperinflation, where the negative relationship may well be stronger, we re-ran the test excluding all countries in which inflation over the relevant period exceeded 50 percent. These latter tests reported in Table 4.4 indeed suggested, as has been also found elsewhere, that the strength of the negative relationship (between growth and nominal variables) is greater in absolute terms among the inflationary outliers. None of the above simple relationships is significantly different from zero but, apart from the relationship between the growth of output and nominal money in 1991, which may have been influenced by very short-term cyclical factors, all the coefficient signs remain negative.

Table 4.4 **Regression of nominal variables on growth (excluding outliers)**

Explanatory Variable	*Dependent variable: average GDP growth in* 1979–1993	1989–1993	1991
CPI Inflation	–0.074	–0.053	–0.104
	–1.25	*–1.03*	*–1.49*
M1	–0.063	–0.054	+0.011
	–1.17	*–1.08*	*0.18*
M2	–0.023	–0.065	+0.068
	–0.43	*–1.16*	*1.39*

Notes: see Table 4.3.

The deleterious effects of hyper-inflation on growth, with the dislocations caused to saving patterns and to the monetary and pricing mechanisms, are fairly obvious. But inflation has, so it is claimed, a negative effect on growth even at low or moderate levels.

In part, this latter effect may be because a higher level of inflation is generally associated with a greater variability of inflation and hence a greater riskiness of longer-term unindexed contracts. We find that the correlation between the level and standard deviation of inflation averaged over the 1979-1993 period for the BoE group was +0.961; the observations shown in Figure 4.2 lie closely along the 45° line.[8] The variability in inflation is also associated within this group with high variability in monetary expansion (correlation +0.879) and in both nominal and real exchange rates vis-à-vis the US dollar, with correlations of +0.516 and +0.347 respectively on a cross-country 15-year basis. Similarly, the variability in real interest rates (lending rate) was significantly positively correlated with the variability in both M2 growth, +0.742, and in inflation, +0.879 (all significant at the 99 percent confidence level).[9] Thus instability in nominal variables, money and inflation, is associated with higher variance (and presumably less predictability) in certain key *real* prices, i.e., real exchange and interest rates, another channel whereby inflation may depress growth.[10]

There are a wide variety of potential channels for both negative and positive effects running from inflation to growth, and *vice versa*. In developing countries, fixed nominal interest and exchange rates may have been particularly harmful (Fry, 1995, ch. 8). As

8 Whereas the mean and the standard deviation of inflation are strongly positively correlated, there is very little correlation between the mean of inflation and its coefficient of variation, i.e., the standard deviation *divided* by the mean. The question of what relative weight we should place on the standard deviation or the coefficient of variation can be given a concrete example. Would we regard a move from an average inflation of 0.8 percent (or 8 percent) to 1 percent (or 10 percent) as disturbing and dislocating as a move to 100 percent from an average inflation of 80 percent? If we held very long term assets, the answer could be yes. But once inflation runs at even a moderate level, the length of contracts, asset durations, etc., tend to shorten, so that the standard deviation is more relevant. Furthermore, our main concern is with real variables, real interest and exchange rates. To estimate the future expected level of such real variables, we have to use our best point estimate of future inflation. Hence *both* the coefficient of variation and standard deviation of such *real* variables will be a positive function of the standard deviation (but not of the coefficient of variation) of inflation.

9 The correlations shown in this paragraph were all estimated exclusive of Argentina whose extraordinary average inflation rate makes it an extreme outlier. If Argentinean data are included, all the correlations rise, with the exception of those between the variability in inflation and the variability in both nominal and real exchange rates. These latter instead fall sharply towards zero and are no longer significant.

10 Besides the nexus of interrelationships between the variability exhibited in money, inflation and both nominal and real exchange and interest rates, there is a second set of such inter-relationships among the BoE group between the variability of the government deficit and the variability in real interest rates, +0.499, in real (but *not* nominal) exchange rates, +0.340, and in output growth, +0.313.

inflation rises, lower real interest rates resulting from fixed nominal rates reduce credit availability and distorts resource allocation, while a fixed exchange rate prices exports out of world markets. Both effects are growth-reducing. Our results are consistent with the present consensus view, that the longer-term effect of inflation on output growth is negative, though the strength of the relationship is variable.

4.2.2 Price stability in central bank statutes

With inflation also being disliked for its own sake, the natural implication is that the objective of a central bank must be to achieve price stability. This objective has come to be widely, if not generally, accepted among central banks in OECD countries. For example, the protocol of the European System of Central Banks (ESCB) in the Maastricht Treaty makes price stability the primary objective, with support for other governmental objectives only possible when price stability has been attained (a lexicographic ordering). The statutes of other European central banks, both in the West, e.g., France, Spain and Sweden, and in the East, e.g., the Czech Republic and Hungary (Hochreiter, 1994), have been altered consonantly.

In virtually all cases, the statutory objectives of the central banks in the BoE group include the preservation of the (external and internal) value of the currency. This was mentioned in 28 out of the 33 responses to question F5 of the questionnaire, where we asked for the statutory objectives of the central bank. However, only four countries (Argentina, Chile, Cyprus and Mexico) gave it the same priority as the ESCB. Five central banks did not answer and four do not have statutory objectives. In Belize the statutes relate to functions rather than objectives and do not mention nominal stability. In the other 26 cases, nominal stability (external, internal or both) was an objective among others. This lack of priority for price stability in part is because central bank statutes are amended only at long intervals. Were all the countries in the BoE group to revise their central bank statutes today, we surmise that a larger proportion would give primacy to the achievement of price stability.[11]

Whether the priority given to price stability would or would not be taken as absolute, it is generally given a high priority by the central banks in the BoE group. Yet the results have been mixed in this respect. Although the experience of the BoE group has been better than the control group of 79 other developing countries, it has been much worse than the developed OECD countries, as shown in Table 4.2. That table shows the average mean level of inflation over the 1979-1993 period. Average mean values are, however, susceptible to large outliers. A variety of additional data on CPI inflation are given in Table 4.5 for the BoE group. These data indicate that the disappointing inflation figures are not just the result of a few very high inflation countries distorting the average value. The problem is much more widespread.

Table 4.5 **The CPI inflation experience in the BoE Group**

Statistic	*Average 1979–1993*	*Average 1989–1993*
Mean	32.20	43.56
Median	12.36	11.41
Standard Deviation	85.64	171.86
Average in bottom quartile	4.34	3.50
Average in top quartile	103.68	154.12
Maximum	555.84	1,120.19
Minimum	0.68	1.79
Top of Q.1/Q.3	6.57 / 21.53	5.54 / 18.92

Nor is there much evidence that inflationary problems have diminished over time in the BoE group. We can compare the same statistical data on inflation for the 5-year period 1989–1993, with those already shown for 1979–1993 in Table 4.5. The mean inflation rate has increased, while the median has diminished slightly. The distribution and standard deviation have become more dispersed and skewed.

[11] Governments, and central banks, in developing countries are more concerned to foster growth than those in the OECD countries. Consequently they might be more prepared to adopt policies, which might seem to promise higher growth, but which also risk higher inflation, even though such higher inflation would have an inimical effect on growth. Indeed, an excessively aggressive push for growth at all costs might even lead, counterproductively, to higher inflation and lower growth.

4.2.3 Money and inflation

Moreover the problem is one of monetary control; inflation is a monetary phenomenon. We rehearse once again, here for the BoE group, the familiar strong positive relationship between inflation and monetary expansion. In Table 4.6 we present the results of regressing inflation against the growth of M1 and M2 as alternative explanatory variables on a cross-country basis over a variety of periods: 15-year average (1979–1993), each of the constituent 5-year averages and 1991 taken by itself. A scatter diagram for the 15-year average (M1) is shown in Figure 4.3. The relationship for 1991 is comparatively much weaker. As expected, the relationship between inflation and monetary expansion appears to be stronger in the medium run.

Table 4.6 **Regression of monetary growth on inflation**

Explanatory Variable	*1979–1993*	*1979–1983*	*1984–1988*	*1989–1993*	*1991*
M1	1.059	1.127	1.093	1.038	0.730
	74.9	*20.9*	*44.1*	*64.6*	*7.0*
	(0.993)	(0.916)	(0.980)	(0.990)	(0.566)
M2	1.258	0.577	1.074	1.456	0.980
	30.9	*10.2*	*24.5*	*20.8*	*10.1*
	(0.959)	(0.721)	(0.937)	(0.913)	(0.726)

Notes: the table presents the coefficient, t-value (in italics) and adjusted R^2 (in parenthesis) of regressions of money growth on inflation; a constant term was used in all regressions but is not presented here to save space.

Some might argue, though it is not an argument that we ourselves would support, that the responsibility of a central bank for monetary control is less immediate when monetary expansion (or variability) is caused by changes in the money multiplier than when it derives from changes in the reserve base. In fact, as expected, the correlations between cross-country changes in the reserve base and in inflation are also very high (1979–1993, +0.971; 1989–1993, +0.990). A decomposition of monetary expansion (M1 and M2) into that part caused by increases in the reserve base or in the money multiplier revealed no systematic effects (data available on request). Correlations between the *variability* in monetary growth (M1 and M2) and in both the reserve base and the money multiplier revealed that the former at +0.998 and +0.913 respectively were much larger than the latter (+0.009 and +0.038).

During the 15 years of our data period, the median level of inflation in the BoE group was 12.4 percent, falling to 11.4 percent over the last five year average; this compares with 6.4 percent and 3.6 percent for the OECD countries. There is perhaps one encouraging feature. Among the worst performers in terms of inflation over the data period were the Latin American countries, e.g., Argentina and Chile. In recent years Argentina and Chile have shown remarkable progress in reducing inflation, as a result of political and economic reforms.

Nevertheless the inflationary experiences of the BoE group have been, at best, patchy. Moreover, since inflation is a monetary phenomenon, central banks must bear a considerable share of the responsibility for this state of affairs. Yet, as already noted, most of the BoE group had a statutory requirement to maintain the value of the currency. So why did most of them fail to meet this requirement? The likely explanation is that central banks were under pressure, for a variety of reasons, to help achieve other objectives, like supporting weak financial systems, and financing their governments, and those to whom their governments wished to provide financial subsidies. The potential conflicts that may arise when central banks are required to pursue other objectives than price stability are the subject of the two following sections.

4.3 Relations with Government and External Constraints

4.3.1 Quasi-fiscal activities

The previous section has demonstrated a great variety of inflationary and monetary experience across the BoE group. Large part of this variation might be due to the differing pressures that governments have placed on their central banks, for a variety of reasons. In the OECD countries such pressures are often ascribed to the myopic desire of governments to engender a short-term feel-good factor for electoral purposes. In developing countries such pressures are, perhaps, caused more by the perceived objective of filling a fiscal hole. Governments generally expect to benefit financially from the monopoly privilege over fiat money that they grant to their central banks. Central banks in some of the BoE countries have generated revenue equal to the government's explicit tax revenue. Over the period 1979-1993, seigniorage revenue in the BoE group equalled 1.7 percent of GDP on average, and was above 4 percent in Argentina, Chile, Israel, and Sierra Leone (where it represented two thirds of government revenue). Even though central bank profits are usually much lower than our seigniorage estimates, they are still sizeable (above 1 percent of GDP in some cases).

Even when they do not transfer large profits to the government explicitly, central banks may be performing a range of quasi-fiscal activities, like providing implicit subsidies through credit or foreign exchange guarantees, or imposing restrictions on the financial system that will benefit the government, such as interest rate controls. From the fiscal viewpoint, interest rate ceilings are imposed to stifle competition to public sector fund raising from the private sector. Over the period 1979-1993, the implicit tax derived from financial repression in the BoE group averaged 2.2 percent of GDP, and was above 5 percent in Guyana, Israel, Sierra Leone, and Zambia.

A central bank that is obliged to provide an important contribution to government financing is likely to have its ability to maintain price stability impaired. Many central banks in the BoE group were not well placed to repel such pressures. Of those who answered question F7, 72 percent stated that the government could require the central bank to finance its deficit. Of those who answered question F8, 41 percent stated that central bank financing of that part of the deficit *not* covered by bond sales was automatic, although there were in all cases some statutory limits.[12]

[12] Fry, Goodhart, and Almeida (1996, ch. 3), present an extensive discussion of the quasi-fiscal activities of central banks in developing countries, and describe the methodology and the individual country estimates of government revenue from seigniorage and financial repression presented in this subsection.

4.3.2 External activities

Monetary and exchange rate policies are closely related in all countries. In some countries the foreign exchange rate regime dominates or constrains monetary policy, while in others the opposite is true. In a number of countries fiscal exigencies are the overriding determinant of the monetary-foreign exchange regime choice: rapid and uncontrollable monetary expansion makes a float virtually inevitable. In all countries fiscal stance, monetary policy and the foreign exchange rate regime are closely intertwined. In the BoE Group, while 20 out of 39 questionnaire respondents indicate that the exchange rate regime was decided, at least in part, by the central bank (question C2), it was determined by the government in 12 cases. In the other cases, it was a matter of historical accident or inheritance.[13]

There is a wide variety of reasons behind the choice of exchange rate regime. Interestingly, only Israel and Hong Kong appear to use the exchange rate explicitly (although Singapore uses it implicitly) as a nominal anchor. Optimum currency area or dominance by a large neighbour explains most cases of definitively fixed exchange rates (Bahamas, Barbados, Belize, Cyprus, Namibia, St. Lucia and Swaziland). However, its use as a nominal anchor lies behind Hong Kong's choice of a fixed exchange rate and oil exports priced in US dollars behind the same choice by Saudi Arabia and the United Arab Emirates. Argentina adopted its recent fixed exchange rate regime "as the only way to guarantee its [the peso's] use by the public and allow the government to collect seigniorage" in the aftermath of hyperinflation and currency substitution in the 1980s.

Various reasons were given for the choice of a managed but not fixed exchange rate. Perhaps the greater flexibility it provides lay behind the responses from Bangladesh and Sri Lanka that the choice was dictated by the liberalisation process. Other reasons include balance-of-payments equilibrium (Chile and South Africa), maintaining export competitiveness (India and Pakistan), unspecified trade-related advantages (Botswana,

[13] For example, Lesotho and Swaziland have their exchange rate regimes determined by South Africa.

Malaysia, Malta and Solomon Islands), and exchange rate stability (Jordan and Kuwait).[14] As already pointed out above, Israel uses its managed exchange rate as a nominal anchor through a crawling peg designed to decelerate domestic inflation towards the world average. Floating exchange rates were chosen on the grounds of balance-of-payments equilibrium (Gambia), liberalisation (Jamaica, Uganda and Zambia), avoidance of speculative attacks (Mexico), avoidance of appreciation in the real exchange rate (Nigeria), and consistency with market-based economic policy (Sierra Leone).

Intervention in the foreign exchange market is decided by the central bank in most of the BoE group, in three cases after consultation with the government. In Argentina, Hong Kong and South Africa, the government takes responsibility for this decision. There was however more involvement by governments in the decisions over exchange controls, although 18 out of 26 central banks played some role in these decisions. In 12 of the BoE group, this question was not applicable since there are no exchange controls.

Perhaps of greatest significance is the fact that the choice of exchange rate regime is associated with the size of the government's deficit. Using average deficits over the period 1979–1993, countries with fixed exchange rates posted deficits of 1.6 percent of GDP compared with 8.9 percent in countries with floating exchange rates; countries with managed exchange rates averaged government deficits of 4.1 percent of GDP.[15] The exchange rate regime is also associated with a country's foreign debt level: fixed exchange rate countries averaged foreign debts equal to 38 percent of GDP compared with 101 percent of GDP for floating exchange rate countries. Again, managed exchange rate countries are between the two, but nearer the fixed rate countries, with debt/GDP ratios averaging 47 percent of GDP.

Some central banks in the BoE group are constrained to operate in an external framework that was decided by their governments. It is possible that this decision may be determined more by fiscal considerations, than by monetary policy concerns. Given the

[14] Presumably in comparison with a floating exchange rate regime.

[15] All the differences and associations mentioned in this paragraph are significant at the 95 percent confidence level.

close connection between monetary and exchange rate policy, a central bank that is faced with an 'inappropriate' exchange rate regime, or has to provide (implicit) subsidies in its external activities, will have increased difficulties to achieve price stability.[16]

4.4 Economic Development and Stability of Financial Systems

Central banks have two main inter-related functions, first the macro-function of maintaining nominal price stability and second the micro-function of ensuring the healthy development of the payments, banking and financial systems. The functions are inter-related because the stability of the banking system will be threatened by high and volatile inflation, while the price mechanism in turn is likely to be disturbed by booms and busts, especially systemic crises, in the payments and banking systems, and perhaps within the wider financial system as well.

4.4.1 Financial development and growth

There is a large literature on the relationship between the growth and development of the real economy and of the financial system, with two-way causation (e.g., Cameron, 1972, Cameron *et al.*, 1967, Fry, 1995, Gerschenkron, 1962, Goldsmith, 1969, McKinnon, 1973, Shaw, 1973, World Bank, 1989). In developing countries, commercial banks are usually the first, and often remain the most important, financial intermediaries. Channelling saving through such intermediaries, with their specialised ability to assess the value of loan projects, should allow both larger and better projects to be financed (than when investment is done directly through family and friends). The development of the banking habit can encourage both saving and investment, and there is an association between a higher bank deposit/income ratio and both the level and rate of growth of output, that

[16] For a more detailed analysis of the external activities of central banks in the BoE group, see Fry, Goodhart, and Almeida (1996, ch. 4).

has been extensively documented (e.g., Gregorio and Guidotti, 1995, King and Levine, 1993a and 1993b, Pagano, 1993, World Bank, 1989).

As an illustration of this, albeit in an exceedingly simple format, we examined the relationship between a number of variables relating to growth, i.e., the level of per capita incomes, the growth rate of real GDP, the saving/income and investment/income ratios over the *whole* period (taken as the average of the 15 years, 1979–1993) and a measure of the comparative development of bank intermediation, the deposit/income ratio, at the *beginning* of our period (taken as the average of the first five years). In the case of two countries, the saving ratio over this period was reported as negative. If these outliers are removed, the fit of the relationship with the saving ratio improves considerably; so this equation is reported with and without these outliers in Table 4.7.

Table 4.7 **Regressions of monetisation on growth**

Dependent Variable	*t value of BD/GDP, 1979–83*	$\overline{R}^2$	*Number of Countries*
GDP per capita	1.77	0.052	40
Real GDP growth	1.06	0.003	36
I/Y	3.75	0.277	35
S/Y	1.45	0.046	24
S/Y without outliers	4.96	0.530	22

Notes: the table presents the t-value of the coefficient of the variable Bank deposits/GDP 1979-1983 average, on regressions of this variable and a constant term on the various dependent variables.

In all these regressions the relationship is positive, and with the investment ratio and saving ratio, excluding outliers, it is significantly so. Of course, the relationship between the increasing use of banks and growth is two-way, which is why we regressed the dependent variable over the whole period on the deposit/income ratio at the start of the period. If we run the relationship the other way around, in this instance by examining the relationship between the deposit income ratio at the *end* of the period (1989–1993) and the growth variables over the whole period (1979–1993), the fit improves for the saving ratio and per capita GDP, but not for the investment ratio, as shown in Table 4.8. It is perhaps plausible to surmise that the main causal forces run from saving to greater use of bank deposits, and from an expansion of financial intermediation through banks to investment.

Table 4.8 **Regressions of growth on monetisation**

Explanatory Variable	*t value on explanatory variable, 1989–1993*	$\bar{R}^2$	*Number of Countries*
GDP per capita	2.93	0.156	42
Growth in Real GDP	1.44	0.028	38
I/Y	2.32	0.093	37
S/Y	1.76	0.080	25
S/Y without outliers	5.56	0.576	23

Notes: the table presents the t-value of the explanatory variable (average 1989-1993), on regressions of this variable and a constant term, on Bank deposits/GDP (1979-1993 average).

4.4.2 Central banks as promoters of financial development

Given this association between financial development and growth, it is only natural that central banks in all countries have great concern for the health, development and stability of their payments, banking and financial systems more broadly, including the development of appropriate financial markets in their countries. But the responsibility of central banks in developing countries for the evolution and improvement of such systems in their own countries is even stronger because of their more predominant role within their own country's financial system. The central bank is not only the centre of the financial system, but in many cases also its architect.

In most cases, the central banks in the BoE group are responsible for running and developing the payments' systems, a somewhat mundane but nevertheless vital aspect both of their functions and of the proper working of the monetary system. Of the 38 central banks that responded to question B3, 26 indicated that they directly run the clearing system, while in 3 other cases the central bank runs it 'partially' (where it has banking offices). Even when it does not, it is almost always intimately involved as a participant and/or supervisor. What we found impressive is that 24 out of the 40 central banks completing our questionnaire stated that there had been major reforms to the payments' system since 1975, and that in these 24 countries reporting major reforms, 16 central banks stated that they had initiated them. Of the others, only in Chile was the initiator clearly reported as *not* being the central bank; in Jamaica 'some' of the reforms were initiated by the central bank, and in the other cases (Argentina, India, Pakistan, East Caribbean, Solomon Islands and United Arab Emirates) this part of question B6 was not answered, or not usably so.

We obtained the impression, from the answers to questions B13 and B14 on financial markets and interest rates, that there was now some considerable momentum, at least among the BoE group of developing countries, towards financial liberalisation and the use of indirect open-market techniques. Of the 40 countries in the BoE group who responded to question B16 about the use of indirect open-market operations, 28 (70 percent) stated that they were already used (and of these two, Malta and Mauritius, referred to new financial instruments and liberalisation being introduced). In some cases, however, the use of such market mechanisms did not extend much further than the introduction of (primary) auctions in treasury bills, or other money market instruments, with little secondary market activity. Of the remainder, two, Cyprus and Trinidad and Tobago, reported reforms (e.g., removal of interest rate ceilings) that should enable them to introduce such techniques soon; Israel only used open-market operations on a limited basis, since the volume of treasury bills was too small for monetary management purposes, but recently the Central Bank of Israel started purchasing government bonds to inject liquidity. Of the nine further countries reporting that they did *not* use open-market operations, two, Bahamas and Barbados, both noted specifically their participation in other respects in financial markets (Bahamas in the government securities market and Barbados in the treasury bill tender), and Namibia replied "Not yet". The other negative replies came from the smallest countries, Belize, Brunei, Guyana, Eastern Caribbean, Solomon Islands and Swaziland.

The change from direct controls to indirect market mechanisms can only take place if developed financial markets exist, and in most cases this requires positive encouragement, by the central bank and other relevant authorities, of financial markets. In order to assess progress on this front, we asked two specific questions, B12 on the current conditions in the money, bond, and equity markets, and B13 on the difficulties being faced in establishing them, in our questionnaire.

Only two countries (Chile and Mexico) can be classified has having fully developed money, bond and equity markets. In four other countries (Hong Kong, India, Singapore and South Africa) the money and equity markets are fully developed, but the market for private sector bonds is still thin. At the other end of the spectrum, the Bahamas, Belize, Eastern Caribbean, Gambia, Guyana, and Sierra Leone do not have any formal money, bond or equity markets. Overall, we found that two thirds of the countries that responded to question B12 had very limited money and bond markets, reduced at most to primary issues of treasury bills or government bonds, and a very thin secondary market on these securities. The situation was similar for the equity market, with 60 percent of the countries having no formal stock market, or where a formally organised stock exchange existed, with few placements and low capitalisation and turnover.

One of the points that emerged from the analysis of questions B12 and B13, is that in both the money market and the bond market, but especially in the latter, there appears to be a need for a market, initially primary and then secondary, to be established in government debt, both to provide a benchmark for pricing, an infrastructure of market making, a culture of investing and portfolio management, and a pool of liquidity, before there is much chance of developing an active market in private sector corporate debentures. Thus in Hong Kong, despite the advanced nature of its money and equity markets, its bond market was relatively dormant until the recent initiative to issue Exchange Fund Bills and Notes. On the other hand the public sector can have such a large appetite for longer-term borrowing that it may seem to crowd out private sector debentures, as in South Africa, and over some periods Israel. In some countries and at some times, moreover, institutional investors have been required to take up government bonds (at unfavourable prices), thereby further weakening the private sector bond market. The relationship between the roles of the public sector and the private sector in the development of the bond market is more complex than in the case of the money and equity markets. This may well account for the fact that we have classified many fewer countries as having a fully developed bond market than in the other two cases.

We noted the large number of responses that reported developments in progress, and that indicated that these were being initiated by the central bank. We also asked what were the three biggest difficulties in establishing these domestic financial markets in question B13. The most frequent complaint, mentioned by 15 of the 31 countries that responded to this question, related to the activities, or rather lack of activity, of private sector participants. You can take the private sector to a liberalised financial sector, but you cannot necessarily expect them to develop an investment 'culture' immediately. Entrepreneurs do not want to go public; investors sometimes seem to prefer a world of fixed and administered interest rates to one in which they have to make portfolio choices, which can go wrong. One question is whether such attitudes will naturally adjust over time; and, if not, what, if anything, the central bank can usefully do to improve the investment 'culture' among potential private sector participants?[17]

Another obstacle, mentioned by 10 central banks, is the small dimension of domestic markets. Relatively few countries reported that the general macro-economic context, or explicit taxes on financial markets, were a major problem; and few also reported that the costs and expenses of actually running the market were a deterrent. A considerably larger number (eight) complained about factors under the general heading of market repression, e.g., administered interest rates, exchange controls, statutory requirements to hold bonds, but most of these complaints were backwards looking, relating to controls and requirements that either had been, or were in the process of being, phased out. The problems caused by market repression would seem to be passing into history.

4.4.3 Stability of the banking system

Central banks within the BoE group not only have an important role in developing their financial systems, but they are also responsible for the ongoing function of maintaining the continuing health of these systems by acting as their regulator and supervisor. Out of 40 central banks in the BoE group responding to our questionnaire, all of them, except Chile, *supervised* their domestic banks, though the Banco de Mexico did so in conjunc-

[17] We suspect, however, that if we had questioned such private sector participants, we would have received rather a different slant on the nature of the problems.

tion with the Comisión Nacional Bancaria.[18] Among the 39 respondents undertaking such supervision, eight countries reported that their supervisory functions were limited to the banking system only.[19] By contrast, in five countries, Brunei, Lesotho, Malawi, Malaysia and Singapore, the central bank was asked to supervise virtually all financial institutions. In the remaining 26 countries the central banks were responsible for the supervision of a variety of near-bank deposit-taking and credit-giving institutions, building societies, etc. In part because of the fuzziness of the dividing line between banks and non-bank financial intermediaries, there is no standardised remit for the ambit of the central bank's supervisory function. That fuzziness, and the resulting uncertainty about the scale and scope of a central bank's supervisory responsibilities, is unlikely to diminish over time.

Whether or not banks (and other financial entities) are supervised, some will make large losses and fail. One of the commonest cause of such failure is fraud, which will certainly entail trying to dupe the external supervisor (e.g., BCCI), and may often involve subverting internal risk-management controls as well (as may have been the case in Barings). Once a bank has prospectively failed, and become potentially insolvent, the question of whether it should be rescued or not is contentious and depends, *inter alia*, on the likelihood of any systemic effect if it is not rescued; on the culpability of the management and owners; and on the relative size of loss that would need to be shouldered by the depositors, if the bank was to fail, and by the central bank, by other commercial banks (if there was to be a 'lifeboat' rescue party), or taxpayers if a rescue was to be mounted.

Consequently the event and size of bank failure is not a measure of the success, or otherwise, of bank supervision. Nevertheless the incidence, resolution and problems involved in, such crisis occasions may be of interest in itself. There was a wide range of experience. Within the BoE group, fourteen central banks [20] (about one-third of the

[18] The Comisión Nacional Bancaria is the supervisory authority; the Central Bank monitors transactions and carries out analysis of risk management and efficiency to prevent excessive risk taking.

[19] Belize, Gambia, Guyana, Mauritius, Saudi Arabia, Sierra Leone, Solomon Islands and South Africa. Moreover, in one of these, Guyana, financial legislation has just been enacted giving, in future, the central bank responsibility for supervising all institutions engaged in banking and/or financial business.

[20] These were Belize, Cyprus, Fiji, Guyana, India, Lesotho, Malawi, Malta, Mexico, Namibia, Saudi

group) reported no failures, or occasions for central bank restructuring, or other reported involvement during our chosen period, 1985–1993, and in six other countries the one problem needing resolution had arisen as part of the BCCI debacle, in Bangladesh, Barbados, Botswana, Mauritius, Pakistan and Sri Lanka, where in most cases the local business of BCCI was merged with another local financial institution (a finance company in Barbados, and a bank in Mauritius, Pakistan and Sri Lanka; it was restructured as a commercial bank in Bangladesh).

At the other end of the spectrum, in Kuwait, following the Iraqi invasion, the whole banking system had to be reorganised and recapitalised at considerable expense to the government. In the remaining 17 cases, where we had data, the number of banks (or supported financial institutions), and percentage of deposits involved in each country were as reported in Table 4.9.

Table 4.9 **Banking failures in the BoE Group**

Number of financial institutions involved	*1*	*2*	*3*	*4*	*≥5*
Number of countries[21]	7	4	1	3	2
Percentage of deposits	*Negligible*	*<1*	*2–5*	*5–10*	*10–15*
Number of countries[22]	3	4	4	2	2

Of the methods of dealing with failing banks, nationalisation (or a version of it) was used in three countries (in two of these temporarily prior to sale to private sector), mergers with another bank (including the BCCI cases) in eleven countries, liquidation in thirteen countries and other measures (mostly recapitalisation and restructuring with central bank

Arabia, Singapore, Solomon Islands and Zimbabwe. Whether there were cases, in these and other countries, of commercial bank 'difficulties' requiring some remedial action by the central bank, e.g., loans at concessionary rates, capital adequacy forbearance, etc., (which did not involve failure or require restructuring), we did not ask and do not know. In any case the definition of 'difficulties' and of 'remedial action' would be amorphous, so it would not be easy to be confident that one was comparing like with like.

[21] One country (Jordan) reported the percentage of deposits involved, but not the number of banks.

[22] In two countries where there was no bank failure as such, but a commercial bank needed some support, no detail of the percentage of deposits in that bank was given.

assistance) in seven countries. Ten countries used two or more methods generally involving the liquidation of some banks, and merging or restructuring others.

Seventeen central banks reported that the support operations had involved them in some expense. In those cases where such costs were heavy, e.g., in Chile (largely before 1985) and Kuwait, the cost of the exercise was predominantly borne by the government. In another case it was reported that there was a public outcry at state funds being used to 'bail out' a private bank. The central bank bore administrative and audit costs, and in several cases, especially of smaller banks, was prepared to give loan guarantees in order to facilitate a merger between the bank in difficulties and another domestic bank. In addition, the central bank in some cases was prepared to make liquidity available on concessionary terms. In Malaysia, although the central bank had to apply a significant amount of funds in the initial restructuring process, most of the cost was recouped when the shares were subsequently resold to the private sector.

Concerns with the stability of the financial system may force central banks to suffer financial losses and to undesired monetary expansion. However, the experience of the BoE group in this area has been positive. If the BCCI related problems are ignored, almost half of the group had no reported difficulties with failing banks. Apart from the special case of Kuwait, and of Chile (though at an earlier date) and perhaps Malaysia and Zambia, the problems of failures in these countries were relatively mild in comparison with those in the OECD countries. Whereas this BoE group of countries compares poorly with the OECD countries in terms of inflation control, they compare well in terms of maintaining systemic stability. Nor is there any evidence that the inflation problems have been systematically caused by measures, e.g., expansionary monetary policy, aimed at propping up a fragile banking system, though it may be argued that the financial fragility of Chile in the early 1980s may have had macro-monetary consequences.

4.5 Central Bank Independence

Research on OECD countries has shown a negative relationship between inflation and central bank independence, with the latter measured in a variety of ways, but usually including various measures of the central bank's statutory status (Grilli, Masciandaro, and Tabellini, 1991, Alesina and Summers, 1993). We sought to explore the same general issues by asking for data on a variety of issues related to the constitutional status of the central bank in section F of the questionnaire, which might help to elucidate how subservient to the government, or alternatively independent, the central bank in each country was, together with a question about how independent each central bank assessed itself as being. In such exercises there is always a problem of getting the periodicity right. The status and independence of a central bank can change, as can its inflation experience (Chile and New Zealand represent two good examples). Moreover it may take time for any changes in the position of a central bank to become apparent in (average) inflation figures. Ideally perhaps we should have sought data for the central bank's status in 1989, and examined whether and how this influenced inflation in 1991 and over the average of the last five years. In practice, we are running the regressions the other way around, comparing the role of the central bank in 1995, with *prior* inflationary experience in 1991 and over the average of 1989–1993. In particular, this caused severe problems in the case of Argentina. During our data period Argentina was the most inflationary country in our group. But in October 1992 its central bank, the Banco Central de la Republica Argentina (BCRA), was given a new Charter, as part of the country's sweeping currency and financial reform process. Following this reform BCRA now assesses itself as one of the most independent central banks in our group. To relate its current status, vis a vis independence, to inflation in 1991 or the average of 1989-93 makes no sense at all. Consequently, where relevant, we exclude Argentina as an outlier.

The first four questions of section F of the questionnaire related to the appointment of the Governor and directors of the central bank. The answers showed very little differentiation, with the exception of question F4. The appointment of the Governor (question F1) was in all cases done within the public sector, by the Head of State, or government, or Head of State on the advice of the government. The term of appointment (question F2) was 5 years in 29 out of 38 cases, usually renewable.[23] The government, or the Head of State with the government, or some public sector body, was also responsible for appointing the directors of the central bank in almost all cases (34 out of 38) (question F3). Only in four cases did the central bank itself (Bahamas, Hong Kong, Solomon Islands) or private sector shareholders (South Africa) play a role. There was, however, a much greater diversity of experience on whether a member of the Ministry of Finance (minister or permanent secretary) or other member of the government was, *ex officio*, a director (question F4). The results from our 37 responses are in Table 4.10.

Table 4.10 **Answers to questions F4, F6, and F9**

F4: Government officials on Central Bank Board	*No*	*No, but may attend*		*Yes: 1*	*Yes: 2*	*Yes: 3+*
Number of Central Banks	11	3		15	5	3
F6: Index of decision making	*0*	*1*	*1½*	*2*	*2½*	*3*
Number of Central Banks	2	9	3	16	3	5
F9: Independence own-rating	*2*	*2½*	*3*	*3½*	*4*	*5*
Number of Central Banks[24]	5	1	12	4	7	3

Question F5, where we asked for the statutory objectives of the central bank, was discussed in Section 4.2. We then asked in question F6 who decided on (a) interest rate changes, (b) changes to administered bank ceilings, ratios, etc., (c) new issues of government debt. Decision (b) was almost always done solely by the central bank (28 out of 38 cases) and jointly with another governmental body in seven more cases. Decision (c) was most usually (22 out of 38 cases) done solely by the government. Decision (a) was

[23] Of the remainder, Nigeria specified that the 5-year term represented a non-renewable maximum; in India the government fixed the duration on appointment with a maximum of 5 years; Pakistan and Singapore had a renewable 3-year term, United Arab Emirates a 4-year term, Fiji a 3–5 year term, Argentina and Mexico 6 years, and Hong Kong was not fixed. Two central banks did not answer this question.

[24] Seven central banks declined to classify themselves.

most frequently shared between the two. Giving a value 1 when the central bank either took the decision itself, or took the lead in a joint decision, and ½ where it was consulted or the junior partner, provided an index of central bank powers over decision making,[25] with the histogram shown in Table 4.10.

Again there was a wide range of answers in response to question F7, whether the government can require the central bank to finance its deficit. In four cases this was not answered; of the remaining 36, 26 stated yes that it could, subject to a variety of limitations, and 10 that it could not. There was again a wide range of responses to question F8, what happens if government bond sales fail to cover the deficit. Out of the 38 central banks responding to this question, six stated that the question was not applicable, in most of these cases and certainly in three (Hong Kong, Singapore and United Arab Emirates) because there was no deficit to finance. Of the remaining 32, three stated that such financing was now prohibited (Argentina, Chile, and Saudi Arabia), 12 that it would normally be provided but *not* automatically, and 13 that it would be provided automatically. Out of the 29 cases where such financing would (normally) be provided, in 25 cases statutory limits on such borrowing almost always in the form of a percentage on government revenue were in place, but the penalty for transgressing these was rarely more than the need to report it to Parliament, and to regularise the position quite soon.

Finally we asked central banks, in question F9, how independent they viewed themselves as being on a scale of 1 (least) to 5 (most). The distribution of answers is presented in Table 4.10. We then investigated whether these differences in the constitutional status were associated with differences in the inflation record. First, we regressed the central banks' self-assessment of independence against inflation, in 1991 and over the last five years (but not over the longer average for the reason earlier stated). The results, omitting Argentina for the reasons specified, are presented in Table 4.11. The independence variable, F9, is significant (at the 95% level for the five year average and at the 90% level for 1991) and with the 'correct' sign.

[25] In quite a number of cases the central bank did not answer, or stated that the question was not applicable to itself. So the alternative to a central bank decision should not automatically be assumed to be a government decision.

Table 4.11 **Inflation and self-assessment of independence**

Dependent variable: inflation in	*1991*	*Average 1989–1993*
Coefficient on F9	–9.979	–14.272
t value	*-1.94*	*-2.45*
$\bar{R}^2$	(0.09)	(0.15)
Number of countries	30	30

Our next step was to examine the simple correlations between the questions F4 to F8 (F1 to F3 being dropped, since the answers were too similar), and both inflation over the last five years and also the self assessment of independence (omitting Argentina in the correlations with inflation). The results are in Table 4.12, where we also indicate our expectation of the sign of the relationship in parenthesis, and emphasise (in italics underlined) when the correlation is significant. In these simple correlations only the relationships between F7 and F8 (which in any case overlap) and independence are correctly signed *and* significant; the same variables have the correctly signed relationship with inflation, but are not significant. Otherwise all the other F variables have an insignificant relationship with inflation or perceived independence, and only the relationships between perceived independence and F5A and F5B have the correct sign. This suggests that it is the relationship with government financing that is the key to the role and status of the central bank.

Table 4.12 **F questions correlations with inflation and independence**

Correlation coefficient	*Inflation (log of)*	*Independence (F9)*
F4: Government officials on CB Board	–0.163 (+)	+0.061 (–)
F5A: Statutory Objective for Price Stability	+0.070 (–)	+0.212 (+)
F5B: Statutory Objective for Growth	-0.110 (+)	-0.216 (-)
F6: Index of decision making powers	+0.092 (–)	–0.188 (+)
F7: Government can require CB financing	0.151 (+)	*–0.595* (–)
F8: Automatic financing if bond sales fail	0.186 (+)	*–0.640* (–)

Notes: The answer to F4 was quantified through an index taking the values 0 if no government officials are on the Board, ½ if they may attend the Board meetings, and the number participating otherwise. Positive answers to questions F5A, F5B and F7 take the value 1, negative answers the value 0. The answer to F8 took the value 0 if financing is prohibited or not required, 1 if financing is normally provided but *not* automatic, and 2 if financing is automatically provided.

This lack of correlation between inflation and the constitutional status of the central bank is in line with the results of Cukierman (1992), and Cukierman, Webb, and Neyapti (1992). The authors' research among their set of developing countries suggested that statutory variables were less effective in explaining inflationary differences than a variable measuring the turnover rate among central bank governors; the lower the turnover rate, the lower inflation. We obtained information on the turnover rate of Governors from question A3. An histogram showing the number of central bank governors in each country since 1975, after correction for the age of the central bank, if founded after 1975, is shown in Figure 4.4.

We replicated Cukierman's exercise regressing the log of the inflation experience over our last 5-year period 1989-1993 against the (corrected) number of governors in each central bank. We extended the analysis by introducing as potential explanatory variables the answers to questions F4 to F8, and by introducing the self-assessment of independence as an alternative dependent variable. We began with this full set of variables, and then progressively eliminated the most insignificant until we reached our preferred equation. The results are shown in Table 4.13. Finally we added the independence variable (F9) back into the best inflation equation. We omitted Argentina throughout this exercise, due to the unusually high level of inflation and turnover of governors before 1992.[26] In addition, the results are shown exclusive of two other outliers (Belize and Zambia) in the second and third regressions.

Our ability to explain a central bank's self-assessment of independence using this set of variables is reasonably good. Two of these variables are straightforward. The *most* important is the primacy given to price stability in the statutes (F5A), and the second most important is the rate of turnover of central bank governors (A3) (though this relationship may involve simultaneous causation, and we are unsure how we could instrument for this). Although not very significantly, the role of the central bank regarding government financing also affects the self-assessment of independence: this is higher

[26] The fit improves dramatically when Argentina is included. For instance, the t-value of A3, in the regression with only this variable, rises from 2.37 to 4.99.

when central banks do not finance the government (F7), and if they do finance it, when such financing is not automatic (F8). In contrast to our prior expectations, we also found a *positive* and marginally significant relationship between the self-assessment of independence and the number of ex officio government participants on the Board of Directors (F4).

Table 4.13 **Inflation and the status of the central bank**

Dependent Variable	*Explanatory variables*								*No. of*
	A3	*F4*	*F5A*	*F5B*	*F7*	*F8*	*F9*	$\overline{R}^2$	*Countries*
Inflation 1989–1993	0.136 *2.37*							0.12	35
Inflation 1989–1993	0.134 *2.30*	-0.263 *-2.04*		-1.008 *-2.17*		0.381 *1.85*		0.35	25
Inflation 1989–1993	0.160 *2.51*	-0.310 *-2.45*		-1.028 *-1.84*		0.247 *0.85*	-0.142 *-0.56*	0.40	21
Independence Assessment	-0.117 *-2.02*	0.178 *1.46*	1.191 *2.36*		-0.623 *-1.46*	-0.297 *-1.20*		0.48	23

Notes: the table presents the estimated coefficients and t-values (in italics) of regressions of the explanatory variables on the dependent variables. In all the regressions a constant term was used, but is not presented here to save space. The last two columns display the adjusted R^2 and the number of observations for each regression.

Our ability to explain inflation using this set of variables is also reasonably good,[27] although we had to exclude two outliers to achieve this result.[28] The results for A3, F4 and F8 are consistent with the results for the independence equation. Once again a major conclusion is that the relationship between the central bank and its government is an important determinant of its role and status in the economy. The *negative* and significant relationship between inflation and F5B (explicit requirement in the central banks' statutes to pursue growth) is hard to believe. It is probably a small sample result, but at least suggests that being statutorily constrained to pursue growth does not induce the central banks to follow inflationary policies. With independence F9 included in the set, the results do not change much, only F8 loses explanatory power.

[27] We also tried entering some variables measuring the extent of the government deficit to be financed, i.e., both the deficit and the debt ratio as percent of GDP, but the number of usable countries (and particularly the degrees of freedom) fell so drastically that we could not pursue this line of enquiry on this data set.

[28] If we include Belize and Zambia in the regressions, the $\overline{R}^2$ falls to 17% and 18%, in the equations with and without F9, respectively.

4.6 Conclusion

In developing countries, monetary policy is conducted in an environment substantially different from that faced by central banks in more developed economies. We detected that there is a general acceptance of the benefits of price stability as the primary central bank objective in the BoE group, consistent with our finding that inflation damages growth. However, it seems that the average OECD central bank gives a higher priority to price stability than the central banks in our sample, judging from their inflation experience and from their statutes.

The poor results in the inflation front are likely to be caused by pressures on the central banks to pursue other objectives. Governments expect their central banks to perform a range of quasi-fiscal activities, and may require them to pursue external objectives that may be incompatible with the domestic objective of price stability. Given the strong association between economic and financial development, central banks in developing countries have a special responsibility for the development and stability of financial systems in their countries. Concerns with the stability of weak financial systems may induce central banks to monetary expansion in excess of what the domestic objective of price stability would require.

A central bank that is obliged to carry out a wide range of activities can hardly aspire to the same degree of independence from government as one which is only required to achieve price stability. The central banks in our sample recognise this in their own assessment of independence. This lack of independence and multiplicity if goals jeopardises their ability to achieve their main objective, price stability.

Appendix 4.A: Relevant Questions from Central Bank Questionnaire

Basic Details

A1. Name of Central Bank:

A2. Date when founded:

A3. Number of Governors since 1975 (or from foundation if later):

(...)

Domestic Role

(1) Payments System

B1. Is there a domestic system(s) for settling payments?

B2. What is its/their daily average turnover?

B3. Is it run by the Central Bank? Please specify relationship of Central Bank to the payments system(s).

(...)

B6. Have there been any major reforms to the payments system since 1975? If so, did the Central Bank initiate these reforms?

(2) Control over Banking System

B7. What balance sheet ratios are imposed on banks (capital, reserves, liquidity, other)? Please give percentages.

B8. What direct controls are imposed on bank loans to the private sector at present?

B9. Do such controls involve selective policies between sectors? If so, please specify.

B10. Are there different Central Bank rediscount facilities for separate sectors? If so, please specify.

B11. Does the Central Bank guarantee any category of domestic loans? If so, which?

(3) Financial Markets

B12. Please specify the dates of development, the form and turnover of the following: (a) formal money market; (b) domestic bond market; (c) domestic equity market.

B13. Please list and explain the three biggest difficulties in establishing all or any of these domestic financial markets.

(4) Interest Rates

B14. Please specify the current interest rate on: (a) Central Bank (discount window) loans to banks; (b) commercial bank lending (please state type of loan and whether the rate is average or prime); (c) Government bonds; (d) commercial bills: (e) treasury bills; (f) priority loans under directed credit schemes.

B15. Which of these rates are either administratively set or have administratively set ceilings?

B16. Does the Central Bank employ indirect (open) market techniques? If so, in which market(s) and how?

External Role

C1. What is the type of exchange rate regime?

C2. Is the exchange rate regime decided by the government, the Central Bank, jointly, or other?

C3. On what basis was the current exchange rate regime chosen (if known)?

C4. Is intervention on the foreign exchange market decided by the government, the Central Bank, jointly, or other?

C5. What are the techniques and modalities of intervention on the foreign exchange market?

C6. Are foreign exchange controls decided by the government, the Central Bank, jointly, or other?

C7. Who administers foreign exchange controls?

(...)

Supervision and Regulation

D1. For which financial markets and financial institutions, e.g., banks, mortgage houses, insurance companies, etc., is the Central Bank the supervisory authority?

(...)

D4. Please specify the extent of bank failure, 1985–1993, in terms of the percentage of total deposits.

D5. Have bank failures been resolved by: (a) nationalisation; (b) merger with another bank; (c) liquidation; (d) other (please specify). [We would be grateful for the numbers of banks and total deposits involved in each case.]

D6. Has the resolution/restructuring of problem banks involved a cost to the Central Bank? If so, did this cause a problem and how was that resolved?

(...)

Central Bank Independence

F1. Who appoints the Governor?

F2. What is the period of the Governor's appointment?

F3. Who appoints other directors of the Central Bank?

F4. Are any directors members of the government or Ministry of Finance? If so, please specify.

F5. Does the Central Bank have statutory objective(s)? If so, please specify.

F6. Who decides on: (a) adjustments of administered interest rates; (b) adjustments of administered bank ceilings, balance sheet ratios, etc.; (c) the issue of additional public sector debt.

F7. Can the government require the Central Bank to finance its deficit

F8. What happens if government bond sales fail to cover the government's deficit? Is Central Bank financing automatic? Are there any limits? If so, what happens if the limits are exceeded?

F9. On a scale 1–5 (1 is least, 5 most), how independent would you rate your Central Bank?

Figure 4.1: Economic Growth and CPI Inflation
(average of annual data 1979-1993, percent)

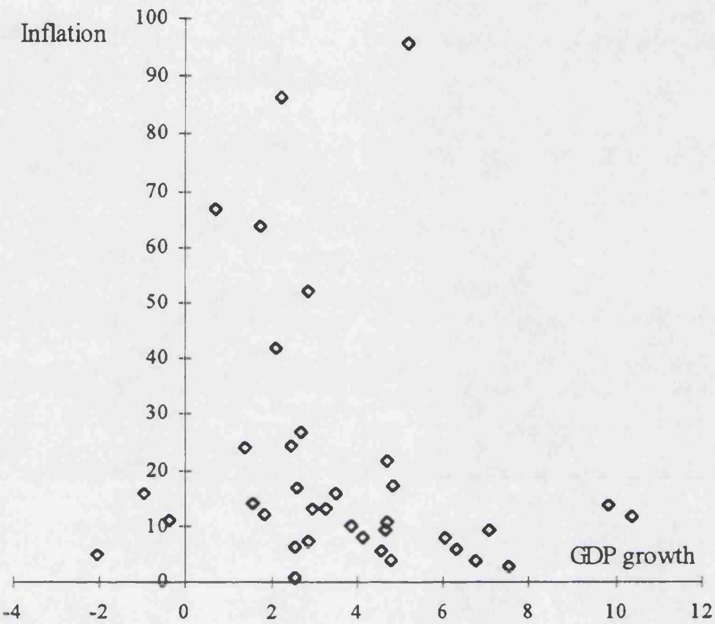


Figure 4.2: CPI Inflation and its Standard Deviation
(annual data, 1979-1993)

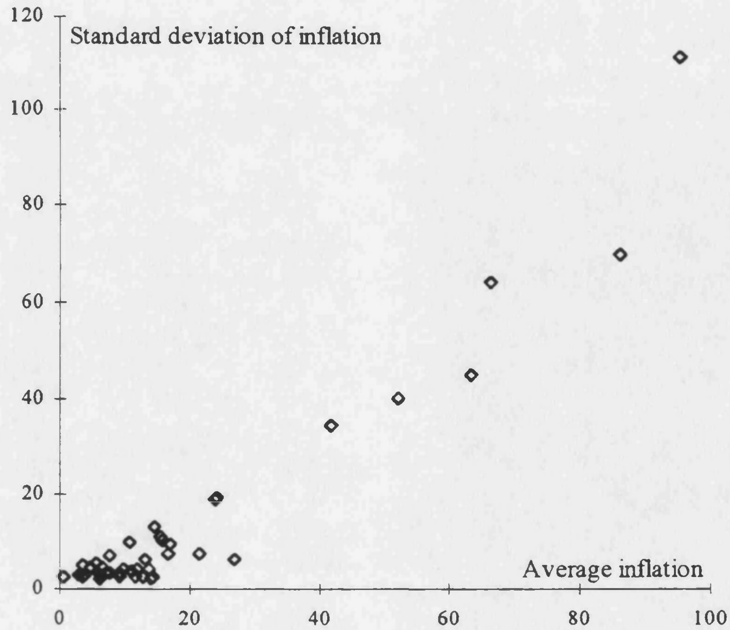


Figure 4.3: CPI Inflation and M1 growth rate
(average of annual data, 1979-1993)

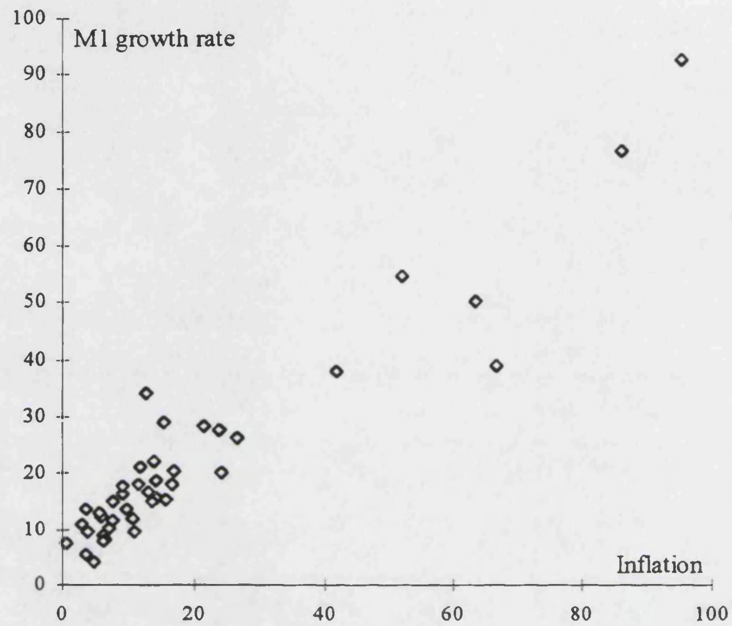
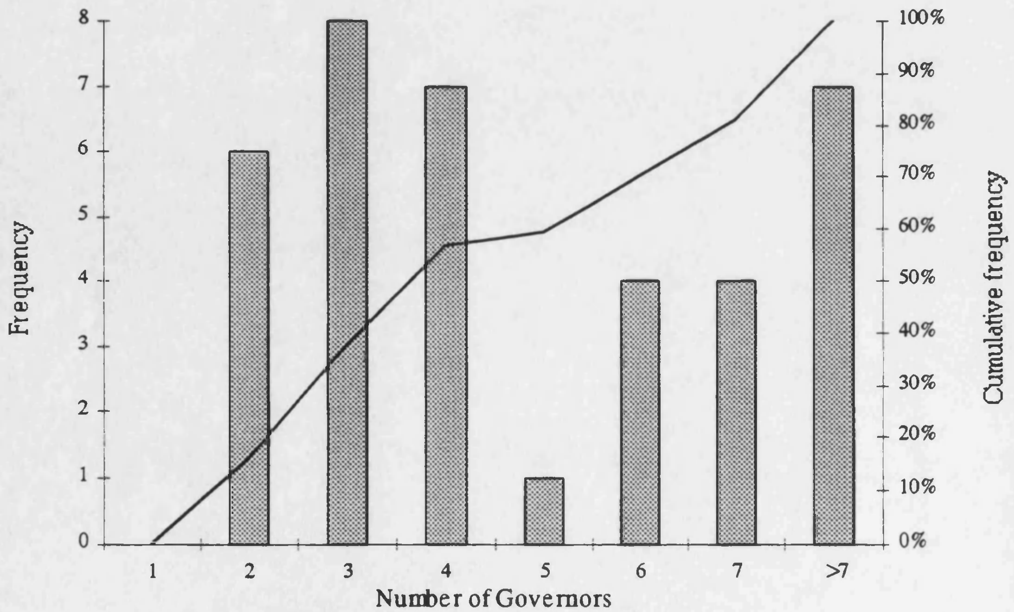


Figure 4.4: Number of Governors since 1975
(corrected for the age of the Central Bank)



Chapter 5

Does the Adoption of Inflation Targets Affect Central Bank Behaviour?

5.1 Introduction

Perhaps both the most difficult, and the most crucial, decision for a study of how those central banks which have adopted inflation targets (IT) have fared, is to decide which central banks to include within the chosen set. Nowadays almost all central banks make price stability their main objective. Price stability is regarded, for this policy purpose, as a low rate of inflation,[1] low enough to prevent agents consciously factoring in expectations of future inflation into their price/wage setting decisions. Consequently virtually *all* central banks have an inflation target, though this may be unquantified and implicit rather than quantified and explicit. Our objective in this chapter is not to discuss the adoption of price stability as the main objective for monetary policy, but to examine the implications of publicly announcing and making this objective explicit and precise. An explicitly numerically quantified inflation target is one feature that is common to all IT

[1] The alternative, of adopting a target for the *price level*, has been discussed by economists in several theoretical contributions, e.g., Fischer (1994), Goodhart (1994), McCallum (1996), but has not yet been considered a serious practical possibility by central banks. See subsection 5.2.2 on this issue.

countries, but not unique to this group. Several non-IT countries also publicly report a numerical value for the inflation rate which they are seeking to achieve at some future date (e.g., France, Italy or Portugal).

What does seem to be somewhat more distinct among IT countries is that there is no other specified, numerically quantified, intermediate target,[2] such as a monetary or an exchange rate target, the achievement of which is treated as a means of achieving the inflation target. But any dividing lines between IT and non-IT central banks remain fuzzy. For example, as we discuss in subsection 5.2.3, the distinction between the role of the concurrent rate of monetary expansion on the monetary policy decisions in Spain and Germany is not that large. In both countries policy decisions are based on a wide set of indicators, with the growth of a money aggregate having a privileged role. The situation is, perhaps, even more indistinct with respect to exchange rates. In all the IT countries, variations in the exchange rate are perceived as having an important influence on future inflation, as we discuss in subsection 5.2.4, although it is not regarded as a target in its own right. Nevertheless, given the inflation target, comfort zones for the exchange rate can be internally defined, and monetary policy could be based on those 'targets'. By comparison, the central banks in Latin America (e.g., Chile, Colombia, Mexico) generally combine both an exchange rate operating target and an inflation objective. But in these cases, the key operational decisions are primarily driven by the exchange rate target rather than the attempt to achieve a numerically specified inflation objective (see Masson, Savastano, and Sharma, 1997).

The most problematical case is that of Israel which combines an intermediate exchange rate objective (a crawling peg) with an explicit numerically quantified inflation target. In their Conference on experiences with Inflation Targets, which the Bank of England hosted in March 1995, the proceedings of which can be found in Haldane (1995a), Israel was included as an IT country. We believe, however, that Israel should be included, with the Latin American countries, as primarily operating on the basis of an intermediate exchange rate target. Although increased importance has been attached to the targeting

[2] The US has no other intermediate targets either, but it is not regarded as an IT country. It has no explicitly quantified, numerical target for inflation, and is currently required (by Act of Congress) to take into consideration several other objectives besides price stability.

of inflation in the last four years, the existence of an announced crawling band may sometimes force the central bank to take policy actions which are only triggered by exchange rate developments and are not related to inflation concerns, as it would happen in a pure IT country, but the distinction is fine.[3]

Our set of IT countries is the same as that adopted by the Bank of England, apart from Israel, which we exclude from our group, and the one adopted by the Bank for International Settlements, and includes Australia, Canada, Finland (until October 1996),[4] New Zealand, Spain, Sweden and the UK. What distinguishes this group from other countries where price stability is the sole objective of monetary policy is that there is an *official commitment* from the monetary authorities to achieve a *clearly defined*, numerically quantified, target for inflation,[5] together with the absence of any other intermediate target.[6] In the IT countries policy changes are usually explained and justified as caused by prospective movements in inflation, for which prior monetary or exchange rate movements will often be a prime explanation; whereas in the non-IT countries, policy decisions will normally be explained and justified in terms of the rate of growth of some intermediate monetary target or some change in the exchange rate, unless there are good grounds for believing that these are not giving a reasonable prediction for future inflation.

The existence of an explicit and precise IT, instead of a simple reference to price stabi-

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3 The role of the exchange rate targets and inflation targets in the monetary policy of Israel is discussed in Ben-Bassat (1995).

4 In October 1996 the Finnish Markka joined the European Exchange Rate Mechanism (ERM) in preparation for becoming one of the initial participants in the Euro in January 1999. Although it was announced that the inflation target of 2% would not be affected "under favourable conditions", at that time the President of the Central Bank clearly stated that the exchange rate would assume increasing importance in the conduct of monetary policy, with precedence over any other objective (Bank of Finland Bulletin, December 1996, p. 3-8). So Finland then ceased to meet our definition of an IT country.

5 Although we chose this sample in part because we thought that these countries had clearly defined targets, after investigation we realised that, at least in some of them, the targets are somewhat less precise than we had initially believed. Still, the definition of the targets in the sample countries is more precise than in non-IT countries, where the policy objective is defined as 'price stability' with few details of what is meant by that.

6 After completion of the first draft, we came across a paper by Svensson (1997) where the set of countries described as having an IT framework is the same as ours, and where the description of the characteristics of the IT framework is similar to our own.

lity being the objective of policy, provides an anchor for inflation expectations and helps to make the monetary authorities more accountable.[7] All of the countries in our sample have recently been granted greater independence from government for determining interest rates.[8] Unless there is an operating exchange rate target (and it is dubious whether the wide band ERM in being since August 1993 necessarily represents an operating target), or an unusually well-behaved demand-for-money (velocity) function, then the grant to central banks of greater independence to vary interest rates ('instrument independence' as defined by Fischer, 1994), has usually in the last few years been accompanied by the acceptance by the central bank of a more transparent, and numerically quantified, inflation target. The exception to that may be the prospective European Central Bank, though it is still possible that it may set such a quantified inflation target for itself. The absence, in the Maastricht Treaty, of any requirement for such transparency and hence accountability has been criticized (Goodhart, 1991 and 1992b, Kenen, 1992, Cukierman, 1995).

Another difficult choice we had to make regarded the dates of introduction of IT in the countries in our sample. It is hard to assign a specific date to changes in policy frameworks, especially for inflation targeting, given the similarities between inflation targeting and other frameworks where price stability is the objective of policy. This is a problem similar to the choice of countries to include in the IT set, and the reasons behind our choice of dates are the same as for our choice of countries. Our emphasis is on the existence of an official *explicit* commitment from the monetary authorities to achieve a *precisely defined*, numerically quantified, target for inflation. Thus, we took the date of introduction of IT to be the date of the official announcement of the commitment to achieve a precisely defined target. According to this criterion, the dates of the announcements of inflation targets were as follows:

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[7] The argument for adopting an explicit IT is discussed in subsection 5.2.1.

[8] In the UK this occurred in two steps. While there was a move in that direction in 1992/93, the formal decision to alter interest rates remained with the Chancellor until May 1997. Then, after the election of the Labour Government, the incoming Chancellor transferred autonomy to vary interest rates to the Monetary Policy Committee of the Bank of England, a committee consisting (after an initial transition period) of five Bank officials and four independent outside experts. Briault, Haldane and King (1996) discuss why there has been a general move towards more central bank independence in recent years.

Australia	1993 [9]
Canada	1991, February 26th [10]
Finland	1993, February 2nd
New Zealand	1990, March 2nd [11]
Spain	1995, January 1st [12]
Sweden	1993, January 15th
UK	1992, October 8th

Policy frameworks are not changed in one day, and it is likely that some central banks were already behaving as IT, even before the official announcement of the target. Furthermore, giving the usually long policy lags, some of the observed performance of IT countries must reflect monetary policies that were in place before the adoption of IT. These problems should be taken into consideration when analysing the results of our exercises that involve the use of the announcement dates.

Our chosen set of countries is small, and they have only adopted IT for a short period. Since our data period ends in most cases at the end of 1996 (in some cases in 1997), it is far too short a period to make any robust claims about the effectiveness of IT, as McCallum (1996)

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9 It is difficult to determine precisely the date of the announcement of IT in Australia. Initially the Central Bank unilaterally adopted a quantified numerical IT without the involvement or blessing of the Government. Subsequently, however, Ministers came to speak approvingly of this initiative, and with a Labour Government having thus consented to it, and the new Liberal Government also in favour, IT in Australia can be viewed as firmly established. For the exercises that require the use of the announcement date, we assumed it to be 1/1/1993.

10 This is the date of the joint announcement of the inflation-reduction targets by the Government, as part of its annual budget presentation, and the Bank of Canada, through a press release. Although the Governor of the Bank of Canada, John Crow, had been publicly stressing for some time (at least since his Hansen Lecture of 1988) that price stability was the monetary policy objective, we believe these statements do not represent the sort of official commitment to a precisely defined target that we take to be the characteristic of IT countries.

11 This is the date the first Policy Targets Agreement (PTA) between the Reserve Bank of New Zealand and the Government was signed. Since April 1988, the Minister of Finance, Roger Douglas, and the Associate Minister of Finance, Peter Neilson (the Ministry of Finance was then responsible for monetary policy), had been making several statements stressing the Government's intention of bringing inflation down to very low levels. Again, as in the case of Canada, we believe that these statements do not fulfil the characteristics of an IT as we define it, and that only after the signing of the first PTA New Zealand had an official commitment to achieve a precisely defined target.

12 In Spain, the IT was announced in December 1994, but was formally adopted as of January 1st, 1995.

also emphasized in his recent review article on inflation targeting. Nonetheless such is the interest in this subject that we could not resist making such attempts.

One of the major problems is that the last few years have been characterized by a special world-wide set of conditions (themselves no doubt partly reflecting the shift of emphasis in monetary policies in many countries). Among these conditions have been a rapid decline in inflation to low levels, which was generally sharper than forecast either by central banks or private sector commentators, and in many, but not all, countries a further increase in unemployment. So, by comparison with their own earlier history, IT countries may be assessed as having been, (a) successful with their prime aim of reducing inflation, (b) congenitally likely to exaggerate the future likelihood of a resurgent inflation, and (c) having only achieved low inflation by higher unemployment. But all these phenomena may result more from the international context, rather than from any special particularities resulting from the adoption of IT itself.

In order to try to guard against such problems we have, in various exercises, tried to compare the results of the IT countries against those from a set of comparable countries. But which countries might be comparable? All our set of IT countries were industrialized OECD countries, so we restricted our comparator group to that set. Most of our IT countries started with middling inflation rates; so we chose as comparator countries those with roughly similar initial inflation rates.[13] Nevertheless, such a choice is always problematical so we chose four, overlapping, non IT control groups. The first two groups consisted of countries with similar inflation levels in the 1980s (one is composed of 5 and the other of 7 countries), the third consisted of 5 countries with similar inflation levels in the period 1987/92, and the fourth is composed by 7 countries that we subjectively chose as facing similar economic environments as the IT countries.

But one cannot make a silk purse out of a sow's ear. Our selected set of IT countries is small, and the selection process debatable. So is the selection of a control group. The

[13] We regard this as an important criterion. Countries that had low inflation at the outset, e.g., Germany, may find it hard to improve on their performance; while the experience of initially high inflation countries may be startlingly good, or bad, and in either case bias the conclusions.

number of years in which the central banks have been applying IT is very small, and these years had some special world-wide characteristics. Given the lack of data, the results are likely to be sensitive to the empirical methods used. It is far too soon to reach any robust, statistically significant conclusions about the effects of that choice on the macro-economic outcome.

Where it may be somewhat easier, at least in some matters, to establish whether the adoption of IT made a major difference is with respect to its influence on the behaviour of the central banks themselves. The adoption of a numerically quantified IT makes the comparative success, or failure, of a central bank more transparent. But the lengthy lags in the effect of interest rates on nominal incomes and on inflation make it necessary to adjust interest rates *now* to *forecast* future inflation, if there is to be much hope of controlling inflation to the desired degree of accuracy. With the central bank now also having greater responsibility for adjusting domestic interest rates, the shift to IT is likely to bring with it the need for revised and expanded communications, with both government and public, about both inflation forecasts and current actions. Moreover, there are some instances where the upwards shock to inflation comes from the supply rather than from the demand side.[14] In general the central bank should *not* seek to offset the first-round effect of that. How easily, if at all, can the central bank not only follow that precept, but also communicate it to the general public?

Large interest rate changes (especially if upwards) are not only unpopular but may also be destabilising to the economy and to the financial system. Moreover, any reversals of direction of interest rate changes within any short period (e.g., up, then down) may give an appearance of vacillation in policy and uncertainty in approach. Whether for these, or other, reasons central banks have typically smoothed interest rate adjustments, i.e., they tend to make a consecutive series of some six, or so, small adjustments (of about ½% each typically) in discount (base) rates over a period lasting several quarters, rather than fewer, larger adjustments, (see Rudebusch, 1995, Goodhart, 1996). This syndrome has been criticized as 'too little, too late', and resulting in strong auto-correlation in inflation. Since the objectives

[14] The existence of continuing supply-side shocks is taken as axiomatic in much of the literature on central bank independence. With the important exception of the various oil shocks, it is less clear how large or frequent such supply-side shocks have been in practice.

of IT have been, as we shall demonstrate, demanding both in terms of level and permitted range of fluctuation (between the bands), has this caused any difference either to central bank's operating techniques or reaction functions? In particular, is there any evidence among IT countries that they have varied interest rates earlier or in larger steps than in the past?

Our main focus is, therefore, on whether and how the adoption of IT may have affected the behaviour of those central banks. This will, we believe, represent our main contribution. In order to obtain more information and understanding, especially on this aspect of the behaviour of IT central banks, we wrote to them in January 1996, and we received full, frank and helpful replies.[15] We are particularly grateful to these senior officials for being so patient, courteous and helpful. Much of the body of this chapter could only have been undertaken with their assistance.

5.2 The Execution of Monetary Policy

5.2.1 Reasons behind the adoption of inflation targets

The adoption of IT has usually followed the recognition of the failure of the previous monetary policy strategy. This is obvious in the cases of the UK, Sweden and Finland, where IT was adopted just after the collapse of the fixed exchange rate regimes.[16] The adoption of IT in Spain, although it followed the granting of autonomy to the Central Bank, also reflected some disappointment with the use of both monetary aggregates and the exchange rate as an intermediate target (following the 1992/93 ERM crisis and consequent widening of the fluctuation bands). In Canada, New Zealand and Australia, the adoption of IT followed a period of discretionary monetary policy, where no explicit

[15] In view of subsequent events, e.g., in the UK in May 1997, we have updated this material for some countries.

[16] The Finnish markka and the British pound were floated in September 1992, and the Swedish krona in November 1992, and IT was adopted in October 1992, January 1993 and February 1993, respectively in the UK, Sweden and Finland.

and quantified target was used, a strategy that was generally judged to have been unsatisfactory and was only implemented in the absence of a better alternative.[17]

Given the differences in the monetary policy strategies previously in place, we should expect the observed effects of the adoption of IT in the behaviour of the central banks in our sample to be substantially different for European and non-European central banks. The transition from a fixed exchange rate regime to a floating exchange rate regime implies, by itself, substantial changes in the execution of monetary policy. For the European countries in our sample, the adoption of an IT coincided with such a regime switch. Thus, we cannot separate empirically the changes in behaviour caused by the change in exchange rate regime and the adoption of IT. This is not the case for the non-European countries, where the adoption of an IT was not accompanied by any other major change in the monetary policy strategy. In the following analysis, such differences between the two groups should be kept in mind.

The adoption of IT can be seen, in all the countries in our sample, as an alternative to discretionary monetary policy, in an environment where the use of exchange rates or money aggregates as intermediate targets is thought to be unsatisfactory. The official statements made at the time of the adoption of IT usually advance two arguments for the abandonment of a discretionary monetary policy: the need to provide an anchor for inflation expectations and the need to make the central bank[18] more accountable. The private sector cannot understand fully the stance and the consequences of a discretionary monetary policy, nor can they anticipate correctly the actions of the central bank. In this situation, the formation of inflation expectations becomes a complicated process, and uncertainty about future inflation is much higher than with a strategy where a credible IT has been previously set. Also, under a discretionary monetary policy it is difficult to evaluate the performance of the central bank, since there are no clear and easy to verify

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[17] New Zealand had abandoned exchange rate targets in 1985. Monetary targets were used in Australia (from 1976 to 1985) and Canada (from 1975 to 1982), but were abandoned because they were not considered to be reliable indicators of policy.

[18] Or, in the UK case, until May 1997, the Chancellor, who was ultimately responsible for monetary policy.

benchmarks against which the performance can be compared. An explicitly and precisely set IT provides such a benchmark, thus making the central bank more publicly accountable.

Where the accountability of the monetary policy decision process was an important reason for the adoption of IT, such targets were set as the outcome of an agreement between the central bank and the government (in New Zealand and Canada) or by the government, acting unilaterally (in the UK). Where the main concern was to provide an anchor for inflation expectations, the IT was set unilaterally by the central bank, although in some cases these targets were later endorsed by the government (as happened in Australia, Finland and Spain). The fact that the IT is announced jointly by the central bank and the government may enhance the credibility of the target, as long as the joint announcement implies a commitment by one party, the agent, which is monitored by the other, the principal, especially if the agent deciding on monetary policy suffers an effective penalty if targets are not met.[19]

The first reason why a joint commitment could be credibility-enhancing is that in some countries budgetary measures may be necessary to help control inflation and inflation expectations. Where fiscal problems were one of the main causes of the past inflationary pressures, and high stocks of public debt can raise the spectre of the government eventually forcing a partial monetization of the debt, low inflation can only be a credible target if measures to reduce the budget deficit are put in place. A strong commitment from both the government and the central bank to an inflation target reinforces the likelihood that the targets will be achieved, if this joint commitment can be interpreted as a sign of monetary and fiscal policy coordination.

The other reason one could expect higher credibility from a joint commitment is the fact that as long as the right incentives are in place,[20] the external monitoring may play the

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[19] Walsh (1995) and Persson and Tabellini (1993) show that an adequate incentive contract for central bankers may eliminate any inflationary bias they may have. The monitoring and associated penalties could be seen as such an incentive contract.

[20] In New Zealand, the Central Bank Governor may be dismissed if the inflation targets defined in the

role of a 'precommitment technology' that could overcome the 'time-inconsistency' problem of monetary policy, as described in Kydland and Prescott (1977) and Barro and Gordon (1983a). For central banks who unilaterally set the IT, there are few effective sanctions. A central bank governor missing a pre-stated target is unlikely to sanction himself, though he might face public obloquy. Even if a government was secretly happy with faster monetary expansion (than the target would imply),[21] the fact of missing a published target to which the government had set its name will give rise to demands for it to respond; sacking, or fining, the governor will be relatively painless for the government itself (in most cases). Also, a joint announcement is more likely to be realistic: knowing that it may be held accountable for missing it, the central bank will not accept the over optimistic targets politicians tend to set.

The only incentive to stick to the target central banks who unilaterally set their target have, is the effect on their long term reputation of missing (or constantly changing) it.[22] If their track record on inflation, before the adoption of IT, is not very good, their current reputation will be low, and losing it would not be a very serious problem. Only

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Policy Targets Agreement, signed between the Central Bank and the Government, are not met. Here the incentives to achieve the target are apparently high, since there are explicit sanctions for failures. In 1995 and 1996 the objective, the underlying CPI index, exceeded the target (then 0-2%) and this led the Governor to tender his resignation in 1996, but it was refused. Subsequently, following the election of a coalition government, the band was widened to 0-3%.

In Canada and the UK there are no pre-set sanctions, but the fact that one party publicly monitors the performance of the other may constitute a sufficient incentive. In the UK the Chancellor was responsible for monetary policy until May 1997, and the Bank of England then monitored the inflation performance: if targets were not met, the Bank of England publicly announced it, and this could have harmed the government politically. From May 1997 onwards, the tables were reversed. The Monetary Policy Committee (MPC) of the Bank of England became responsible for achieving the inflation target, set as 2½% for RPIX on a continuous basis. If, and when, RPIX diverges from this target by more than 1% on either side, the MPC is required to write a letter to the Chancellor explaining why this has happened and outlining its intentions for restoring inflation to target. As the (then prospective) Deputy Governor, Mervyn King, remarked (1997), "Given past experience of inflation volatility, it is likely, even allowing for the change in policy regime, that the MPC will have many opportunities to restore the lost art of letter-writing to British life."

In Canada, the fact that an explicit target set by the government is missed may be used as a political argument not to reappoint a central bank governor the government dislikes; if the targets are met, the non reappointment of a governor that achieved the targets the government itself has set might be politically difficult to explain. The incentives to stick to the target exist in the three countries, although it may be argued that they are not strong enough to make the IT fully credible.

[21] The inflationary bias of politicians was one of the main arguments the Roll Committee Report (1993, Sections 2.5 and 3.3) advanced against joint targets.

[22] Reputational solutions for the time-inconsistency problem may be found, for example, in Barro and Gordon (1983b).

after the central bank has established a track record by meeting the targets for a reasonably long period, will the inflation target become credible, since only then will the damage to the reputation of reneging the announced targets have a significant cost. Rogoff (1985) suggested that if the central bank is independent from the government, and the central bank governor is 'conservative', i.e., places a higher relative weight upon inflation stabilisation, the 'time-inconsistency' problem may disappear. Thus, it could be argued that an IT announced by an independent central bank could be as credible as a joint commitment. The adoption of IT in the countries in our sample has been associated with changes to, or attempts to change, the legal framework of the central bank to make it more independent (although in the case of the UK, the adoption of IT in 1992 preceded the grant of greater autonomy to the Monetary Policy Committee (MPC) of the Bank of England in May 1997, and the passage of the associated Bank of England Act in 1998). However, even in the case of an independent central bank the credibility of the IT will not be as high as in the joint announcement with sanctions case:[23] first, because legal independence does not necessarily mean actual independence; second, because an independent central banker is not necessarily the same as a 'conservative' central banker.[24] To repeat, only after a reasonably long period of proving that the central bank is actually independent and the governor is 'conservative' will the IT become credible. Making the central bank independent does not eliminate the need for reputation building. Only the existence of external monitoring associated with an appropriate incentive scheme may have a short term effect on credibility.

The issue discussed in the paragraphs above refers to what Andersson and Berg (1995) call 'operational credibility' of IT, i.e., the likelihood that the IT will effectively be met, given the current institutional framework, which they distinguish from the 'political credibility' of IT, i.e., the likelihood of a regime shift, where the current framework may

[23] Note that the argument for joint announcements only holds if the central bank is effectively independent from the government. If this is not the case, government and central bank are the same entity in terms of decision power, and in this case a joint announcement is in fact an unilateral announcement.
[24] Mexico provides an example of a central bank to which formal independence has been granted, but is perceived to be not completely independent from the government. Russia provides an example of an independent central bank that was less 'conservative' than the government: under Governor Gerashchenko, the monetary policy in Russia was highly inflationary, much more than the Yeltsin government desired.

be replaced by another not favouring price stability. 'Political credibility', *inter alia,* depends on the size of public debt and current budget deficits (as incentives to generate inflation in the future), but it depends above all on the support given to the IT framework by the political opposition. Any legislative framework favouring price stability introduced by one government may be reversed by future governments. If the opposition political parties are against the IT, the long term credibility of the framework is seriously affected.[25] Only an IT endorsed by the current government and by all the opposition political parties that are likely to become (part of) the government in the medium term may be credible, and varying degrees of support by opposition parties is likely to be reflected in empirically observed varying degrees of credibility.[26]

5.2.2 Choice of target

An IT must be credible, to provide a good anchor for inflation expectations. This implies that it should be stated in a simple and clear way, and it has to be feasible. It must be flexible, in the sense that it should allow for monetary policy to accommodate some unexpected (supply) shocks and to adjust to changing economic environments. It must be easily verifiable, to make the central bank accountable. These desirable characteristics of an optimal IT restrict the choice of each central bank, but there is still some scope for differences. Table 5.1 compares the targets adopted by the countries in our sample, and the main trade offs are briefly discussed below.

[25] Svensson (1995) and Andersson and Berg (1995) argue that in the case of Sweden the main problem was of 'political credibility', especially before the elections of September 1994. The opposition social-democrats were against the IT, and they were expected to change the Riksbank board (and adopt inflationary policies) if they would win the elections, as they eventually did. After the election the social-democrats surprised observers by appointing an independent chairman to the board, who reinforced the IT as the monetary policy objective. Ammer and Freeman (1995) refer to similar doubts about the medium term permanence of the IT before the 1993 elections in Canada. The 'political credibility' of the New Zealand IT was also affected in 1995 by calls to abandon the PTA framework by two opposition parties. After the election there in 1996 there was some uncertainty whether one of the parties in the new coalition government (New Zealand First) would accept continuation of IT. In the event the regime was extended, subject to a 1% widening of the band, a reform which many had felt to be technically desirable in any case. In the UK, the previous Conservative Chancellor, Ken Clarke, publicly opposed giving greater autonomy to the Bank in May 1997, but the position of the Conservative Party, as a whole on this issue has remained (at least at the time of writing at end 1997) unclear and probably divided.

[26] Evidence regarding the credibility of IT is presented below in Section 5.4.

Table 5.1 **Design of inflation targets**

Australia	*Index:*	underlying CPI (excluding fruit and vegetables, petrol, interest costs, public sector prices and other volatile prices)
	Caveats:	none
	Target:	2% - 3% on average
	Horizon:	immediate
Canada	*Index:*	CPI (underlying CPI - excluding food, energy, and first round effects of indirect taxes - is used as the base for policy decisions)
	Caveats:	large increases in oil prices, natural disasters
	Target:	2% ± 1%
	Horizon:	1995-98 (new target to be set by 1998)
Finland	*Index:*	underlying CPI (excluding effects of taxes, subsidies and housing related capital costs)
	Caveats:	none
	Target:	around 2%
	Horizon:	from 1995 (until effectively terminated in October 1996)
New Zealand	*Index:*	CPI
	Caveats:	significant changes in indirect taxes or government charges, significant changes in import or export prices, interest costs, natural disasters (in practice, the target is an underlying CPI index, calculated by the RBNZ as the CPI modified by the caveats)
	Target:	0% - 3% (since December 1996; previously 0-2%)
	Horizon:	to the end of Governor's term [27]
Spain	*Index:*	CPI
	Caveats:	only generic caveats (e.g., role of fiscal policy and wage behaviour)
	Target:	2%
	Horizon:	from 1998
Sweden	*Index:*	CPI
	Caveats:	none
	Target:	2% ± 1%
	Horizon:	from 1995
UK	*Index:*	RPIX (RPI excluding mortgage interest payments)
	Caveats:	effects of indirect taxes and subsidies and interest costs
	Target:	2.5% (an explanatory letter has to be written when deviation from target is ±1%)
	Horizon:	indefinitely until revised by the Chancellor of the Exchequer, which revision can be made at any time

[27] The description of the New Zealand target refers to the situation as of November 1997. Following the announcement of the reappointment of the Governor for a further term of office to 31 August 2003, a new PTA was signed on 15 December 1997. This PTA extends the 0-3% target out to the expiry of the Governor's next term. It also changes the formal target from the CPI (headline inflation) to the CPI excluding the credit services component (CPIX). The RBNZ has subsequently announced that it will cease calculating underlying inflation, and instead will use CPIX as the only target measure. It also will explain the effects of shocks on the CPIX measure, rather than adjust the target measure itself for the effect of those shocks.

When defining an IT, the first choice to be made is which price index is going to be targeted. All central banks in our sample target consumer price inflation. The Consumer Price Index (CPI) is the best known and most commonly used (e.g., in wage negotiations) measure of inflation. It also has some technical advantages, like being promptly released and seldom revised. The impact on expectations and credibility of such a measure of inflation should be greater than alternative measures that rely on complex statistical treatment or are released with a considerable lag, like the GDP deflator.

However, the headline CPI is affected by a number of shocks that cannot be controlled by monetary policy, and do not reflect the underlying inflationary pressures the central bank should be worrying about. Changes in indirect taxes or subsidies are not usually related to inflationary pressures, but can have a significant (short run) impact in the CPI. When the CPI includes interest related costs, it responds perversely to monetary policy changes: a tightening of policy in reaction to rising inflation will imply higher interest costs, and thus even higher CPI. Some supply side shocks that raise inflation and lower output (like large changes in commodity prices or natural disasters) should be accommodated, to avoid the adverse implications for real activity of a restrictive monetary policy.[28] A flexible monetary policy, able to adjust efficiently to these problems, should be based on a target expressed in terms of some measure of underlying inflation that would exclude the effects of this type of shocks. The problem with the underlying CPI is that usually it does not have similar desirable features of statistical simplicity and general acceptability as the headline CPI. Thus, a target expressed in terms of underlying CPI tends to have a smaller impact on expectations. The alternative is to set the target in terms of headline CPI, but to include some escape clause (or caveats) that would justify missing it, in order to allow for some flexibility in monetary policy.

In both solutions mentioned above, transparency and accountability are affected. The

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[28] Usual references to supply side shocks are to those increasing inflation, such as the oil price increases of the 1970s, but there is no reason to rule out supply side shocks of the opposite sign. The disinflation process of the 1990s might be partially explained by such shocks, e.g., the increased retail competition in the UK or the decline in food prices as a result of Finland's EU membership.

performance of the central bank can only be easily verified if the targeted price index is calculated by an independent agency. In our sample, targets based on an underlying CPI are only used by Australia and Finland, and in both countries the underlying CPI targeted is computed by statistics agencies independent of the central bank, and thus accountability is not jeopardised. The problem is that in most countries even when the statistics agencies publish some underlying CPI, it seldom excludes all the relevant shocks. In this case, the central bank has to choose between calculating its own index (with the corresponding loss in transparency and credibility) or using the less adequate external index. A similar choice must be made regarding the caveats if the target is set in terms of headline CPI. Transparency suggests that the list of caveats must be precise and exhaustive, but this reduces flexibility, since some shocks are unpredictable, even in nature. It should be stressed, however, that in practice the distinction between headline and underlying CPI targets tends to become blurred. In all the countries where the formal target is based on headline CPI, monetary policy decisions are based in some measure of underlying inflation, not headline inflation. Judging from our sample, it seems that there is no effective choice, and ITs have to be set in terms of underlying CPI, since this is the price index monetary policy is best able to control.[29] The only real question arises in the long term, if the two measures exhibit persistent differences.[30] Then, if the target is defined in terms of headline CPI, the operating policy targets for underlying CPI have to be changed so that headline CPI comes within the target range. If the target is defined in terms of underlying CPI, no change is needed, and headline CPI will deviate from the target, but this may have an important impact on inflation expectations.

The design of IT in our sample suggests that central banks believe that monetary policy is able to control underlying inflation but not in a precise and accurate way. The targets are either range targets or point targets that are only supposed to hold on average, and

[29] See Section 5.3 on the controllability of inflation.

[30] Underlying inflation is supposed to capture the fundamental trends in headline inflation, and deviations between the two indices are usually assumed to be temporary, but this is not necessarily true. Yates (1995) presents some evidence (although not conclusive) that different price indices in the UK are not directly substitutable even in the long term (although they cointegrate).

in either case this means the inflation rate is not going to be kept constant at some pre-set level. Some (limited) volatility of the inflation rate will be tolerated since some uncontrollable shocks are likely to affect inflation and monetary policy technology is not considered to be accurate enough to forecast, or bring about, finely calibrated changes in the inflation rate. Where the target range is precisely defined, the usual band width is 2 or 3 percentage points.[31] The optimal band width involves a trade-off between the credibility-enhancing effects of choosing a demanding target and achieving it, and the credibility-damaging effects of missing it (Goodhart and Viñals, 1994). This would suggest that central banks that need to build a reputation should choose narrow range targets, whilst more credible central banks may opt for wider bands. A highly credible central bank could even set a soft-edged band, similar to Finland's, where only the mid-point is defined and no explicit deviation ranges are set.[32] The choice of 2 percentage point bands seems to reflect a preference for credibility-enhancing narrow bands. If so, the question is whether monetary policy is precise enough to achieve an inflation level inside such a band. In Section 5.3 we discuss this issue in the light of the outcomes of monetary policy prior to the adoption of IT and the ex-post success of the central banks in our sample in achieving their targets.

A common feature in our sample is the absence of price level targets. Price level targets reduce the uncertainty about the future price level, but are more restrictive since they imply that high inflation in one period must be compensated by low inflation next period. Also, since price levels are permanently affected by supply side shocks they are less

[31] In Finland and Spain the target ranges were not precisely defined. In both countries the 2% target should be interpreted as the mid-point of a soft-edged band; the Bank of Finland explicitly stated that deviations on both sides would be allowed, but no explicit toleration ranges were specified. The target for Australia should be interpreted as a 'thick' point rather than a range. In the UK, from May 1997, only the mid-point target is defined, and the MPC is required to write an explanatory letter whenever RPIX diverges more than 1% from this. However, as King (1997) emphasized, "The inflation target is not a range of 1½% to 3½%, it is a target of 2½% on average. Indeed, one of the main purposes of the open letters is to explain why, in some circumstances, it would be wrong to try to bring inflation back to target too quickly. In other words, the MPC will be forced to reveal in public its proposed reaction to large shocks."

[32] It is arguable, however, whether its high credibility was the reason behind the Bank of Finland's choice, given the country's inflation history and substantial depreciation of the markka at the time of the adoption of their point target. The single figure was preferred since it was considered that it would provide a better guide for the formation of inflation expectations (Brunila and Lahdenperä, 1995, p. 129).

flexible in accommodating those shocks. Central banks in our sample may have opted for price change (i.e., inflation) targets because they prefer to have more policy flexibility (even at the cost of higher uncertainty), but it could also be that they decided to go one step at a time. The new monetary strategy was tried first with the less restrictive version of price change targets, instead of going straight to the stronger version of targeting price levels. If this was the case, we might expect to see some of them adopting price level targets some time in the future. But although there are no price level targets, there are point targets for inflation that should hold on average, as in Australia.[33] This kind of target might be interpreted as (moving) price level targets, since both have the same effects in terms of reducing uncertainty about the future price level. Setting an average inflation rate of 2%, strictly means setting the future price level at any point in time, if 'average' means that an inflation rate of 3% in one period implies a rate of 1% the next period.[34] We are doubtful, however, whether average targets should be interpreted so strictly. In the event bygone misses are unlikely to be compensated by an (over) correction on the other side of the 'average'.

The adoption of IT reflects the view that price stability should be the only (medium and long term) objective of monetary policy. However, price stability does not necessarily

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[33] Economists at the Bank of England (e.g., King, 1996) also interpreted the UK target, pre May 1997, as a point target that should hold on average, together with an indication of the range within which ex-post inflation might be expected to lie if policy was directed at this point.

[34] Note that a price level target is not necessarily a constant level target. One may set a target for the price level that is higher than the current price level. In the short run (over one period), there is no fundamental difference between an inflation and a price level target: if the current price level is 100, it is equivalent to set an inflation target of 0-2% or a price level target of 100-102. This is not the case over several periods, since inflation targets allow for base drift, but price level targets do not. If inflation is higher than the inflation target in one period, the price level is permanently affected, since the future inflation targets will refer to the current (higher) price level. This is not the case under a price level target, since too high inflation in one period must be compensated by lower inflation in the following periods. A similar result arises if we use an inflation target that must hold on average, since for the average to hold, high inflation in one period must be compensated by low inflation in the following periods. For example, assume the current price level is 100, and price stability is defined as an inflation rate of 2% per period. If the targets are continuously met, it is (roughly) equivalent to set the targets as (i) an inflation target that should hold every period, (ii) an inflation target that should hold on average or (iii) a price level target. The price level on the second period will be (approximately) 104 in every case. But assume that inflation in the first period is 3%, i.e., the price level is 103. Meeting the targets in the second period implies for target (i) an inflation rate of 2%, i.e., a price level of 105; for target (ii) an inflation rate of 1% (so that the average is 2%), i.e., a price level of 104; for target (iii) a price level of 104, i.e., an inflation rate of 1%. The outcome is the same for targets (ii) and (iii), but not for target (i).

mean a zero inflation rate. In fact, for all the countries in our sample, the target is a positive rate of inflation, although small (around 2%). The question of the optimal rate of inflation, and the empirical and theoretical arguments that imply that the optimal rate of inflation is positive, has been extensively discussed.[35] The main theoretical arguments against a zero inflation rate refer to the non-negativity of the real interest rates (the 'Summers effect'),[36] to the existence of downward nominal rigidities in the labour and product markets,[37] to the optimal inflation tax,[38] and to bias in measures of consumer price inflation.[39] Of these, the only argument that one can find in the official statements of (some of) the central banks in our sample is the last one.[40] The IT of around 2% is said to reflect the average bias in the CPI caused by the introduction of new goods, the improvement in the quality of existing goods, and changes in consumer demand in response to changes in relative prices for which the measured CPI does not account. Estimates of this bias in different countries, however, suggest that the bias is in the 0.5%-1.5% range.[41] Thus, some (or all) of the other arguments may also be behind the choice of a 2% target, although not explicitly stated.[42] Given the likely differences among countries in this statistical bias, and especially in the effects of the other arguments for a positive inflation rate, we find the similarity of the target levels striking. The mid point of the ranges is now between 1.5% and 2.5% for all countries, with the

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[35] Yates (1995) provides a good review of the discussion.

[36] Summers (1991a) pointed out that since nominal interest rates are always non-negative, a zero inflation rate implies that real interest rates must also be non-negative. Summers' argument for a positive inflation rate is that in some circumstances (like in a deep recession), negative real rates of interest might be appropriate. Even if the need for negative real interest rates may be infrequent, they could be very important in those rare cases and should not be ruled out by the adoption of a zero inflation rate.

[37] If there is some downward nominal rigidity in the labour market, short run decreases in the real wage cannot be achieved under zero inflation. In countries where the labour market structure is such that nominal wage cuts are rare (or ruled out by law), a positive rate of inflation may be the less costly way of generating short run real wage decreases.

[38] An inflation tax may be part of the optimal mix of revenue-raising methods a government can use, and thus should not be ruled out by adopting a zero inflation target.

[39] On this, see the Boskin Report (1996).

[40] For example, this was the argument used by the Bank of England (1992).

[41] Brunila and Lahdenperä (1995) claim that the bias in the CPI might be as high as 1.5-2% in the US, but is likely to be smaller in the UK and in Canada (of the order of 0.5-1%).

[42] Only for New Zealand, which had a mid-point target of 1% until 1996, might one argue that the statistical bias was the only reason behind the choice of a positive inflation target. However, since it is likely that in New Zealand the bias in the CPI is smaller than elsewhere (Archer, 1995), i.e., smaller than 0.5%, even for this country some of the other arguments were probably (implicitly) behind the choice of target.

majority concentrating on 2%. We are not aware of any studies quantifying the optimal rate of inflation in each country, supporting *ex-ante* the choice of a given target. Perhaps, central banks just assume that 2% is the small positive number that theoretical arguments suggest the optimal rate of inflation should be, or simply chose to target the same inflation level other countries were targeting.[43]

Given the long lags in monetary policy, the target is usually set initially for some future date, at least 2 years ahead.[44] Where the current inflation was above the target, the central banks in our sample set a downward path for inflation, to reap as soon as possible the benefits of lower inflation expectations the IT is supposed to provide. These 'transition targets' could serve as a benchmark against which the progress towards the ultimate objective could be measured, and meeting the 'transition targets' would help to establish the credibility of the final target,[45] since it is likely that the credibility of the target, and its impact on expectations, would only be achieved by success in meeting it, and not by its simple announcement (see Section 5.4 further below). Table 5.2 describes the timing of the targets in our sample. The inflation rate at the time of the announcement was above the final target range in Canada, New Zealand, Spain and the UK, but the intermediate targets only demanded a strong deflationary effort in Spain, since current inflation was inside the first 'transition target' in the other countries. The impact on expectations of a less ambitious target will tend to be smaller, although a too ambitious target might not be credible. The differences between less and more ambitious targets should be kept in mind when analysing whether inflation outcomes were consistent with the targets (in Section 5.3) and the impact on expectations of the announcement and subsequent inflation performance (in Section 5.4).

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[43] In Finland and Sweden the 2% target was chosen because this was the level of inflation other European countries were seen to be targeting.

[44] Note that usually an initial date for the application of targets is set, but not a final date. At first, a planned path for a reduction in inflation may be set, but once inflation reaches the final target it should stay there indefinitely. The exceptions are Canada and New Zealand, where current targets hold only until 1998 and 2003, respectively, and new targets must be set before those dates to hold in subsequent periods.

[45] The 'transition targets' could also be useful as a guideline for policy decisions. Nicholl and Archer (1992) claim that was the case in New Zealand, where the 'transition target' gave the RBNZ "a clear framework for policy decisions, and has provided the motivation to take policy actions that might be politically difficult" (p. 322).

Table 5.2 **Timing of targets**

	Date of announcement	*Current inflation*[46]	*Target*	*Target date*	*Transition path*
Australia	1993	1.9%	2 - 3 %	1993	none
Canada	Feb 1991	3.9%	1 - 3 %	1995	2-4% Dec 1992; 1.5-3.5% mid 1994
Finland	Feb 1993	2.6%	2 %	1995	none
New Zealand	Mar 1990	3.3%	0 - 2 %	1993	3-5% Dec 1990; 2.5-4.5% Dec 1991; 1.5-3.5% Dec 1992 [47]
Spain	Jan 1995	4.3%	2 %	1998	3.5-4% early 1996; <3% early 1997; 2.5% end 1997
Sweden	Jan 1993	1.8%	1 - 3 %	1995	underlying inflation not increasing
UK	Oct 1992	4.0%	1 - 2.5 %	1997	1 - 4% [48]

5.2.3 Reaction function

Under an IT strategy the final objective is targeted directly, and no intermediary targets are used. Given the lags in monetary policy, this means that a (explicit or implicit) forecast of future inflation is the intermediary target.[49] In principle, the monetary policy decision process would start with the computation of a point forecast for inflation X periods ahead, with X being the policy lag. Then, monetary conditions would be ad-

[46] Current inflation refers to the formal target index on the quarter before the announcement, except for Canada and New Zealand where it refers to the underlying inflation index used for policy decisions.

[47] The final target in this table refers to the one set in the second and third PTA's. The targets in New Zealand were changed three times before November 1997. The first Policy Targets Agreement (PTA), signed in March 1990 set the final target of 0-2% by the end of 1992, and in April the RBNZ announced the 'transition targets' of 3-5% in December 1990 and 1.5-3.5% in December 1991. A new PTA was signed in December 1990 extending the final target for the end of 1993, and following this the RBNZ announced in February 1991 the new 'transition targets' of 2.5-4.5% and 1.5-3.5% in December 1991 and 1992, respectively. A third PTA was signed in December 1992 where the target was set to hold from that moment until the end of the Governor's term in 1998. Finally, this target was revised to 0-3% in a fourth PTA signed in December 1996. We took the targets to be the ones set more recently at each point in time, that is, the 'transition targets' to be 3-5% in December 1990, 2.5-4.5% in December 1991, 1.5-3.5% in December 1992, the final target of 0-2% to hold from the first quarter of 1993 until the fourth quarter of 1996, and the new target of 0-3% to hold from the first quarter of 1997. A fifth PTA was subsequently signed on December 1997 (see footnote 28 for details).

[48] This transition path refers to the first inflation target announced in October 1992, which determined that inflation should be in the 1-4% range from that moment on, and in the lower half of that range "by the end of the current Parliament" (1997). This target was revised by the new Labour Government elected in May 1997.

[49] Svensson (1997) provides a formal analysis of the inflation forecast role under an IT strategy.

justed according to the relative position of the forecast to the target range: if the forecast is on target, no action is required; if the forecast is above the target, monetary conditions should be tightened; if the forecast is below the target, monetary conditions should be relaxed. Thus, IT would be different from the money or exchange rate targeting strategies because policy reacts to a quantified inflation forecast, and not to current changes in the ex-post, actual data for some financial variable. Also, in principle, IT involves a quasi-formalised reaction rule, that distinguishes it from a discretionary monetary policy. However, the actual policy decision processes do not always follow the simple rules outlined above, and the distinction of IT from other policy strategies is less clear than the process outlined above might suggest.

In principle, IT involves the computation of a quantified inflation forecast that is going to be compared with the target. As we show in Table 5.3, although quantified inflation forecasts are used in all the central banks in our sample, policy decisions are not based exclusively on those quantified forecasts, but also on a subjective evaluation of several leading indicators. In some countries (e.g., Australia, Finland), quantified inflation forecasts are just one of the indicators used for policy decisions. Even in the countries where quantified inflation forecasts are the key input in the policy decision process, much subjective judgement is put into the forecasts, and furthermore the policy makers also look at other indicators, not only the point forecast. This is usually justified on the grounds that point inflation forecasts are deemed to be unreliable and subjective judgements of the inflationary pressures in the economy are thought to improve the results. Another way of avoiding the limitations of point forecasts is to do some form of 'risk analysis', by computing different forecasts under alternative scenarios,[50] or describing the inflation forecasts as a probability distribution and not a point estimate.[51] For an extended discussion of this issue, see Haldane, Nicoletta, and Whitley (1998).

[50] For example, at the Bank of Canada the staff prepares a base forecast and several alternative forecasts according to different scenarios for the exogenous variables; the management then will treat the different alternatives according to their view of the likelihood of such scenarios (Longworth and Freedman, 1995).

[51] For example, the Bank of England stresses that the uncertainty surrounding inflation forecasting will make the inflation outcome 'always' different from the forecast. For this reason, since February 1996, the inflation forecasts in the *Inflation Report* are presented as confidence intervals, and not as point forecasts.

Table 5.3 The inflation targeting monetary policy strategy

A. BASIS FOR POLICY DECISIONS *(quantified forecasts or subjective evaluation of indicators)*

Australia	subjective evaluation of several indicators, including inflation forecasts
Canada	use econometric model (including judgement) to estimate the time path of monetary conditions necessary to keep future inflation (approximately 2 years ahead) near midpoint (monetary aggregates are used as an independent check on the economic projection)
Finland	subjective evaluation of several indicators; since October 1995, also inflation forecast 6 to 8 quarters ahead
NZ	use econometric model (including judgement) to estimate the time path of monetary conditions necessary to keep future inflation (approximately 2 years ahead) near midpoint
Spain	use of econometric models and subjective evaluation of several indicators
Sweden	inflation forecast 1-2 years ahead
UK	inflation forecast 2 years ahead

B. MAIN INDICATORS USED AS INPUT FOR POLICY DECISIONS

Australia	inflation expectations, wage settlements, output gap
Canada	M2+, M1, output gap, wage indicators
Finland	wages, inflation expectations, exchange rate, yield curve, money aggregates
NZ	exchange rate
Spain	ALP (liquid assets held by private sector) growth of not more than 8% is used as a reference
Sweden	output gap, inflation expectations, yield curve
UK	output gap, inflation expectations, observed prices, M0, M4

C. OPERATING TARGETS

Australia	money market overnight rate
Canada	monetary conditions index (MCI)[52], where the 90 day commercial paper rate weighs 75% and the exchange rate index 25%
Finland	evaluation of monetary conditions, where the key interest rate is the one month tender rate
NZ	MCI, where the 90 day bank bill rate weighs 1/3 and the exchange rate index 2/3
Spain	money market overnight rate
Sweden	MCI, where the money market overnight rate weighs 75% and the exchange rate 25%
UK	commercial banks' base rate

D. POLICY INSTRUMENTS

Australia	operating target for the overnight money market rate
Canada	operating band for the overnight money market rate
Finland	tender rate
NZ	settlement cash balances at the RBNZ (used to influence the money market overnight rate)
Spain	intervention rate (10 day repo rate)
Sweden	repo rate
UK	money market dealings rate

[52] Given that the countries in our sample are medium and small open economies, the operating target is usually some combination of a short term interest rate and the (trade-weighted) exchange rate. This combination is sometimes expressed in terms of a computed 'monetary conditions index'. The role of a 'monetary conditions index' in the conduct of monetary policy has been given considerable attention in recent research, in particular at the Bank of Canada (see, for example, Freedman, 1995b).

Another of the distinctive features of the IT strategy is the use of several indicators as inputs into the decision process and forecasting procedure, with no indicator having a predominant role, as an intermediary target would have. In practice, this distinction is less clear, since some central banks in our sample give a large weight to a particular variable, like the exchange rate in New Zealand or broad money in Spain (see Table 5.3, panel B). It is difficult to see, for instance, where the behaviour of the Banco de España differs, in this respect, from the behaviour of the central banks who use a monetary target strategy, like the Bundesbank. In Spain, the growth of the monetary aggregate ALP (liquidity assets held by the private sector) is the main indicator behind policy decisions, although other indicators are also considered, and the liquidity growth targets are not taken as fixed rules, but just as a mean of achieving price stability. In money targeting countries, interest rate changes are said to be conditioned on the movement of some monetary aggregate, like the M3 in Germany, but other indicators are also considered, and the money targets are frequently overruled due to other economic factors.[53]

Finally, the IT framework differs from a discretionary policy because a quasi-formalised reaction rule exists. In practice, the straightforward application of the rule raises several problems, whose solution generally involves considerable discretion for the policy makers.[54] The first question is whether the target is the range or the mid-point of the range. In the latter case, the bands may be interpreted as confidence intervals indicating where ex-post inflation might be expected to lie if policy is directed at the mid-point, and the central bank should act whenever the forecast differs from the mid-point. In Canada and the UK (post May 1997), for example, policy actions are directed at kee-

[53] Clarida and Gertler (1996) claim that in Germany, the money targets are meant as guidelines and in no sense do they define a strict policy rule (p. 2), that the Bundesbank has tolerated deviations from the targets as a reaction to the development of economic activity (p. 7), and that moderating market interest rate fluctuations takes precedence over monetary targeting (p. 11). Helmut Schlesinger, former President of the Bundesbank, quoted in von Hagen (1995, p. 108) said that the Bundesbank has never conducted a rigid policy geared at the money supply alone, and all available information about financial markets and the economy is analysed regularly. Bernanke and Mihov (1997) claim that the Bundesbank is a 'closet' inflation targeter.

[54] The degree of ongoing discretion may be reduced by describing thoroughly all the details of the operation of the targets the moment they are announced. Many central banks have described in some detail how they interpret the targets, and this implies that many of the choices discussed in this and the following paragraphs were made *ex-ante*. However, this was not always the case, and some central banks still have some degree of discretion in some of the issues discussed.

ping forecast inflation near the mid-point of the band. Where the target is the band, strictly, the rule only demands action when the forecast is outside the target range. However, even in this case a prudent central bank might wish to act as long as the forecast is close to the boundaries, to minimise the risk of missing the target given the uncertainty surrounding any inflation forecast. In New Zealand, where the target is the band, the RBNZ initially would not react as long the forecast was inside the band. But, after an unexpected and short-lived surge in the price of fresh vegetables that drove underlying inflation 0.2% above target in the second quarter of 1995, although all the previous forecasts for that quarter were inside the target range, the RBNZ decided to adopt the strategy of acting as long as the forecast is close to the boundaries (Mayes and Riches, 1996).

The second problem is whether any deviation from target, no matter how small, should trigger a reaction, or whether policy should only respond to significant deviations. The credibility and accountability of the IT would suggest reactions to any deviation, to minimise deviations from target, but some central banks will only react to significant deviations. The reason is that small deviations imply small adjustments in monetary conditions, and small adjustments might be undesirable.[55]

The final question is, if the forecast lies off the target in one period, whether the policy response should be strong, so that inflation quickly returns to the range, or gradual. Again, the credibility and accountability issues would suggest a sharp response, to minimise the number of periods the target is going to be missed. However, some central banks (e.g., in Sweden and Spain) prefer a gradual approach, because a radical response could be destabilising and drive inflation through the other end of the range, since forecasts are not precise and the effects of policy are not known exactly.[56]

The main concern relates to the trade-off that exists in the short-run, given wage/price

[55] For instance, until now the Bank of England has only initiated interest rate changes of at least ¼ p.p., although the MPC has recently reaffirmed that it would be prepared to make step changes of whatever size that it thought appropriate (see Inflation Report, November 1997, p. 71).
[56] Such concern is termed multiplicative, or Brainard, uncertainty (see Brainard, 1967).

rigidities in that horizon, between output variability and inflation variability. With such rigidities in place, there remains a downwards sloping short-run Phillips curve, and thus such a trade-off exists. As Haldane, Nicoletta, and Whitley (1998), demonstrate, any attempt to use monetary policy aggressively to restore inflation to its target as soon as possible will cause avoidable instability in output, whereas a very slow adjustment will cause avoidable instability in inflation. Perhaps superficially surprising, the appropriate choice of inflation target horizon appears largely able by itself to deliver the best combination of inflation/output variability without any need to enter an output-gap variable into the central bank's reaction function (Haldane, Nicoletta, and Whitley, 1998, p. 30).

5.2.4 Foreign exchange rates

The IT strategy differs from other policy strategies in terms of the final objectives (a quantified level for inflation) and intermediary targets (no single intermediary target). There is no apparent reason why the adoption of IT would imply changes in policy instruments or operating targets. In fact, no central bank in our sample claimed to have made such changes due to the adoption of IT. Panels C and D of Table 5.3 describe the policy instruments and operating targets currently in use in the countries in our sample. Changes in policy instruments have occurred in the IT period, for instance in Finland, Sweden and the UK, but usually for microeconomic reasons. Nevertheless, being a new policy strategy, IT should lead to different policy responses, that could be translated into a different usage of the policy instruments and in a different behaviour of the operating targets. We try to identify any changes the adoption of IT induced in these operating targets, by looking at the behaviour of exchange rates, in this subsection, and short term interest rates, in the following subsection.

If the sole objective of monetary policy is the control of inflation, then central banks must be prepared to accept the level of the exchange rate that is compatible with the inflation target, whatever that level is. This does not mean that IT is necessarily incompatible with some (loosely defined) desired level for the exchange rate. If inflation levels are similar at home and abroad, IT is also a rough mechanism for maintaining the external value of the currency, as long as PPP holds. However, conflicts between external and internal objectives may often arise. Under IT this must be resolved by the abandonment of the external objective, which implies that IT countries must be prepared to accept larger short and medium term swings in the exchange rate, if necessary.

Obviously, IT is an alternative to, and is different from, a regime of exchange rate targets. It could be argued that exchange rates fixed to low inflation currencies and IT are not fundamentally different, since they are just different ways of achieving price stability, and, if inflation is low at home and abroad, exchange rates will tend to be stable even under IT. However, in the presence of significant real shocks, under IT we might observe large swings in the nominal exchange rate, with no changes in inflation levels, as the real exchange rate adjusts to the new economic conditions.[57] This type of adjustment could not occur under exchange rate targeting, at least as long as targets are kept unchanged.

Table 5.4 **The role of the exchange rate in the policy decision process**

Australia	exchange rate is only relevant if excessive depreciation threatens future inflation
Canada	exchange rate is a component of the 'monetary conditions index', the operating target
Finland	before October 1996, large changes in the exchange rate were allowed, although some of the actions of the Bank of Finland in early 1993 were motivated by the threat of the collapse of the markka and it did occasional interventions on both sides to stop sharp intra-day movements (but not affecting the trend)
NZ	exchange rate is the key variable in the operation of monetary policy due to its strong and rapid influence on prices, but it is not a target in its own right; given the inflation forecasts, comfort zones for the exchange rate are defined, and adjusted as parameters are revised; movements of the exchange rate within the zone are normally tolerated until the rate approaches the margins; however there is no direct intervention on forex markets
Spain	there is a formal commitment to keep the peseta within the widened bands of the ERM, but only permanent trends (not temporary fluctuations) shape policy decisions and as long as it may endanger the inflation target; forex stability is viewed more as a result that will come about with price stability than an end in itself
Sweden	return to exchange rate targets only when it is compatible with price stability
UK	there are no targets for the exchange rate

[57] Examples of such an adjustment are the Finnish experience of 1992-94, and the UK experience of 1996-97.

Table 5.4 describes the role of foreign exchange rates as policy targets under IT. In the countries in our sample, exchange rates have, at least, an informative role in the policy decision process. In some cases, exchange rates may act as operating targets, but they are not intermediary targets. Medium term control of the exchange rate is only attempted if large changes threaten the IT, and short term control is abandoned. No central bank in our sample has tried to stabilise the exchange rate in the short term, except the Bank of Finland who occasionally did intervene to avoid sharp intra-day movements.

Exchange rate volatility

The abandon of exchange rates as policy targets should imply higher short term volatility of the exchange rate for the European countries, who had exchange rate targets before the adoption of IT. Figure 5.1 plots the absolute value of the daily changes in the exchange rate of the countries in our sample from 3/1/1986 to 11/12/1997.[58] Visual inspection of Figure 5.1 suggests that the adoption of IT was associated with higher short term exchange rate volatility in Finland and Sweden, and with lower short term volatility in New Zealand.

To test formally for the existence of such changes in volatility we used the ARCH framework, where we allowed the conditional variance to be affected by changes in the monetary policy strategy. Following Baillie and Bollerslev (1989) and Hsieh (1989) we assumed daily exchange rate returns follow a GARCH(1,1) process of the form:

$$r_{i,t} = \mu_i + \varepsilon_{i,t} \qquad 5.1$$

$$\varepsilon_{i,t} \;/\; \psi_{i,t-1} \sim G(0,h_{i,t}) \qquad 5.2$$

$$h_{i,t} = \gamma_i + \alpha_i\, \varepsilon^2_{i,t-1} + \beta_i\, h_{i,t-1} + \delta_i D_{i,t} \qquad 5.3$$

where $r_{i,t}$ is the change in exchange rate i in period t, $D_{i,t}$ is a dummy variable, taking the

[58] The exchange rate data are US dollar Bankers' Trust mid-quotes at 3:00 pm EST, available from *Datastream*. The DEM rates were computed from the USD rates. For the Australian, Canadian and New Zealand dollar the exchange rates used are US dollar rates; for the Finnish markka, the Spanish peseta and the Swedish krona, DEM rates are used; for the British pound both USD and DEM rates are presented. The vertical dashed lines indicate the date of the adoption of IT. In some of the charts, large outliers were truncated for presentational purposes.

value 1 before the adoption of IT, and μ_i, γ_i, α_i, β_i, and δ_i are parameters. The conditional distribution *G(.)* was assumed to be normal. The unconditional variance of the model in equations 5.1-5.3 for the IT period, σ^2_{iT}, and for the non-IT period, σ^2_{iN}, are given by

$$\sigma^2_{iT} = \gamma_i \,/\, (1 - \alpha_i - \beta_i) \qquad 5.4$$

$$\sigma^2_{iN} = (\gamma_i + \delta_i) \,/\, (1 - \alpha_i - \beta_i) \qquad 5.5$$

Table 5.5 reports the results of estimations of this model, for the countries in our sample, over the period 3/1/1986 to 11/12/1997 (t-statistics in italics).[59] A simple comparison of the exchange rate volatility in the IT and non-IT period, reveals significant decreases in the IT period for Australia, Canada, Spain, the UK, and, in particular, New Zealand, where average exchange rate volatility fell more than 75% after the adoption of IT. On the other hand, volatility increased with IT in Finland and Sweden. For these countries (and also for Spain and the UK, to a smaller extent) the non-IT period was mainly a period of fixed exchange rates, and that may explain the increase in volatility.

Table 5.5 **Volatility of daily exchange rates before and after IT**

	Dummies definition	γ_i (x 10000)	α_i	β_i	δ_i (x 10000)
Australia	D: t<1/1/93	0.0673 *13.5*	0.1250 *11.2*	0.7510 *56.9*	0.0213 *5.3*
Canada	D: t<26/2/91	0.0103 *15.8*	0.1000 *12.7*	0.8210 *100.4*	0.0012 *2.4*
Finland	D: t<2/2/93 or t>12/10/96	0.4270 *16.5*	0.2580 *16.9*	0.5870 *46.0*	-0.2196 *-9.9*
New Zealand	D: t<2/3/90	0.0933 *21.1*	0.1620 *15.3*	0.6680 *53.9*	0.3060 *22.7*
Spain	D: t<1/1/95	76.207 *14.5*	0.2821 *33.9*	0.6515 *99.5*	45.953 *9.7*
Sweden	D: t<15/1/93	2.9959 *17.0*	0.3599 *39.9*	0.3628 *19.7*	-2.3148 *-14.6*
UK	D: t<8/10/92	0.0703 *12.9*	0.1034 *17.0*	0.8605 *166.7*	0.0133 *2.7*

59 The results reported for Finland were obtained from a model that included 2 dummies taking the value of 1 in 14/11/1991 and 9/9/1992, respectively, when major devaluations occurred. Without the inclusion of these dummies the variance (conditional on the monetary regime) would not be stationary.

In order to separate the effects of the adoption of IT and the floating of the currency, we estimated a model similar to the one in equations 5.1-5.3, but with equation 5.3 replaced by

$$h_{i,t} = \gamma_i + \alpha_i \, \varepsilon^2_{i,t-1} + \beta_i \, h_{i,t-1} + \omega_i M_{i,t} + \lambda_i F_{i,t} \qquad 5.3'$$

where $M_{i,t}$ is a dummy variable taking the value 1 during the period of discretionary monetary policy, and $F_{i,t}$ is a dummy variable taking the value 1 during the fixed exchange rate period.[60] The results of the estimation of this model are reported in Table 5.6. When we control for the existence of a fixed exchange rate period, then we observe that exchange rate volatility in the IT period is significantly higher than in the fixed exchange rate period in the 4 countries where such a regime existed, but significantly lower than in the discretionary regime for all the countries in our sample.

Table 5.6 **Volatility of daily exchange rates during IT and the fixed rate period**

	Dummies definition	γ_i *(x 10000)*	α_i	β_i	ω_i *(x 10000)*	λ_i *(x 10000)*
Finland	M: 8/9/92<t<2/2/93 or t>12/10/96 F:t<=8/9/92	0.5394 *16.1*	0.2500 *15.2*	0.5280 *33.2*	0.5348 *3.7*	-0.2858 *-10.7*
Spain	M: t<19/7/89 or 15/9/92<t<1/1/95 F: 19/7/89<t<15/9/92	209.303 *17.1*	0.3669 *30.5*	0.4052 *28.9*	179.463 *15.1*	-85.777 *-8.2*
Sweden	M:18/11/92<t<15/1/93 F: t<=18/11/92	3.4193 *16.3*	0.2599 *14.7*	0.3374 *12.8*	13.5662 *10.2*	-2.6681 *-14.4*
UK	M: t<5/10/90 or 15/9/92<t<8/10/92 F: 5/10/90< t<15/9/92	0.0919 *15.0*	0.0962 *15.0*	0.8500 *136.6*	0.0582 *8.0*	-0.0420 *-6.6*

The evidence in Tables 5.5 and 5.6 supports the hypothesis that exchange rate volatility was significantly lower during IT than during the discretionary period, for all the countries in our sample. Compared to a discretionary monetary policy, IT seems to be able to provide more stable foreign exchange rates. This could be explained by a reduction in the uncertainty of market participants regarding the future monetary policy, that the existence of a clear target for monetary policy could provide. Compared to exchange

[60] We chose to include the exchange rate targeting of the ERM participants after the September 1992 crisis (Spain, Finland after October 1996) in the discretionary period because the exchange rate movements allowed under this regime are too large to be compatible with any definition of a fixed exchange rate regime.

rate targets, the adoption of IT leads to a cost in the form of an increase in short and medium term exchange rate uncertainty, as would be expected, but allows for easier adjustments to real shocks and reduces the probability of speculative crises in the forex market.

5.2.5 Short term interest rates

Given that a different policy strategy should imply different policy responses, we investigated whether the adoption of IT implied a change in the use of the interest rate instrument. Our first hypothesis was that central banks would raise interest rates earlier than before, relative to observed inflationary pressures. The argument is that under IT, central banks can resist pressures not to raise them more easily, since interest rate changes can be justified with reference to the inflation forecast and the target. Although there is some evidence that could indicate a more forward looking behaviour in the non-European countries, we could not find evidence of a systematic change in behaviour in the data available so far: the timing of interest rate changes, after the adoption of IT, was not unusually early relative to observed inflation, especially for the European countries. However, a general change to a more forward-looking attitude might have occurred, but the tests performed, presented in Appendix 5.A, were not powerful enough to detect it, given the relatively short data series available.

The argument that central banks can justify their actions more easily under IT, would also suggest that we would observe less interest rate smoothing, at least in the non-European countries. Supported by their inflation forecasts, a central bank could compute the necessary interest rate change to achieve the desired level of inflation, and do the change in one move, instead of doing it in a series of small changes of the same sign.[61] Again, we could not find such a change in behaviour in the data for our sample,

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[61] It could be argued that with free international capital movements, any interest rate changes are conditioned on the interest range changes in the core currency countries. If these countries smooth interest rates, then other countries have to smooth them too, and thus we should not expect a significant change in behaviour in that respect just due to the adoption of IT.

although for some countries (e.g., Australia and Canada) there are some indications that the adoption of IT might lead to a more vigorous use of the interest rate instrument, as we describe in Appendix 5.B. For the European countries, who previously had exchange rate targets, it is likely that before IT interest rates would be changed more frequently and in larger amounts. When the target is the exchange rate, the effects of the policy change are almost immediately observed, and policy must be continuously adjusted. Exchange rate targets demand monitoring and policy reactions almost to the minute, and it is possible that some of those reactions might have to be quick and vigorous, particularly during speculative attacks to the exchange rate. No such emergency policy reactions are needed under IT, and interest rate adjustments can be made more gradually, if interest rate smoothing is seen as desirable. The lack of accuracy of inflation forecasts and the uncertainty about the nature of shocks and the effects of monetary policy might recommend such gradual actions.[62]

Short term interest rate volatility

Where we did find some differences in the behaviour of interest rates is on short term volatility of money market rates. Figure 5.2 plots the absolute value of the daily changes in the 3 month market interest rate of the countries in our sample from 3/1/1986 to 10/12/1997.[63] The visual inspection of Figure 5.2 suggests the adoption of IT is associated with lower daily volatility of short term interest rates. This pattern can be seen in all the countries in our sample, except for Canada, where sufficient data for the period before IT were not available.

To test formally for the existence of such changes in volatility we used a version of the EGARCH model developed by Nelson (1991), where we allowed the logarithm of the

[62] For a detailed analysis on why central banks might prefer to smooth interest rates, see Goodhart (1996).
[63] The data were provided by *Datastream* and refer to Treasury bill rates for Australia, Canada, Sweden and the UK and interbank rates for Finland, New Zealand, and Spain. For some countries, restrictions in data availability reduced the sample period. The vertical dotted lines indicate the date of the adoption of IT. In order to keep the scale the same in all charts, large outliers were truncated for presentational purposes in some of the charts.

conditional variance to be affected by changes in the monetary policy strategy. The model used was the following:

$$c_{i,t} = \mu_i + \varepsilon_{i,t} \qquad 5.6$$

$$\varepsilon_{i,t} \;/\; \psi_{i,t-1} \sim P(0,h_{i,t}) \qquad 5.7$$

$$g_{i,t} = \left|\frac{\varepsilon_{i,t}}{\sqrt{h_{i,t}}}\right| - \sqrt{\frac{2}{\pi}} - \phi_i \frac{\varepsilon_{i,t}}{\sqrt{h_{i,t}}} \qquad 5.8$$

$$\ln h_{i,t} = \gamma_i + \alpha_i \ln h_{i,t-1} + \beta_i g_{i,t-1} + \delta_i D_{i,t} \qquad 5.9$$

where $c_{i,t}$ is the weekly change for interest rate i at period t,[64] $D_{i,t}$ is a dummy variable taking the value 1 before the adoption of IT in country i, and μ_i, γ_i, α_i, β_i, ϕ_i, and δ_i are parameters. The conditional distribution *P(.)* was assumed to be normal. Table 5.7 reports the results of estimations of this model, for the countries in our sample, over the period 3/1/1986 to 10/12/1997 (t-statistics in italics).

Table 5.7 **Volatility of weekly interest rates before and after IT**

	Dummies definition	γ_i	α_i	β_i	ϕ_i	δ_i
Australia	D: t<1/1/93	-0.3103	0.9240	0.2009	-0.3410	0.1323
		-3.9	*50.2*	*7.9*	*-5.2*	*4.0*
Finland	D: t<2/2/93 or t>12/10/96	-0.0147	0.9906	0.2093	-0.3963	0.0240
		-1.4	*359.8*	*10.7*	*-5.7*	*3.2*
New Zealand	D: t<2/3/90	-0.2344	0.9057	0.4382	-0.1273	0.1144
		-3.8	*46.1*	*10.2*	*-2.4*	*2.3*
Spain	D: t<1/1/95	-0.1083	0.9664	0.4155	-0.2083	0.0374
		-3.9	*143.0*	*11.3*	*-4.5*	*2.2*
Sweden	D: t<15/1/93	-0.3409	0.8815	0.4635	-0.7217	0.2517
		-6.2	*48.0*	*14.8*	*-6.6*	*8.4*
UK[65]	D: t<8/10/92	-4.9646	-0.2028	0.0008	10.755	1.5526
		-5.6	*-1.0*	*0.0*	*0.0*	*5.7*

A simple comparison of the interest rate volatility in the IT and non-IT period, reveals significant decreases in the IT period in all the models estimated,[66] that confirm the

[64] In our sample, the variance of daily interest rate changes tends to be integrated. Using weekly data, the likelihood of finding integrated variances is reduced.

[65] The model used for the UK was modified by replacing equation 5.6 with:

$$c_{i,t} = \mu_i + \rho_i c_{i,t-1} + \varepsilon_{i,t}.$$

[66] We did not estimate a model for Canada because we did not have a sufficiently long data series for the period before IT.

inferences from the visual inspection of the charts. The lower short term interest rate volatility after IT in the European countries was expected, for the arguments presented above regarding interest rate smoothing. But we also found a lower short term interest rate volatility in Australia and New Zealand, that cannot be explained by the transition from a fixed to a floating exchange rate. It seems under IT interest rates might be less volatile than under either discretionary or exchange rate targeting monetary policy strategies. The reason for the difference with the former could be that, as we already mentioned for the exchange rate, the adoption of IT provides market agents with a guideline that reduces uncertainty about future monetary policy.[67]

Moreover, the variance and mean level of inflation are strongly positively correlated; the coefficient of variation is nearly constant (see for example Chapter 4, subsection 4.2.1). Consequently if the adoption of IT, or other aspects of the conjuncture, help to stabilise the level of inflation at a lower mean level, then its variance can be expected to decline also. Such a decline in the volatility of inflation will help to reduce the variance of interest rate reactions. Causation is clearly two-way.

The main apparent changes in the behaviour of the instruments or operating targets are related to the short term volatility of financial market prices, interest and exchange rates.[68] Some of the changes are probably associated with the change from fixed to floating exchange rates, and not to the adoption of IT directly, although it is questionable whether we should consider these two events as completely distinct. The differences, in this respect, between the discretionary and the IT strategies suggest that IT could be a key factor in providing stability to financial markets. Markets need a transparent monetary policy, one they can anticipate and understand, and this increase in transparency is one of the main reasons behind the adoption of IT. If this is true, then IT may be the only feasible floating exchange rate strategy in some situations. In an economy where money demand is not sufficiently predictable to allow for money targe-

[67] This topic is analysed extensively in Chapter 6.

[68] We also looked at the behaviour of narrow and broad money aggregates, before and after the adoption of IT. Again, we could not find any significant change. These tests are not reported here, but may be obtained from the authors.

ting and the credibility of a discretionary monetary policy is not high enough to satisfy financial markets, then the only options available are between an exchange rate target or floating exchange rates with IT. The timing of the adoption of IT in the UK, Sweden and Finland, right after the abandonment of fixed exchange rates, suggests that this was probably the case in these countries.

5.2.6 Communication with public and government

One major area of change initiated by the adoption of IT is the communication of central banks with the public and government. Under IT, the effects of central banks' policy actions can only be observed after a long time, since monetary policy takes several quarters to influence inflation. Under other strategies, the existence of intermediate targets that reflect policy actions more quickly makes monitoring of central banks easier, but no such intermediate targets exist with IT. We claimed above that credibility and accountability concerns were the main forces driving the adoption of IT. For these reasons, IT demands that central banks develop new forms of communication, to transmit clearly and precisely and to explain their policy actions to other agents. All the central banks in our sample improved the communication channels with the public and government, in recent years. Although some of the changes were not contemporary with the adoption of IT, they are all part of the same trend towards increased transparency and accountability. The main changes introduced by each central bank regarding communication are described in Table 5.8.

The public must know what policy actions the central bank is taking in order to have an impact on credibility, and they need to understand and believe those actions to be the appropriate ones to achieve the target. In order to achieve these goals, the central bank may use a set of different communication channels. First, a central bank can immediately and fully disclose policy changes, and the reasons for the change, through press releases issued at the precise moment the measures are taken. This is particularly important in those countries where there is no administratively set interest rate, and the

Table 5.8 **New communication channels**

Australia	- "Semi-Annual Statement on Monetary Policy" introduced in May 1997; previously the "Quarterly Report on the Economy and Financial Markets" included a large section on inflation and extensive discussion of monetary policy changes - press releases announcing changes in policy, explaining in detail the reasons for the change
Canada	- "Monetary Policy Report" introduced in May 1995, published twice a year - publication of the Governor's comments to the Board of Directors on "Economic and Financial Conditions and Monetary Policy" (after the following Board meeting) - press releases announcing changes in policy - regular meetings of the Governor and Minister of Finance - appearances by the Governor before committees of the House and Senate - "outreach program", under which members of the Board of Directors and senior Bank officials meet with groups of Canadians in all parts of the country
Finland	- quarterly article on policy with focus on inflation outlook in the monthly "Bank of Finland Bulletin" (in English) and in the quarterly "Markka & Talous" (in Finnish) - press statement after policy changes - more use of public speeches by the Governor to inform on monetary policy and inflation outlook
New Zealand	- "Monetary Policy Statement" introduced in April 1990, published twice a year - quarterly "Economic Projections" (which include a monetary policy assessment section), published in the quarters between the 'Monetary Policy Statement' - occasional statements on unexpected developments that affect monetary policy - public scrutiny of the Governor by Parliament's Finance and Expenditure Committee - extensive programme of private and public speaking engagements by the Governor to inform on and explain policy developments
Spain	- "Inflation Report" introduced in March 1995 - press releases to explain some policy changes - Banco de España's "Annual Report" and monthly "Economic Bulletin" improved to include more information on monetary policy - appearances by the Governor before the Parliamentary Committee for Economic Affairs
Sweden	- "Inflation Report" introduced in October 1993 (initially under the name "Inflation and Inflation Expectations in Sweden"), published quarterly - public hearings before the Finance Committee of the Parliament - more regular and public reviews of Central Bank's actions, in speeches and lectures by the Governor and staff
UK	- "Inflation Report" introduced in February 1993, published quarterly - formalisation of the regular monthly meetings between Governor and Chancellor, prior to May 1997, and since then of the Monetary Policy Committee (MPC) - publication of the minutes of the meeting (two weeks after following one, between April 1994 and May 1997, and one week after since May 1997) - press notice after each policy change explaining the main reasons for the change - Governor and other members of MPC appearances before the Treasury Select Committee - more use of public speeches by Governor and Directors - published open letter to the Chancellor from the MPC should inflation deviate more than 1% from central target.

central bank acts mainly through intervention in money markets. For instance, the Reserve Bank of Australia immediately announces, through press releases, any change in its operating target range for the money market rate, instead of just signalling it through market interventions, as happened previously. The disclosure of this information reduces uncertainty about current policy, and may contribute to reduce instability in financial markets, besides allowing agents to form a more informed view of future inflation prospects. Even in the countries where the nature of the policy instrument implies an immediate disclosure of the change, the accompanying press release has an important role in explaining the reasons for the move. For instance, in the UK, changes in the main instrument, the money market dealings rate, have to be immediately disclosed, since it is an administratively set rate. Nevertheless, the press release is important because it explains in some detail the reason for the change, and this justification may contribute to persuade the agents that the move is consistent with the inflation target, thus strengthening the credibility of monetary policy.

Another channel central banks may use to improve the credibility of their policy is regular monetary policy and inflation reports. These reports could take the form of a separate publication or they could be included in regular central bank bulletins. Most central banks in our sample (6 out of 7) preferred to introduce a separate publication, probably thinking that it would have a stronger impact on agents' expectations, because a separate publication will receive more attention from the media than a bulletin article. Through these reports, the public can monitor and evaluate monetary policy with an inflation target. In some countries (e.g., Spain) the report is sent to Parliament, increasing the transparency and political accountability of the central bank's activities. The main role of the Reports is to make public the central bank's inflation outlook and explain how this outlook was formed. The reports may also be used to provide a detailed justification of current monetary policy actions, and explain why these actions are consistent with the inflation target. Finally, the reports may be used to educate the public on the problems involved in the execution of monetary policy, and the importance of price stability.

We would expect, in a situation where the public (i) believe the central bank's implicit objectives coincide with the inflation target, (ii) believe the model the central bank is using is adequate, and (iii) believe all available information is being used by the central bank, that the report would have a major impact on expectations. In fact, in the ideal situation described above, there is no reason why agents would not take official forecasts as their own inflation expectations. However, that is not what we observe, as we will see below, when we discuss the quality of official forecasts and their impact on expectations, which suggests that the public suspects that the central bank's 'secret' objectives are different from the IT, or is sceptical about the technical abilities of the central bank's staff, or believes that the Central bank has some private information that they are not disclosing.

The information disclosed in press releases and inflation reports may be complemented by regular speeches by the Governor and other senior officials. These speeches may play an important role in explaining policy decisions, or the importance of price stability, specially because they can address the particular concerns of specific audiences. For instance, the Governor of the RBNZ explained the implications of the New Zealand's new policy strategy to exchange rate developments in a speech delivered to the Auckland Manufacturers' Association, whose members had been expressing some concern about the need to have a 'favourable' exchange rate (Brash, 1992). These tactics have been pursued by some central banks in our sample (specially the RBNZ), who have increased significantly the number of contacts of Central Bank senior officials with the public, since the adoption of IT.

All this information disclosure improves, by itself, the accountability of the central bank. But democratic accountability could be enhanced by regular contacts with parliament and government. Being forced to explain their policies to democratically elected powers is an additional source of pressure that forces central banks to stick to targets, especially if penalties could be imposed on the central bank's governor if the policy is not consistent with the IT. This is the case in New Zealand, where the Governor can be dismissed if targets are not met, and inflation outcomes are closely monitored. When in June 1995 underlying inflation overshot the target by 0.2 percentage points (and again in March 1996, when the target was overshot by 0.1 percentage points), the Minister of Finance immediately called for an official report on the performance of the Governor from the non-executive Directors at the RBNZ Board.

Finally, communication channels can be powerful policy instruments. In certain cases the communication of future developments in inflation is an instrument of monetary policy in itself. For example, in New Zealand the financial markets almost invariably deliver the necessary monetary conditions as a reaction to the Central Bank's comments on inflation outlook. These comments are the instrument the RBNZ has used most frequently; the settlement cash instrument was used only 3 times since 1991.[69] In the UK, the Bank of England's comments on the inflation outlook may have had the effect of putting pressure on the Chancellor, who prior to June 1997, had to decide on interest rate changes.[70] In so far as financial markets believe that central banks are truly committed to their ITs, they can work out for themselves (using their own models) what interest rate adjustments may be necessary to meet the target, and hence shift the term structure of (forward) rates to reflect that view. Consequently monetary policy may seem to become more "boring" as policy adjustments more often validate prior expectations.

In general, if communication succeeds in shaping agents' expectations it will give an important contribution to the final objective of controlling inflation, since inflation expectations play a key role in inflation developments. But agents will only be convinced if the quality of the information is high, and the central bank is credible. The quality of central bank forecasts and the credibility of monetary policy are the topics of the following sections.

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[69] Mayes and Riches (1996, p. 8).

[70] It has been argued by some commentators (for example, Svensson, 1997), that this is why the Bank of England's "Inflation Report" is, by far, the more detailed of all the reports. Although all the reports have similar structures, the detail of information provided varies significantly, with some (e.g., Canada and New Zealand) relying more on non-technical text and charts (with very few tables), and others (e.g., UK) providing a more technical analysis and large amount of data. It could be argued this was a consequence of the incentives for writing the report, with the former being directed at influencing the expectations of the non-expert general public and the latter being directed at influencing the Chancellor.

5.3 Inflation Forecasting and Controllability

The IT strategy implies that an (explicit or implicit) inflation forecast is the intermediate target of policy. Svensson (1997, pp. 14-15) argues that the inflation forecast is an ideal intermediate target because it possesses a number of desirable characteristics:

- the inflation forecast is the variable that has the *highest correlation* with the policy objective (future inflation);
- the inflation forecast is *controllable* through changes in monetary conditions (and it is even more controllable than future inflation itself);
- the inflation forecast is *easy to observe* (and easier to observe than future inflation).

Inflation forecasts have these characteristics virtually by definition, and we are not going to discuss whether inflation forecasts are better intermediate targets than other possible alternative intermediate target. In this section, we investigate whether inflation forecasts are intermediate targets good enough to deliver the policy outcomes implicit in the design of the IT. The fact that inflation forecasts have the highest correlation with future inflation, certainly does not imply that this correlation is 1, and not even that it is high enough to be consistent with staying within the target range. Inflation forecasts are not precise, and in subsection 5.3.1 we discuss whether they are sufficiently accurate as a guide to future outcomes to serve as an intermediate target in a policy directed at keeping inflation inside a narrow range. Not only are inflation forecasts inaccurate, but uncertainties about the timing and strength of monetary policy actions together with other limitations on their unfettered use, imply that such actions cannot generally be taken to bring such forecasts back to their desired central level wisely and quickly, i.e., that inflation *forecasts*, as well as current inflation, cannot be precisely controlled. These facts, as well as late shocks affecting inflation after it is too late for monetary policy to be sensibly used to offset them, given the lengthy lags in their normal operation, will cause inflation outcomes to deviate from any pre-set target, and in subsection

5.3.2 we discuss whether monetary policy may be expected to keep inflation inside a 2-3 p.p. wide band. In the remainder of this section, we compare the macroeconomic performance of IT countries with non-IT countries, to assess whether the IT strategy has delivered superior outcomes. Subsection 5.3.3 analyses the level and variability of inflation, while in subsection 5.3.4 we look at the speed and costs of the disinflation process.

5.3.1 Forecasting record

Inflation forecasts are central to the IT strategy: as described in subsection 5.2.3, the policy rule is defined in terms of an inflation forecast. Thus, an efficient IT policy strategy demands good inflation forecasts, i.e., forecasts implying low forecast errors. We tried to assess the quality of the forecasts made by some of the central banks in our sample. The only data available are for Australia, New Zealand and the UK. Table 5.9 describes the forecast mean error and mean absolute error (MAE) for these 3 countries, over different periods of time, of the forecasts of inflation made 1 year before.

Table 5.9 **Inflation forecast errors**

	Australia		*New Zealand*		*UK*	
	Mean	*MAE*	*Mean*	*MAE*	*Mean*	*MAE*
1981/88 *	-0.3	1.7	-0.6	2.1		
1988/92	0.2	1.1	0.3	1.6		
1993/96	0.2	0.5	-0.6	0.6	0.4	0.6
1994	0.5	0.5	-0.2	0.3	0.8	0.8
1995	-0.1	0.1	-0.7	0.7	0.3	0.4
1996	0.9	0.9	-1.0	1.0	0.1	0.5

* 1974/88 for New Zealand

Evidence from Table 5.9 suggests that the RBA and the RBNZ tended to underpredict inflation during the high inflation period of the 1980s, and to overpredict it during the deflationary period of the early 1990s. More recently, this tendency to overestimate inflationary pressures has continued to be verified in the RBA, but in the RBNZ it has been replaced by a slightly regular underestimation of the inflationary pressures. The mean absolute forecast error tends to be relatively large, even in the period of low and less volatile inflation, compared to the width of the target bands. Even if these central banks manage to keep forecast inflation exactly at the mid-point of the band, the error margins implicit in the target ranges (0.5 percentage points in Australia and 1.5 percentage points in New Zealand and the UK) are not much larger than the MAE, which suggests that the probability of missing the target must be high. Early in our sample period forecasts tended to be less accurate. This is probably due to the higher levels of inflation, but it could also be the result of an improvement in the quality of forecasts, because of a learning process inherent in any period of transition between regimes.

The forecasts on Table 5.9 were prepared under the technical assumption of unchanged monetary policy. It could be argued then that the differences between the outcomes and the forecasts could be explained by the policy actions taken on the basis of these forecasts, and are not a consequence of forecasting inaccuracy. Although we accept this could explain part of the divergence, we believe that this problem has a small influence, and most of the divergence reflects forecasting inaccuracy. First, because monetary policy is supposed to act on inflation with a lag of at least 6 quarters, policy changes made after the forecast should not have a significant effect in the 4 quarters ahead forecasting period. In a study of inflation forecasts in Australia, over the period 1985-1994, Stevens and Debelle (1995, p. 89) adjust the inflation outcomes for the effects of policy changes; using their data, and comparing them with official forecasts, one still gets MAE of around 1.3 p.p., versus 1.8 p.p. before the adjustment. Second, evidence provided in the February 1996 Bank of England's Inflation Report suggests private forecasts tend to be no better or even worse than the Bank's forecasts. Data from the RBNZ also suggest that in New Zealand forecasts from the private sector are no better than the Bank's. Stevens and Debelle's data provide similar evidence: the official forecasts in Australia have MAE that are roughly equal to the ones of private forecasts (around 1.8 p.p.). Private forecasts should not have the drawback of assuming unchanged policies, and the errors in their forecasts may be taken as evidence of the limitations of current forecasting technology.

The results suggest that the probability of the targets being missed is quite high, even if the forecast is kept always at the mid-point of the band, if the forecasting accuracy does not improve. Also, central banks tended to over estimate or under estimate inflation for quite long periods. Nevertheless, there are some encouraging signs. The quality of the forecasts seems to be improving over time, which could suggest that the initial errors were the result of a period of learning of how to operate in a new framework, and that in time forecasts may achieve an improved level of accuracy.

Forecasting inflation several quarters in advance is difficult. Central banks recognise that, either in their words (e.g., King, 1996, p.5) or their actions, since they do not apply the inflation target rule blindly and mechanically. As we have seen above, in practice there is not always a clear distinction between a discretionary policy and IT, since policy decisions are not based exclusively on inflation forecasts. The forecasting record of some of the central banks so far suggests that it is prudent to do so. In particular, the Bank of England emphasizes the probability distribution (in its now famous fan-chart) of its forecast for inflation and refuses to provide a single point estimate. Also note that the MPC tries to assess the varying balance of risk, so that the probability distribution is generally skewed which has the consequence that the mean, median and mode of the probability distribution all differ from each other.

5.3.2 Inflation controllability

Before the adoption of IT, the general opinion was that inflation could not be controlled easily or precisely, and the initial comments on the adoption of IT reflected this view. This was also the view among the central banks that adopted this strategy, and this was reflected on the adoption of ranges, instead of point targets, and on some clauses that determine the targets should not be met at every moment but should only hold on average. Past behaviour of inflation and simulation studies justified such caution and suggested that even 2 percentage points bands might well be too narrow.[71]

[71] Freedman (1995a, p. 27) notes that empirical work undertaken at the Bank of Canada at the time of the IT adoption suggested bands wider than 2 p.p. should be used. Simulations for Australia (Stevens and Debelle, 1995) and the UK (Haldane and Salmon, 1995) also suggest that the optimal band width

We tried to assess how controllable inflation is from the experience of the central banks in our sample, by comparing the targets that they had set with the inflation outcomes. The purpose of this exercise is to measure how easy it is for a central bank to set a target and achieve it, and not to measure the success of monetary policy. This is for several reasons; first, because in some countries the design of the IT does not require inflation to be inside the target range all the time, and thus missing the target in one quarter does not constitute a failure.[72] Second, because some targets are not precise enough to determine objectively if a given outcome is a success; we had to make some assumptions that may be questioned.[73] Finally, because some of the results include 'transition targets' that may have a secondary status relative to the 'final targets'.

Figure 5.3 plots quarterly data, from the first quarter of 1988 to the third quarter of 1997, for the headline and underlying (where available) Consumer Price Inflation, as well as the inflation targets adopted by each central bank.[74] The charts in Figure 5.3 show that in most cases inflation was close to the target, although in some quarters it did not fell inside the target range. Table 5.10 quantifies the number of quarters the targets have been in force up to the third quarter of 1997, and in how many of those the targets have been missed. We interpret the results in Table 5.10 as evidence that the

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should be higher than the width adopted.

[72] For example, the Bank of Canada recognizes that the role of monetary policy is not to keep inflation permanently inside the target range, but to ensure that inflation returns to the range if some shock pushes it outside. Other targets (e.g., New Zealand) are meant to hold at all times.

[73] The first assumption refers to the definition of the Bank of Finland's IT: it is not obvious what should be considered as 'around 2%'. Given that the point of this subsection is to assess how easy it is to meet a range target of the usual 2-3% width, for Table 5.10 we assumed the Bank of Finland had a 2% ±1.5% target. The Banco de España set 'transition targets' for 'early 1996' (which we took to mean the first quarter average), and upper references of 3% for the 'opening months of 1997' (assumed to be the first quarter) and 2.5% 'at the end of 1997' (assumed to be the fourth quarter). For the 1997 targets, the width of the band was assumed to be 2%. Finally, the RBNZ set 'transition targets' that were changed several times, and only refer to inflation in the 4th quarter of 1990, 1991 and 1992. The assumptions regarding the change of targets are described in footnote 47, and the targets for the 1st, 2nd and 3rd quarters of 1991 and 1992 assume a steady downward path for inflation.

[74] Headline inflation data were obtained from the *International Financial Statistics*. The underlying inflation series for Australia, Canada and New Zealand were provided by the respective central banks, and the data for Finland's underlying inflation were published in the *Bank of Finland Bulletin*. The 'RPIX' series for the UK was obtained from *Datastream*. Except for Australia and New Zealand, where the inflation data are released quarterly, the quarterly inflation was computed as the average of the monthly inflation rates. The thick solid line represents inflation measured by the index officially targeted, the thin dashed line represents the other measure of inflation, and the horizontal dotted lines represent the target limits.

uncertainty surrounding inflation forecasting and the effects of monetary policy makes it difficult to set a 2 p.p. target range and achieve it. Only in Spain inflation was inside the band every quarter, but the number of observations is small. More data are available for the UK, where the targets have almost always been met, but there the width of the band was 3 p.p. until 1997:Q1.[75] In Australia, Canada, New Zealand, and Sweden, the band seems to be too narrow, since inflation was outside the range for the official target almost half of the quarters.[76] In New Zealand and in Canada, the inflation target is defined in terms of the headline CPI, but with some caveats, so that in practice the target is considered to be a measure of underlying inflation that extracts the influence of the caveats from headline inflation. Using these indices of underlying inflation, the likelihood of meeting the pre-set targets increases, but remains relatively low, as shown at the bottom of Table 5.10.

Table 5.10 **Inflation targets and inflation outcomes**

	Quarters with target	*Quarters outside target range*	
		Number	*Percentage*
OFFICIAL TARGETS			
Australia	19	8	42%
Canada	23	10	43%
Finland	8	8	100%
New Zealand	28	14	50%
Spain	2	0	0%
Sweden	11	5	45%
UK	19	1	5%
UNDERLYING INFLATION			
Canada	23	7	30%
New Zealand	28	11	39%

[75] In the UK the only observed miss was marginal, and occurred in the only quarter when the band width was 1.5%. This happened in 1997:Q2, the quarter corresponding to the end of the previous Parliament, when inflation should be below 2.5%, according to the initial IT. It turned out that average inflation for the quarter was 2.56%.

[76] When analysing Table 5.10, it must be taken into consideration that in Australia the targets are supposed to hold on average. The average underlying inflation for the period 1993:Q1 to 1997:Q3 in Australia was 2.3%, which means that so far the Reserve Bank of Australia has been meeting their target. Also, the Bank of Finland did not have an explicit band. Although the inflation outcomes would be outside a 3 p.p. band, it is a matter of judgement whether inflation outcomes in Finland were 'around 2%'. Anyhow, the mean absolute deviation from the 2% target, for the period 1995:Q1 to 1996:Q4 was 2.0 percentage points, which we interpret as evidence supporting our claim that ±1 p.p. bands are too narrow.

It is still too early to make any definitive judgements, given the short experience in most of the countries, but the results so far suggest that the target ranges have been set too narrowly. In New Zealand and Canada, the countries where IT was first introduced, headline CPI (the formal target) was outside the set target range for almost 50% of the quarters. In Canada, all the target misses consisted of undershooting the transition path, and do not relate to the 'final' target.[77] In New Zealand, most of the deviations from target can be explained by the exemption caveats or an unexpectedly early success in reducing inflation, that caused inflation to undershoot the 'transition' targets. Still, even if the Bank of Canada and RBNZ can claim that they were successful in reducing inflation even faster than expected, these results raise two questions. First, although the results for New Zealand improve if we use underlying inflation, i.e., a measure of inflation that controls for all the caveats in the Policy Target Agreement, it is questionable whether we should use this measure when analysing the controllability of the IT. After all, the target is set in terms of headline CPI, and that measure of inflation was significantly outside the target for several quarters. If underlying inflation is the target, *de facto*,[78] then it would probably be better, from the point of view of credibility, to set the formal target in terms of the underlying inflation index. Second, while it can reasonably be argued that given the prior history of high inflation in the countries in our sample, an undershooting of the transition path was a good outcome, not a bad one, from the point of view of *controllability*, this is still a sign that inflation was not accurately forecast, and hence easily controllable. If the central banks could have accurately forecast inflation, then they would have set a steeper transition path, compatible with what they thought was the desirable outcome for inflation.[79]

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[77] 'Final' targets are the ones which correspond to the definition of 'a low and stable level of inflation' for each central bank. 'Final' targets are defined in opposition to 'transition' targets, which set a downward path for inflation. This does not mean that 'final' targets cannot be changed, as it happened in New Zealand in December 1996. These 'final' targets have been in force in New Zealand, since the first quarter of 1993 (19 data points available), in Finland and Sweden, since the first quarter of 1995 (11 data points available), in Canada since the fourth quarter of 1995 (8 data points available) and in the UK since the second quarter of 1997 (2 data points available). The Australian target is in force since 1993 (19 quarters), but if we take the target to be the average inflation, then only 1 data point is available.

[78] As officials in the RBNZ claim it to be, and as it seems to be accepted by the public in New Zealand.

[79] A related question is whether reactions to a breach in a final target range should be symmetrical. Will governments and public tend to accept undershooting, but not overshooting, of the target? In terms of final targets we do not have much evidence so far, but the reaction to the undershooting of the

The results for some of the other countries (Australia, Spain and the UK) were more encouraging, with the targets being met so far.[80] The fact that the targets in Australia and the UK (initially) were less ambitious (wider bands or average inflation) might have helped their better performance. Anyhow, even if the data are not rich enough to allow for definitive judgements, two conclusions may already be drawn. First, headline CPI is not as easily controllable as underlying CPI, a fact that puts into question the credibility of narrow targets set in terms of this index. The impact on expectations of establishing a target and missing it half of the time, even if you can justify the deviations using the caveats, is probably less than the impact of a target set in terms of a less transparent but more controllable index of underlying inflation. Second, as it is obvious, even underlying inflation cannot be controlled perfectly, and some of the central banks in our sample have already missed the target for some quarters.

5.3.3 Inflation performance in IT and non-IT countries

If we accept the view that, given the prior history of high inflation in most of our sample, for many of the central banks it was more important to reduce inflation than to keep it inside a narrow range, the performance of the central banks in our sample could then be described as good. Average inflation after the adoption of IT was 2.3%, against 6.0% in the period between 1987 and the adoption of IT. The average standard deviation was also lower (1.2% against 2.4%), although the decrease in variability of inflation is due to the lower levels of inflation (the coefficient of variation has increased from 0.37 to 0.58).

However, inflation performance in IT countries benefited from favourable international conditions. Tables 5.11 to 5.13 report the inflation outcomes in selected OECD coun-

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transition paths suggest that this is a possibility.

[80] The only missed observed in the UK was marginal. In Australia the target does not have to hold at all quarters, only on average, so formally there was not a failure to meet the target, although inflation was outside the target range for more than a third of the quarters. In Finland, the target does not define explicit bands, so one cannot claim it was missed, although the deviations from the 2% target are larger than would be compatible with a band 3 p.p. wide.

tries compared to the outcomes in our sample.[81] When making this type of comparisons, two main problems arise. The first problem is the choice of the period over which the exercise is going to be made. Somewhat subjectively, we decided to make the comparison over two sets of periods, 1980/89 versus 1990/97 and before IT (since 1987) versus after IT. Since the first IT was introduced in 1990, the first periodicity compares the 1980s, a decade when the world did not know IT, with the 1990s, the decade of IT. The second periodicity tries to compare the inflation performance of each country (in a shorter period) before and after IT. Since four of the countries in our sample introduced IT near the end of 1992, for the non-IT countries the period before IT was taken to be 1987/92 and the period after IT, 1993/97.[82]

The second question, the choice of a comparable group, is always problematical. In order to obtain more robust results, we chose to select four (overlapping) control groups, according to different criteria, as follows:

- Group 1: the countries where average inflation for the period 1980/89 was within the range of average inflation in the IT countries (6.5-11.9%): Denmark, France, Ireland, Italy and Norway; this is a group of countries of similar inflation experiences in the 1980s;

- Group 2: group 1 plus the US and Portugal, the two countries where average inflation in the period 1980/89 was, respectively, immediately below and above Group 1; this group was chosen to give Group 1 the same number of countries as in the IT group;

- Group 3: a group of countries chosen to have the same average inflation in the period 1987/92 as the IT countries before IT (6.0%): Italy, Norway, Portugal, Switzerland and the US; the reason for the choice of this group is the same as in group 1, but according to the before IT versus after IT periodicity;

- Group 4: a group of 7 countries that face similar economic environments as IT countries; this group is composed of Japan, the US, Norway and Denmark, France and Portugal, and Italy, that we subjectively chose to be the closest match to Australia, Canada, Finland and Sweden, Spain and New Zealand and the UK.

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[81] The data are quarterly consumer price inflation from the *International Financial Statistics*.

[82] The data for 1997 do not include the fourth quarter.

Table 5.11 reports the average inflation level in each of the periods considered, for these four groups as well as for our sample of IT countries. Also reported are t-statistics for two types of test. Test 1 compares the IT group with each control group, where the null hypothesis is that the control group and the IT group have the same average inflation. Test 2 compares the group average in both periods, for a given group, and the null hypothesis is that the group average is the same in both periods.[83] The data show that average inflation has fallen significantly in the IT countries, but it also fell in the non-IT countries. The results for test 1 show that average inflation in IT countries is not significantly different from any of the control groups, either before or after the adoption of IT. The inflation experience of the IT countries seems to be shared by all our control groups, and it is not a specificity of the adoption of IT. The only data that might suggest IT countries are different refers to test 2. The significance level of the fall in inflation is generally higher than for the control groups, but this probably a consequence of the fact that the IT group is more homogeneous than the control groups.[84]

Table 5.11 **Average inflation in selected OECD countries**

	Group average inflation				*Test 1*				*Test 2*	
	80s	*90s*	*Before*	*After*	*80s*	*90s*	*Before*	*After*	*90s*	*After*
IT	8.5	3.8	6.0	2.3					-6.5	-5.8
G1	8.6	2.8	4.0	2.3	-0.1	0.9	2.4	-0.1	-6.3	-2.6
G2	9.5	3.5	5.0	2.7	-0.6	-0.2	0.8	-0.8	-3.6	-2.2
G3	9.2	4.1	5.9	2.9	-0.3	-0.9	0.1	-1.1	-2.0	-2.1
G4	8.5	3.3	4.9	2.5	0.0	0.0	0.9	-0.4	-2.6	-2.0

After realising that IT did not have any significant impact in the level of inflation, we tested for differences in inflation uncertainty, measured by the standard deviation of quarterly inflation. Table 5.12 reports the results of those tests. Again there is no evidence the adoption of IT had a significant impact on inflation uncertainty. Inflation uncertainty decreased significantly in IT countries, but it also decreased in non-IT countries. Inflation uncertainty after IT is higher in IT countries than in the control

[83] The '90s' are compared with the '80s' and the 'after' with the 'before' IT.

[84] The standard deviation of inflation levels in the IT group is lower than in the control groups. The lower standard deviation implies that any test to the average inflation in the group will tend to have higher significance levels.

groups (and significantly higher in one of the groups), but it was also higher before the adoption of IT.

Table 5.12 **Inflation uncertainty in selected OECD countries**

	Average standard deviation				*Test 1*				*Test 2*	
	80s	*90s*	*Before*	*After*	*80s*	*90s*	*Before*	*After*	*90s*	*After*
IT	3.6	2.2	2.4	1.2					-2.9	-1.9
G1	4.7	0.9	1.1	0.7	-1.4	3.6	1.7	2.7	-4.9	-1.2
G2	4.9	1.3	1.2	0.7	-1.7	1.6	1.8	2.1	-4.4	-1.5
G3	4.3	1.9	1.5	1.0	-0.8	0.6	1.1	1.0	-2.1	-1.6
G4	4.2	1.4	1.3	0.8	-0.8	1.5	1.8	2.0	-3.5	-1.6

Finally, we tried to assess whether or not the lower standard deviation was a consequence of the lower levels of inflation, by looking at the coefficient of variation, reported in Table 5.13. Here the results are somewhat different for IT and non-IT countries: the coefficient of variation increased in the IT countries more than in all the control groups. Although inflation variability fell in absolute terms in all groups, it increased in relative terms, and this effect was felt more significantly in the IT countries. This different behaviour in the two sets of countries could be a direct consequence of the adoption of IT: since IT central banks are trying to keep inflation inside a narrow range, they will tend to force it up and down more frequently than the non-IT countries, that are content to let inflation drift and only react to large swings. However, this could also be a small sample result, not related to IT adoption.[85]

Table 5.13 **Relative inflation variability in selected OECD countries**

	Average coefficient of variation				*Test 1*				*Test 2*	
	80s	*90s*	*Before*	*After*	*80s*	*90s*	*Before*	*After*	*90s*	*After*
IT	0.43	0.69	0.37	0.58					3.1	2.1
G1	0.54	0.32	0.27	0.28	-1.6	4.0	1.1	3.2	-3.2	0.2
G2	0.53	0.36	0.25	0.27	-1.7	4.0	1.6	3.7	-2.8	0.4
G3	0.50	0.46	0.29	0.37	-1.2	2.1	0.8	1.6	-0.5	0.6
G4	0.56	0.43	0.31	0.40	-1.7	2.3	0.7	1.2	-1.2	0.6

[85] The behaviour of the coefficient of variation in the individual countries suggests this result might be robust. Among IT countries, only in the UK did the coefficient of variation decrease after the adoption of IT. Among the OECD countries, the coefficient of variation decreased in 7 out of the 17 non-IT OECD countries.

Inflation performance in IT and non-IT countries is very similar. The fall in the levels and variability of inflation can be observed in all control groups. The only difference relates to the coefficient of variation, that increased significantly more in the IT countries than in the non-IT countries. The fact that relative variability increased in the IT but not in the non-IT countries could mean that IT causes inflation to become more unstable in the short term. In order to keep inflation inside a narrow range, IT central banks may have to seek constantly to pull it up and down, whether non-IT central banks may let inflation drift. Perhaps, the target instability that was observed in money and exchange rate targets may also apply to IT.

5.3.4 Disinflation, growth and unemployment

Even if the final results in terms of the fall in inflation were similar in the IT and non-IT countries, this does not mean that the adoption of IT did not make a difference for the disinflation processes. Because the adoption of IT may generate expectations of lower future inflation, it might have facilitated the disinflation process, inducing faster and/or less costly (in terms of increased unemployment or output lost) disinflations.

We analysed disinflation episodes in IT and non-IT countries from 1981:Q1 to 1997:Q1, and tried to assess whether disinflation under IT was easier than before, and/or easier than in other non-IT countries, by measuring the speed of disinflation, and the costs in terms of unemployment and output growth in each episode. Apart from the countries in our sample, we analysed disinflations in the 4 control groups considered in the previous subsection.[86] Disinflation episodes were identified using a methodology similar to Ball (1994): each disinflation episode is a period when 'trend' inflation falls substantially.[87]

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[86] The quarterly data were obtained from the *International Financial Statistics* and *OECD Main Economic Indicators and Quarterly National Accounts.* The inflation data are the yearly changes in consumer prices from the *IFS*, the unemployment data are OECD standardised unemployment rates, and the GDP data are OECD standardised GDP volume indices (except for New Zealand, which were obtained from *Datastream*).

[87] 'Trend' inflation is defined as a centered, nine-quarter moving average of actual inflation. To identify disinflation episodes, we identify 'peaks' and 'troughs' in trend inflation: a 'peak' is a quarter in which trend inflation is higher than in the previous four and the following four quarters, and a

In each inflation episode we examined the disinflation rate and the cost in terms of unemployment and output. The rate of disinflation was computed as the average fall in inflation per quarter, measured in percentage points, between the quarters with the highest and the lowest inflation in each episode. Table 5.14 summarises the results for each IT country and for each of the four control groups considered, for the whole 1981/97 sample and for 3 subsamples, for the periods 1981/89 (*80s*), 1990/97 (*90s*) and after the adoption of IT (*IT*).[88] With few exceptions, one episode in the *80s* and another in the *90s* were identified. The speed of disinflation in the *90s* episode is lower than in the *80s* episode across all countries (except for Sweden) and groups. In the *80s* episode, the average speed of disinflation was similar in the IT and non-IT countries, but in the *90s* it was significantly higher in IT countries, whatever the control group used. If we assume the *90s* corresponds to the period of IT, then it would seem that IT was associated with a higher rate of disinflation. However, note that for some of the IT countries the *90s* episode occurred (or at least started) before the adoption of IT (although when we take only the period under IT the results are not significantly affected).

Table 5.14 **Rate of disinflation in IT and non-IT countries**

	No. of episodes			Rate of disinflation (p.p./qtr.)			
	80s	*90s*	*IT*	*80s*	*90s*	*IT*	*81-97*
Australia	1	2	1	1.1	0.8	0.8	0.9
Canada	1	1	1	0.6	0.5	0.5	0.6
Finland	1	1	#	0.4	0.3	*0.2*	0.4
New Zealand	2	2	2	2.0	0.9	0.9	1.5
Spain	1	1	#	0.6	0.1	*0.3*	0.3
Sweden	1	2	1	0.4	0.7	0.4	0.5
UK	2	1	#	1.0	0.9	*0.8*	1.0
IT	1.3	1.4		0.9	0.6	0.5	0.7
G1	1	1.2		0.7	0.2		0.5
G2	1.1	1.1		0.8	0.3		0.5
G3	1.2	1.2		0.8	0.3		0.5
G4	1.1	1.1		0.7	0.3		0.5

'trough' is defined by an analogous comparison. A disinflation episode is any period that starts at an inflation peak and ends at a trough with an yearly rate of inflation at least 2 percentage points lower than the peak. See Ball (1994) for a justification of the procedure.

[88] Results for each individual episode and country are not presented here but may be obtained from the authors. The episodes under IT are included in the *90s* group. Only for Australia, Canada, New Zealand, and Sweden can we identify a complete disinflation episode after IT. For Finland, Spain, and the UK the *90s* episode ended under IT, but started before; in these cases, marked '#', the data for the *90s* are for the whole episode, but the data for IT are just for the period after IT.

Disinflation processes are usually associated with increases in unemployment and lower output growth. By contributing to create lower inflation expectations, the adoption of IT could help to reduce the unemployment and growth costs of disinflation. For each of the inflation episodes identified using the methodology above, we computed sacrifice ratios in terms of unemployment and output. The ratio for unemployment was computed as the increase in unemployment (Δu) over the decrease in inflation ($-\Delta\pi$), between the quarters with the highest and lowest inflation in each episode. Output lost due to a disinflation episode (λ) was computed as the difference between potential and actual output growth over the same period, with potential output growth assumed to correspond to an yearly rate of growth equal to the average over the 1981/94 period, for each country. The sacrifice ratio in terms of output growth is the ratio between the output lost (λ) and the decrease in inflation ($-\Delta\pi$). Table 5.15 summarises the results for the sacrifice ratios in terms of unemployment and output, for the same countries, groups, and periods used in the previous table.

Table 5.15 **Sacrifice ratios in IT and non-IT countries**

	Unemployment ($\Delta u/-\Delta\pi$)				*Output growth ($\lambda/-\Delta\pi$)*			
	80s	*90s*	*IT*	*81-97*	*80s*	*90s*	*IT*	*81-97*
Australia	0.2	0.6	0.1	0.3	-0.3	1.0	0.1	0.2
Canada	0.4	0.0	0.0	0.3	0.1	0.1	0.1	0.1
Finland	0.1	2.0	0.9	0.9	-1.0	2.0	-2.6	0.2
NZ	0.1	0.3	0.3	0.2	-0.9	-0.7	-0.7	-0.9
Spain	0.4	1.4	-0.2	0.6	-0.3	1.2	0.0	0.1
Sweden	0.0	0.3	0.3	0.2	-0.8	-0.2	-0.9	-0.4
UK	0.2	0.5	0.1	0.3	-0.1	0.7	0.0	0.2
IT	0.2	0.7	0.2	0.4	-0.5	0.6	-0.6	-0.1
G1	0.2	0.7		0.3	-0.1	1.1		0.2
G2	0.1	0.5		0.2	-0.1	0.9		0.2
G3	0.1	0.3		0.2	-0.1	0.9		0.2
G4	0.1	0.5		0.2	-0.1	1.5		0.4

In all countries (with the exception of Canada) and groups the sacrifice ratios are higher for the *90s* episode. In terms of unemployment, the IT countries have ratios similar to Group 1, and above the other groups, either in the *80s* or in the *90s*. In terms of output, the sacrifice ratio is lower in the IT countries, but again this happens in both periods. If one takes only the period under IT instead of the *90s* the performance of the IT countries improves; both ratios are lower than for any other group. Significance tests for the difference between the averages of the IT and the other groups (not presented here) show that the sacrifice ratio in terms of output (but not in terms of unemployment) is significantly lower under IT than in any other group. However, these results rely substantially on the data for Finland and the UK where the episode under IT is just part of a larger episode that started in early 1990. If one takes only the countries with a complete episode under IT, then the sacrifice ratios are not significantly different for the IT and other groups, although they are still lower. Even if one takes all the qualifications into account, the results on Table 5.15, although not conclusive, still suggest that the adoption of IT may have made the disinflation processes somewhat less costly, especially in terms of output growth lost.

The adoption of IT was associated with faster disinflation, at least relatively to disinflations in non-IT countries in the same period. It also seems that under IT the disinflation process is less costly, especially in terms of output lost, although the evidence is less conclusive in this issue. Thus, although the OECD countries with high inflation in the 1980s managed to reduce it in the 1990s, whether they adopted IT or not, how they did it seems to depend on the monetary policy strategy. The adoption of IT might have helped the disinflation process.

To conclude this section, we must ask whether inflation is controllable to the point that we can expect inflation targets, with a 2-3 p.p. range, to be met if the central bank follows a sensible policy? It is too early to reach a conclusion, but it seems that it is not possible to control headline inflation, precisely or quickly. It is probably possible to control, on average and over a period of time, some measure of underlying inflation within a reasonable range,[89] but this might come at the cost of an increase in the short term variability of inflation. If this lack of controllability is confirmed by future evidence, then the positive effects on the credibility of monetary policy that IT is hoped to have, could even turn out to be of the opposite sign.

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[89] This is something of a tautology, because the measure of underlying inflation is designed to include only the inflationary pressures monetary policy can control.

5.4. Credibility of the Inflation Target

One of the major objectives (if not the major) of the adoption of IT was to provide an anchor for inflation expectations. In this section we try to evaluate if this objective was achieved, based on data from household and business surveys, financial markets and wage settlements. Again the lack of data prevents us from reaching definitive conclusions, but some tentative results can be extracted from the available information, although one must not forget that expectations are affected by an array of factors of which the monetary policy strategy is just one; at the specific moment when IT was adopted, other factors (e.g., fiscal policy concerns or political instability) might have been affecting expectations in a way that would conceal any (eventual) impact of the IT adoption. Also, in some countries (e.g., Canada, New Zealand) price stability was seen as being the objective of monetary policy even before the central bank announced an explicit IT, and this might have reduced the impact of the announcement. Nevertheless, in this latter case, since the aim of this chapter is to discuss the effect of publicly announcing an explicit IT, the lack of an announcement effect is still a sign that IT, as such, does not have an impact on credibility, at least not more than doing what many countries not included in our sample have done, that is adopting price stability as the objective for monetary policy.

5.4.1 Households' and businesses' inflation expectations

Figure 5.4 plots data of different surveys of inflation expectations. The surveys are of two types. In the first, used for the non-European countries and Sweden, individuals are asked which inflation rate they expect in the next 12 months. In the second, used for Finland, Spain and the UK, individuals are asked if they expect future inflation to be higher or lower than current inflation, and the results presented correspond to the difference between the number of the two responses. The vertical dashed line marks the moment of the adoption of IT and the horizontal dotted lines the inflation targets.[90]

The main conclusions that may be drawn from Figure 5.4 are that the announcement of IT does not seem to affect inflation expectations and that in some cases households and businesses do not find the targets fully credible. In Australia expectations were practically unchanged at about 4% from 1991 (before the adoption of IT) to 1996, and only recently they have started to converge to the 2-3% target. In Canada, the data correspond to the expectations of professional forecasters, not to the expectations of the common non-expert household or business. These have been inside the target range most of the time, and might have been affected by the announcement. However, one cannot tell whether this is a consequence of the adoption of IT or just a good forecast of the actual inflation performance.[91] In New Zealand, household expectations are still above the 0-3% target. The RBNZ survey, which covers households and businesses, tends to show lower inflation expectations, but even those lie outside the target range for some periods. Only in Sweden do households seem to find the IT credible: since the target was adopted, household inflation expectations were always inside the 1-3% target range (but had been at those levels even before IT). However, initially the target was

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[90] The expectations refer to the next 3 months for the business surveys, and to the next 12 months for the household surveys. The data sources and expectations series for Figure 5.4 are:

Australia: Westpac/IAESR inflation expectations survey (provided by *Datastream*);
Canada: Conference Board of Canada quarterly Survey of Forecasters (provided by the Bank of Canada);
Finland: Consumer survey of Statistics Finland; Business survey of the Confederation of Finnish Industry and Employers (published in Kuismanen and Spolander, 1995);
NZ: Marketscope survey of inflation expectations (households), Reserve Bank survey of expectations of senior business leaders and other key opinion leaders (provided by the Reserve Bank of New Zealand);
Spain: European Economy - Consumer opinion on economic and financial conditions; Ministerio de Industria e Energia - Survey of manufacturing industry (provided by Banco de España);
Sweden: Statistics Sweden; National Institute of Economic Research (published in *Inflation Report*, Sveriges Riksbank, December 1997)
UK: Confederation of British Industry monthly inquiry - expected prices of domestic orders (provided by *Datastream*).

The dates in the charts correspond to the moment the surveys were made. The targets were shifted back 12 months so they refer to the same period as the expectations do.

[91] The Bank of Canada's *Monetary Policy Report* of May 1996 mentioned that 83 per cent of respondents to the Conference Board business confidence survey expected inflation to be 2 per cent or less, which suggests that also among the business community the IT has (at least now) gained substantial credibility.

not fully credible for industrial agents, whose expectations tended to lie outside the target range until recently. Finally, although the evidence for Finland, Spain and the UK is more difficult to interpret, it shows that inflation expectations were not significantly affected by the IT announcement. In the UK (and to a smaller extent in Finland) there was even an increase in inflation expectations, which suggests that also in these countries the target announcements were not fully credible.

This lack of relation between the announcement of IT and inflation expectations suggests that the *announcement* of IT does not provide a credible anchor for inflation expectations: words without actions are not enough, as one would expect; it would be surprising to find that a central bank may earn credibility simply by setting a target. However, one would expect that words with actions should have an impact, and that the ability to follow a policy consistent with the target would build credibility: after some years of low inflation and some track record of meeting the targets, these should become credible, and expected inflation should be inside the target range. Figure 5.4 suggests that the targets are in general credible now, even though in some countries this only happened after several years of observed low inflation.

5.4.2 IT credibility in financial markets

Long term government bond yields

Figure 5.5 plots the redemption yield on long term government bonds,[92] daily from 1/1/1988 to 12/12/1997. The vertical line marks the date of the IT announcement. From the charts, we cannot find any significant impact of the IT announcement. In Finland, Sweden and the UK the announcement is associated with a fall in bond yields, but these were already falling before the announcement, and were subsequently rever-

[92] The data in Figures 5.5 and 5.6 are indices of long term government bonds computed by *Datastream*. The maturities of the bonds used on these indices differ slightly across countries: 10 years for New Zealand, 7 to 10 years for Australia, Sweden and the UK, 3 to 5 years for Canada, all maturities for Finland and 'long term' for Spain.

sed. The change in bond yields for these three countries is most likely associated with the adoption of a floating exchange rate (and subsequent depreciation of the currency) than with IT.

Figure 5.6 plots the same data, but only for a few months around the date of IT announcement,[93] so the specific effects of the announcement of IT may be easily identified. Finland, Sweden and the UK have similar patterns: a fall in bond yields on the day of the floating (particularly large in Sweden),[94] followed by subsequent falls for several weeks that extend beyond the IT announcement. The only effect the IT announcement appears to have in these countries is to reinforce the decreasing trend in yields. In the weeks immediately before the announcement, yields seem to have stabilised (in Finland) or slightly increased (in Sweden and the UK), but start falling again immediately after the announcement. If this pattern is really a consequence of IT, this would mean that IT helped to provide credibility to the monetary policy of countries where it had been questioned by the abandonment of the previous policy strategy. However, this effect is exclusive of these countries, since it cannot be found in Canada, New Zealand or Spain.

Long bond yield differential to selected non-IT countries

Government bond markets are global markets, thus changes in bond yields might not be caused by domestic factors, but be related to international events. In order to eliminate the effect of international conditions on bond yields, we computed the differential in bond yields between the countries in our sample and some reference country, which we took to be the US for the non-European countries and Germany for the European countries.[95] Figure 5.7 plots the monthly long bond yield differential, in percentage points. Apart from the fall in yields in Finland, Sweden and the UK we had already

[93] Figure 5.6 does not include Australia, because we are not aware of a specific IT announcement date for this country.
[94] In the day of the floating bond yields fell 123, 34, and 17 basis points, respectively, in Sweden, Finland, and the UK.
[95] The differential was computed using *Datastream* long term government bond indices. Given the strong links between the UK and the US economies, we also computed the differential in bond yields in these two countries.

identified (and had associated more with the floating exchange rate regime than with the adoption of IT), the remarkable feature of Figure 5.7 is the fall in the average yield differential in New Zealand from about 400 b.p. until the end of 1990, to about 150 b.p. from mid 1991 onwards. This dramatic change is not associated with the announcement of IT, since it occurred approximately one year after it, but it is contemporaneous with a large fall in inflation and the achievement of the first targets. Although it can be claimed that bond yields were only reacting to the fall in inflation, the size and the speed of the adjustment were probably increased by the achievement of the first inflation targets and its impact on monetary policy credibility.

Inflation expectations in bond markets

Changes in inflation expectations are just one of the many factors that determine bond yield changes. Comparing the yields in fixed rate and index-linked bonds allows a better measure of financial markets expectations about inflation to be computed. In some of the countries in our sample such measures of long term inflation expectations are available. Figure 5.8 plots quarterly data for the bond market implied inflation rates for Australia, Canada, Sweden and the UK.[96] The vertical dashed line marks the moment of the adoption of IT and the horizontal dotted lines the (medium term) inflation targets. The common pattern of Figure 5.8 is that inflation expectations are now consistent with the targets, even though at the time of the announcement the targets were not fully credible.

The implied inflation data could also be used the analyse the impact on expectations of

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[96] The data for Sweden and for the 2 years horizon in Canada are not computed from market yields, but are based on surveys of bond market investors. The series used in Figure 5.8 are:

- Australia: difference between nominal and indexed 10 year bond yields, adjusted for an 8 month indexation lag (provided by the Reserve Bank of Australia);
- Canada: differential between conventional and real return 30 year bond yields (calculated using the appropriate compound interest formula), *Consensus Economics Inc.*'s "Consensus Forecasts 2 years ahead (average)" (published in the Bank of Canada's *Monetary Policy Report*, May 1996);
- Sweden: Aragon Fondkommission - Survey of bond investors' inflation expectations (published in *Inflation and inflation expectations in Sweden*, Sveriges Riksbank);
- UK: Bank of England's estimated market expectations of inflation, based on 2 and 10 year bond yields.

the announcement of IT. Figure 5.9 plots 2 and 10 years implied inflation in the UK, daily from 17/6/92 to 31/12/92, a period that covers both the change in exchange rate regime and the adoption of IT. The implied inflation data for the UK reinforce the pattern we observed in the previous charts. Expectations were affected by the floating of the British pound, but not by the announcement of IT, although the announcement is associated with the stabilisation of the inflation expectations that had been increasing since the floating of the pound. This evidence supports our previous claim that IT helped to provide credibility to the monetary policy of countries where it had been questioned by the abandonment of the previous policy strategy.

IT credibility

The evidence that long term government bond yields were affected by the announcement of an IT is scarce.[97] Either in absolute terms or relative to the yield in Germany or the US, there was no significant change in long term government bond yields. There are only some (weak) signs that the adoption of IT may have contributed to the credibility of monetary policy in four countries. The evidence for the European countries is probably related to the exchange rate regime change, and in New Zealand the change was not contemporaneous with the adoption of IT, although it might be argued it was helped by the achievement of the IT targets. Data for bond market inflation expectations also reveal the relatively low initial credibility of the announcements: long term expected inflation was above the target ranges, and even in the shorter horizons of 2 years expected inflation was not always inside the target ranges. However, recent data suggest that the targets may now be credible.

Whatever the measure of expectations used, a common feature among the countries in our sample is that inflation expectations were not significantly affected by the IT announcement, and the IT's credibility remained low during the early stages of the adop-

[97] In the UK, even though bond yields did not respond to the announcement of IT, there was an important reaction to the Chancellor's May 1997 statement, granting more independence to the Bank of England. On that day, long nominal gilt yields immediately fell by 50 basis points (½ p.p.) both absolutely and relative to the yields on indexed gilts.

tion of the strategy. In most countries, there are some signs (e.g., medium term expectations in Canada or bond yield differential in New Zealand) that early successes in meeting targets improved the credibility of monetary policy. However, the evidence is also consistent with a scenario where expectations formation is adaptive, and lower expected inflation is a consequence of the lower observed inflation, the adoption of IT having no effect whatsoever.

Most measures of long term expectations are now consistent with the targets, suggesting that the IT has 'political credibility' as well as 'operational credibility'. Note that agents could believe that under the current strategy the targets may be achieved (operational credibility), but could fear that the strategy was not going to be maintained (political credibility), and that future policy strategies would be more inflationary. In this situation, long term inflation expectations would be above the IT. The recent fall in these expectations may be associated with an increase in the political credibility of IT in countries where former opposition parties that gained power reaffirmed their commitment to the IT framework (e.g., New Zealand, Sweden, and the UK).

5.4.3 Wage settlements

One of the major channels through which inflation expectations are supposed to affect actual inflation are wage settlements. We have no hard evidence of changes in the wage setting behaviour, specially because it is still to soon to have a sufficient long time series of wage agreements to make any form of quantified statement. We only have anecdotal evidence from several sources, including the central banks in the answer to our letter. Some of this evidence, reported in Table 5.16, suggests the IT may have had some effect in centralised wage bargaining, and that in some countries wage increases have been relatively low. These are encouraging signs, given the importance of wage cost increases in inflationary processes. However, it is still too early to tell whether these changes in wage settlements are a result of the credibility of the target, or just a consequence of the unfavourable conditions workers faced in labour markets in this period. The relatively high levels of unemployment experienced in the early 1990s in all the countries in our sample are likely to have weakened the bargaining power of the workers in general, and the unions in particular. A definitive conclusion can be drawn only after we have observed some wage settlements reached under excess demand conditions in labour markets, although the evidence from New Zealand suggests that the IT might provide a good anchor for inflation expectations even under conditions more favourable to workers.

Table 5.16 **Wage settlements**

Australia	"Accord" between unions and government refers to the IT
Canada	some anecdotal evidence that negotiators pay more attention to IT
Finland	two year centralised wage agreement (for 1996-98) provided very moderate pay increases with a reference to the inflation target; after IT, initially there were no nominal wage increases because of 'crisis consciousness' but comparatively high wage increases were negotiated at branch level for 1995
New Zealand	unions recognised the implications of the IT; wage settlements have been remarkably low in recent years (most in the 0-3% range, except for small categories of skilled staff), and that despite the fact that unemployment fell from 10.9% in 1991 to 6.1% in December 1995
Spain	wages have been bargained taking the IT as reference and wage settlements in 1995-97 were roughly in line with the IT (before 1994 wage increases were regularly above official inflation projections)
Sweden	wage formation remains troublesome; despite the increased unemployment, wage increases have been higher than in the rest of the world; the centralised bargaining process is presently turning out around 4 per cent annual increase in nominal wages, on top of a 6% increase in 1996, even at a rate of unemployment of 10%
UK	wage settlements have been consistent with IT; wage growth has undershot current inflation, and has been subdued even in the face of the tightening labour markets and falling unemployment in 1996/97

Households and businesses probably do not understand the implications of the adoption of an IT, and it is even likely that in some cases they were not immediately aware of such a change. It was not surprising, then, that we did not find any impact on survey data expectations of the announcement of an IT. But asset prices are supposed to reflect the actions of well informed agents, who should be able to assess the true meaning of changes like the adoption of an IT, and we have only been able to find a few cases of a significant impact of the announcement of an IT on financial markets data. It seems that contrary to some central bankers and economists, market agents have initially believed that IT is not a substantially different policy strategy, or at least, that in practice nothing has really changed yet with the adoption of IT.

5.5. Conclusions

In Scottish law, criminal cases do not have to be adjudged either guilty, or not guilty. There is a third category, unproven. Mainly because we have too few data on which to base our judgement, that, we believe, is for the time being the appropriate judgement. One needs a longer experience with IT for any significant differences in central bank behaviour to emerge, if they exist. There are some signs that IT might have had a positive impact, especially in the countries where it has been in force for a longer period (New Zealand and Canada), but most of these are country specific. Systematic patterns across all IT countries are hard to find.

The IT countries have been more successful than their central banks, or outside commentators, had initially expected in lowering, and then holding their inflation rates to the low desired mean levels. But then so equally were our various control groups. Both groups were helped in this by the international context, although the IT countries may have achieved low inflation faster and at a lower cost in terms of output growth. On the other hand, IT countries have missed their own targets on several occasions, which suggests that in order to IT be successful the target ranges should be wider than the usual 2 percentage point bands.[98]

Many of the apparent changes in operational characteristics among IT countries were the natural and self-evident results of shifting from an exchange rate target (Finland, Spain, Sweden, UK) to an inflation target (i.e., the exchange rate becomes more volatile, the interest rate less so). Apart from those changes, there are few signs of any significant shift in operating behaviour. It seems that the adoption of IT is instrumental in achieving stability in financial markets, since it is associated with lower exchange rate and interest rate volatility. On the other hand, we looked hard to see if there was any evidence of interest rates being adjusted earlier or in larger jumps (more aggressively) in response to prospective inflationary

[98] This point received a lot of attention in New Zealand, the country with a longer experience in IT. In New Zealand there was in 1996 widespread criticism of the then current 2 p.p. bands, and several critics (including opposition parties) called for wider bands, which were introduced after their election.

pressures. There are a few straws in the wind (notably in Canada) and several of the central banks concerned are aware that such a change in behaviour might be needed, if the demanding targets are to continue to be kept. But the bulk of the evidence, so far, does not allow us to dismiss the null hypothesis of no significant change in operating behaviour.

We have, at several places in this chapter, drawn a distinction between those IT central banks whose target is jointly set with the government, and those where it is unilaterally set by the central bank itself. Pace the Roll Report, we believe that the former, joint setting is likely to prove a far firmer bulwark against resurgent inflation. Consequently, we do see a greater likelihood of success in the Anglo-Saxon than in the continental European cases.[99] Perhaps because of this differentiation, it is in the Anglo-Saxon countries that there are some signs of a credibility effect. For the rest (including the UK) it is not, once more, possible at the moment to dismiss the null hypothesis of no maintained effect.

If expectations and inflation outcomes are not significantly affected, is there anything really new in the IT strategy? The differences with an exchange rate target strategy are the obvious differences between operating in a fixed or in a floating exchange rate regime. There is no fundamental difference between monetary targeting and IT; money targeting is just IT when inflation forecasts are exclusively based on money aggregates. When money aggregates are not good predictors of future inflation, IT is a clearly superior strategy, and money targeting is not really an option. Where there is an option is between IT and a purely discretionary framework, compared to which IT has two main (positive) differences: the adoption of a quasi-formalized rule, that explicit states price stability as the only objective for monetary policy, and increased transparency and accountability. The evidence we gather suggests that the impact on credibility of the adoption of a policy rule is small, and limited to the short term.

The main difference is probably on the transparency and accountability side. The one

[99] In Finland, Spain and Sweden because it is not clear how much the government is committed to the target; but in Finland and Spain the issue is likely to be overtaken by their participation in the Euro; and, perhaps, later also for Sweden and the UK. So for the European countries the experiment with an IT regime may be short-lived.

field where there is clear evidence of a change in behaviour is in the nature of communications with both the public in general and government in particular. As documented earlier, such communication has generally become quicker, fuller and franker. In some instances some part of this shift towards greater transparency pre-dated the move to IT. Moreover this trend, towards more open communication, has been world-wide. Nevertheless we believe, (though such a qualitative issue is hard to test statistically) that such greater openness has gone further, faster in IT countries than in non-IT countries. This is one patent benefit of the regime change, even if elsewhere much remains unproven.

Appendix 5.A:Inflation and Interest Rate Changes

The hypothesis tested in this appendix is whether the adoption of IT changed the timing of interest rate changes relative to observed inflation (see argument in main text). In order to test for Granger-causality between quarterly inflation and central bank controlled interest rates,[100] the following bivariate VAR was used

$$\begin{aligned} p_t &= \alpha_1 + A(L)\,p_{t-1} + B(L)r_{t-1} + \varepsilon_t \\ r_t &= \alpha_2 + C(L)\,p_{t-1} + D(L)r_{t-1} + \mu_t \end{aligned} \qquad 5.10$$

where p_t and r_t are first differences of inflation and short-term interest rates,[101] respectively, and *A(L)*, *B(L)*, *C(L)* and *D(L)* are polynomials in the lag operator L, with four lags. F-tests on the parameters of *B(L)* and *C(L)* provide tests of Granger-causality from interest rates to inflation and from inflation to interest rates, respectively.

If the parameters in *C(L)* are jointly significant, then inflation Granger-causes interest rates, which may be interpreted as meaning that central banks react to past inflation, increasing interest rates only when the inflationary pressures are evident. The interpretation of joint significance for the parameters in *B(L)*, that is interest rates Granger-causing inflation, is less straightforward. The monetary policy transmission mechanism provides the theoretical economic causation from interest rates to inflation, with higher

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[100] The headline inflation and interest rates data are from the *International Financial Statistics*. The headline inflation series are the quarterly average of year-on-year consumer price inflation. The interest rates used were the average of the overnight money market rate for Australia, Canada, Finland and Sweden, the end of period discount rate for New Zealand (although New Zealand does not have a discount rate, this is the name the *IFS* uses for the bank rate they provide) and Spain, and the end of period London clearing banks base rate, for the UK. The data for Sweden exclude the abnormally high interest rates of September 1992. The common assumption for all these rates is that they are determined by the central banks, and thus reflect accurately the monetary policy stance. We would prefer to use money market data in all countries, but sufficiently long series were not available. Tests over the sample periods for which data for both bank and market rates were available indicated the conclusions of this and other exercises on the chapter would be similar whatever the interest rate used. The underlying inflation series for Australia, Canada and New Zealand were provided by the respective central banks. The 'RPIX' series for the UK was obtained from *Datastream*, and for Finland underlying inflation is the series 'Indicator of underlying inflation (1990=100)', published in the *Bank of Finland Bulletin*.

[101] First differences were used because pretesting of the data indicated that for all countries in our sample, the quarterly inflation and interest rate series are I(1). The use of error-correction models was ruled out because pretesting also indicated that inflation and interest rates are *not* cointegrated. Details of these tests can be obtained from the authors.

interest rates today causing lower inflation in the future. However, if central banks react to expected future inflation, increasing interest rates when expected future inflation is higher, then the data would also show Granger-causation from interest rates to inflation, not related to the transmission mechanism.[102] Our choice of lags in this exercise, makes the latter more likely to be the legitimate interpretation. The monetary policy lag is usually considered to be longer than four quarters, but it is likely that central banks react to expected inflation four quarters ahead, given the difficulties in forecasting. Also, the two interpretations have different implications for the signs of the coefficients, since the transmission mechanism interpretation suggests a negative relationship between interest rates and inflation, but the second interpretation implies a positive relationship. Thus, the signs of the coefficients in $B(L)$ could provide some clue to which is the legitimate interpretation. If the hypothesis tested here is true, then before IT inflation would Granger-cause interest rates, but after IT interest rates would Granger-cause inflation. An additional problem of interpretation arises in the countries where the headline CPI includes interest rate related costs; there, interest rates could Granger-cause inflation just because they are one of the components of the CPI. To avoid this problem we used indices of underlying inflation where available, but since the underlying inflation series usually do not cover the period before IT, we report the results with the headline CPI also.

Table 5.17 summarises the significance levels of the Granger-causality tests performed, for the null hypothesis of non-causality.[103] The tests were performed over two subsamples of the period 1982:Q1 to 1997:Q3: the first subsample, corresponding to the period before IT, ran from 1982:Q1 to the quarter of the adoption of IT; the second subsample, corresponding to the period after IT, ran from the quarter following the adoption of IT to 1997:Q3. Note that the number of degrees of freedom involved in the estimation of

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[102] In general, time series that reflect forward-looking behaviour, such as financial asset prices, tend to Granger-cause many key economic time series. This does not mean that those series *cause* inflation or GNP to move up or down. Instead, the value of those series reflects the anticipated future movements in inflation or GNP. Granger-causality tests for such series may be useful for investigating whether markets (or central banks) are concerned with future inflation, but should not be used to infer a direction of economic causation. On the use of Granger-causality tests to assess forward-looking behaviour see Hamilton (1994), chapter 11.

[103] Details of the estimation and the tests may be obtained from the authors.

the VAR is small, especially for the 'after IT' model, and that tends to increase the significance levels of the tests. Thus, a high significance level should be interpreted as a signal that the data are not rich enough to allow for any conclusions, and *not* as a rejection of the causality hypothesis. On the other hand, a low significance level may be interpreted as a rejection of non-causality, i.e., one may accept the causality hypothesis.

Table 5.17 **Granger-causality between interest rates and inflation**

Granger causality		*from Inflation to Interest rates*		*from Interest rates to Inflation*	
		Before IT	*After IT*	*Before IT*	*After IT*
Australia	headline	35%	33%	5%	14%
	underlying		97%		0%
Canada	headline	44%	14%	77%	1%
	underlying		88%		4%
Finland	headline	99%	99%	73%	77%
	underlying		86%		57%
New Zealand	headline	1%	23%	41%	17%
	underlying		36%		4%
Spain [104]		18%	68%	47%	55%
Sweden		81%	39%	30%	69%
UK	headline	46%	91%	6%	3%
	underlying	53%	50%	30%	24%

Using the traditional significance levels, the results of the test suggest that after IT the central banks in the non-European countries have a forward-looking behaviour, although the available information does not allow one to rule out that this behaviour existed even before IT. In Canada, the headline inflation data suggest that this was not the case: Granger-causality from interest rates to inflation is evident in both indices after IT, and it did not exist in headline inflation before IT. In Australia, the opposite occurs: Granger-causality from interest rates to inflation is evident in both indices before and after IT, suggesting that no change in behaviour occurred. Finally, in New Zealand there is only a non significant improvement in the only index that is available for both periods, in terms of Granger-causality from interest rates to inflation, although it seems that before IT the RBNZ had a backward-looking interest rate setting behaviour, that might have been abandoned.[105] For the European countries there is no significant

[104] In the case of Spain, the tests were performed using 2 lags, instead of 4, so that the model could be estimated over the 'after IT' period.

[105] In all the cases interest rates were found to Granger-cause inflation, the significant coefficients in

evidence of Granger-causality from interest rates to inflation or vice-versa, with the exception of the former for the RPI in the UK (before and after IT), which is likely to be due to the importance of interest-rate related costs in this index.

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the *B(L)* polynomial were positive, supporting the view that this Granger-causality should be interpreted as central banks reacting to future expected inflation, and not as a consequence of the transmission mechanism.

Appendix 5.B: Aggressiveness of Interest Rate Increases

Using monthly data on short-term interest rates from the *International Financial Statistics*,[106] we tried to assess whether after the adoption of IT the central banks in our sample raised interest rates more aggressively than before. Since under IT the argument for not smoothing interest rates seems to be stronger (see main text), one could expect that after the adoption of IT increases in interest rates would be larger and quicker than before. Figure 5.10 plots selected short-term interest rates for the countries in our sample. The vertical dashed lines indicate the date of the adoption of IT, the dotted lines the monthly rates, and the solid line is a 'centered' 12-month average, used to capture the 'trend' in interest rates.

Visually one cannot detect significant changes in the aggressiveness of interest rate increases after the adoption of IT. If interest rate changes were quicker, the interest rate curves would be steeper, but the slope of the curves does not seem to have changed significantly. The only apparent change seems to be in the magnitude of the changes, which seem to be smaller after IT. In order to provide quantified data that support these visual conclusions, the following table describes the average monthly rate of change, magnitude and duration of significant interest rate increase episodes in the period January 1977 to September 1997.[107]

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[106] The interest rates used were the same as in Appendix 5.A, just the frequency was changed from quarterly to monthly (see Appendix 5.A for details). We have reasons to believe that the data for Australia and New Zealand in late 1983, early 1984 are inaccurate, but used them in the absence of a better alternative. None of the results is significantly affected by this.

[107] Interest rate increase episodes were selected using a methodology similar to Ball (1994). First, 'trend' interest rate (the 12-month moving average) is used to identify 'peaks' and 'troughs'. A peak is a month in which 'trend' interest rate is higher than in the previous six and the following six months; a trough is defined by an analogous comparison. An interest rate increase episode is any period that starts at an interest rate trough and ends at an interest rate peak, with the 'trend' rate more than 1 percentage point higher than the trough. Then, the lowest and the highest monthly rates in each episode were used to compute the statistics in the table. The 'duration' is the number of months between the month with the lowest and the month with the highest rates, the 'magnitude' is the difference between the rates in these months, and the 'monthly rate of increase' is the ratio of the 'magnitude' over the 'duration'. Statistics for each episode are not provided here, but may be obtained from the authors.

Absolute and relative changes are both used to describe interest rate increases because there are large differences in the level of interest rates across the sample period, ranging in some cases from 5%

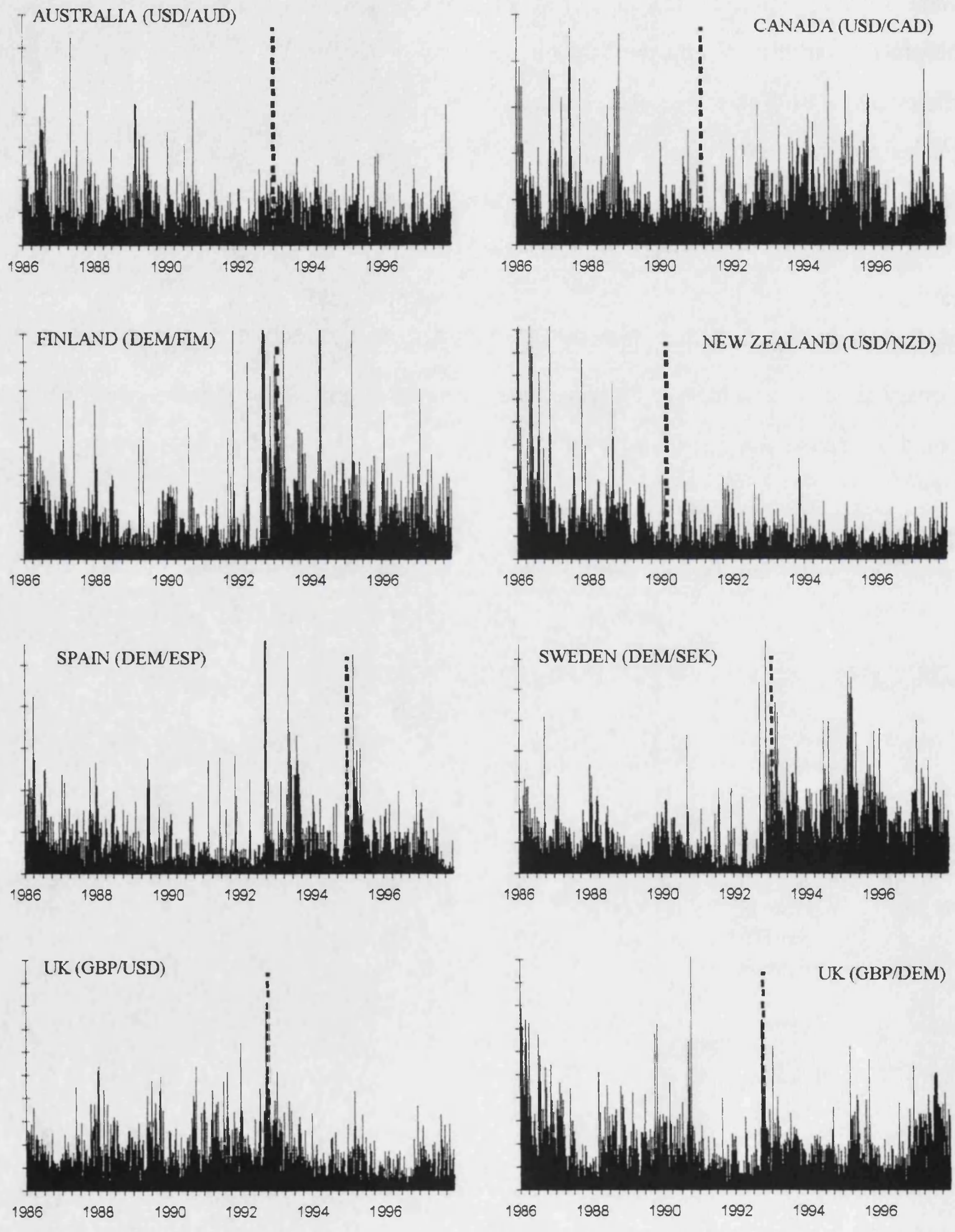
The evidence in Table 5.18 suggests that the interest rate increase after IT was less aggressive than previous interest rate increases, either in terms of magnitude or rate of increase. For all the countries in our sample, both the magnitude and the rate of increase were smaller, either in absolute or relative terms, than the average of the increases before IT, with the exception of the rate of increase in Australia and Canada. However, the evidence on Table 5.18 should not be interpreted as suggesting the central banks in our sample became less aggressive after the adoption of IT, because the data are too scarce. One of the reasons why the interest rate increases were less aggressive was because the shocks they were counteracting were milder. The only episode of interest rate increases after IT was in 1994-95, when the inflationary shock and the interest rate increases worldwide were relatively mild by historical standards. If the 1994-95 inflationary shock is assumed to be mild, then the rates of increase in Australia and Canada could be seen as more aggressive, since they are higher than the historical average.

Table 5.18 **Episodes of interest rate increases**

		Number of episodes	*Avg. duration (months)*	*Avg. magnitude*		*Avg. monthly rate of increase*	
				Absolute	*Relative*	*Absolute*	*Relative*
Australia	before IT	3	24	9.4	117%	0.39	4.8%
	after IT	1	6	2.8	60%	0.46	10.0%
Canada	before IT	3	31	9.0	132%	0.32	4.6%
	after IT	1	13	4.4	121%	0.34	9.3%
Finland	before IT	4	12	6.1	63%	0.60	6.4%
	after IT	1	16	1.3	28%	0.08	1.7%
New Zealand	before IT	3	11	11.9	126%	1.17	10.6%
	after IT	1	19	5.2	97%	0.27	5.1%
Spain	before IT	5	15	13.0	164%	1.12	14.6%
	after IT	1	6	1.9	25%	0.31	4.2%
Sweden	before IT	4	24	8.4	122%	0.38	5.3%
	after IT	1	13	2.0	28%	0.15	2.1%
UK	before IT	3	17	8.0	116%	0.50	6.8%
	after IT	1	6	1.5	29%	0.25	4.8%
All IT	before IT	25	19	9.5	121%	0.66	8.0%
countries	after IT	7	11	2.7	55%	0.27	5.3%

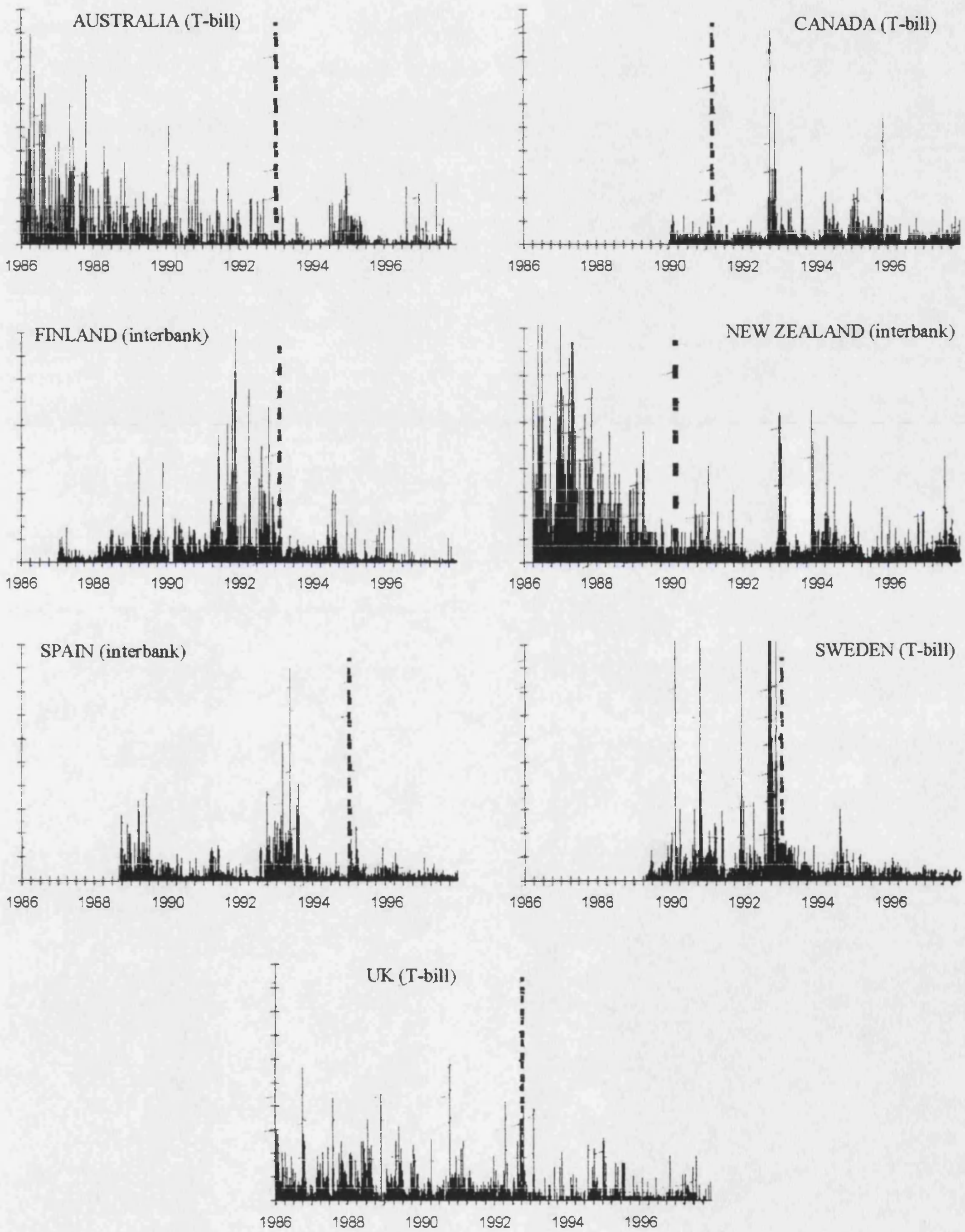
to 35%. The problem this large difference causes when comparing the size of different rate increases is whether we should consider an 3 p.p. increase from 5 to 8% or from 32 to 35% as being similar changes. The alternative is to consider as similar two 50% increases, be they from 5 to 7.5% or from 20 to 30%. The impact on real interest rates suggests we use the former criterion, but we also present the latter to provide a measure of the relative change.

Figure 5.1: Exchange rate daily absolute changes



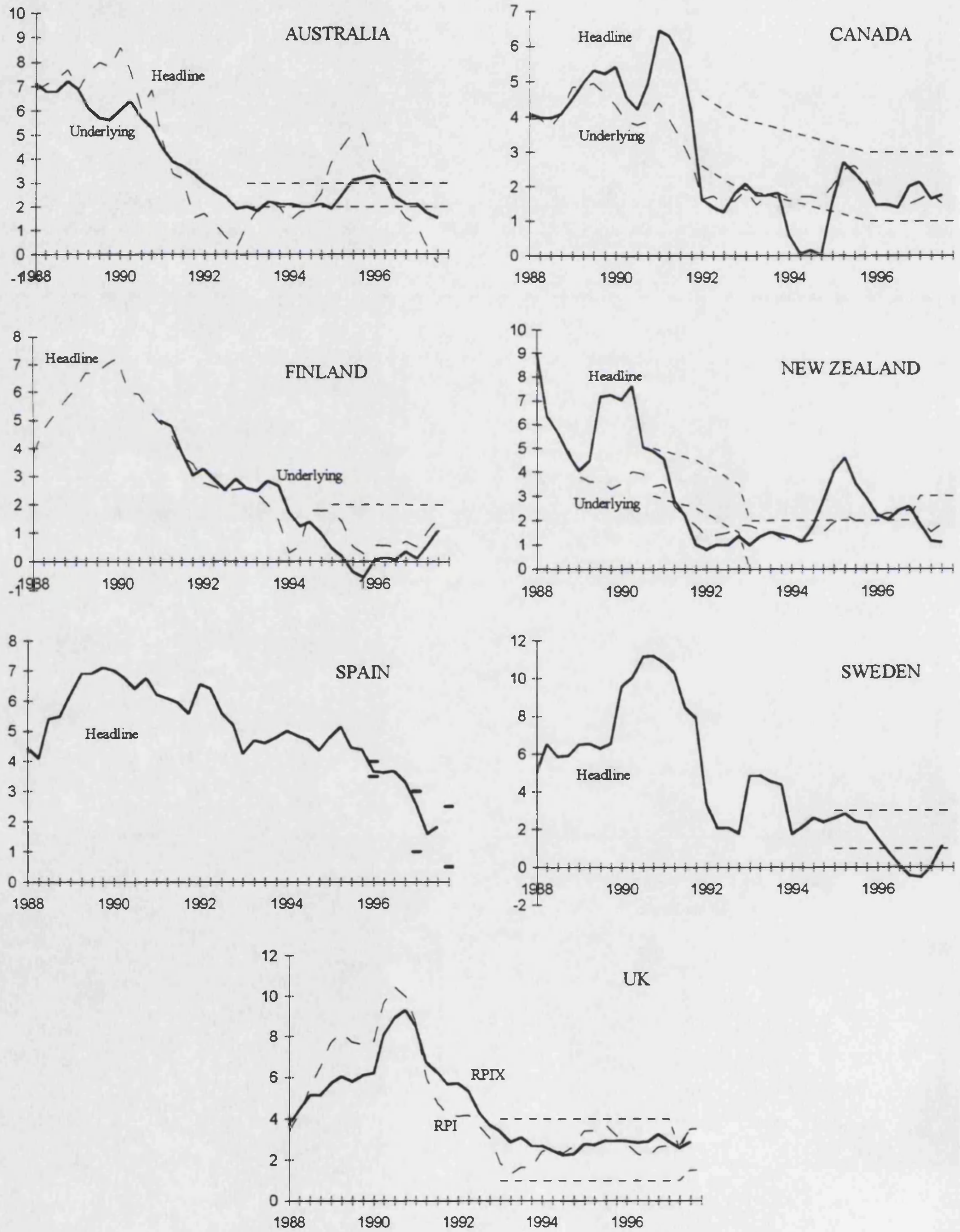
Notes: see footnote 58 in main text.

Figure 5.2: 3-month interest rate daily absolute changes



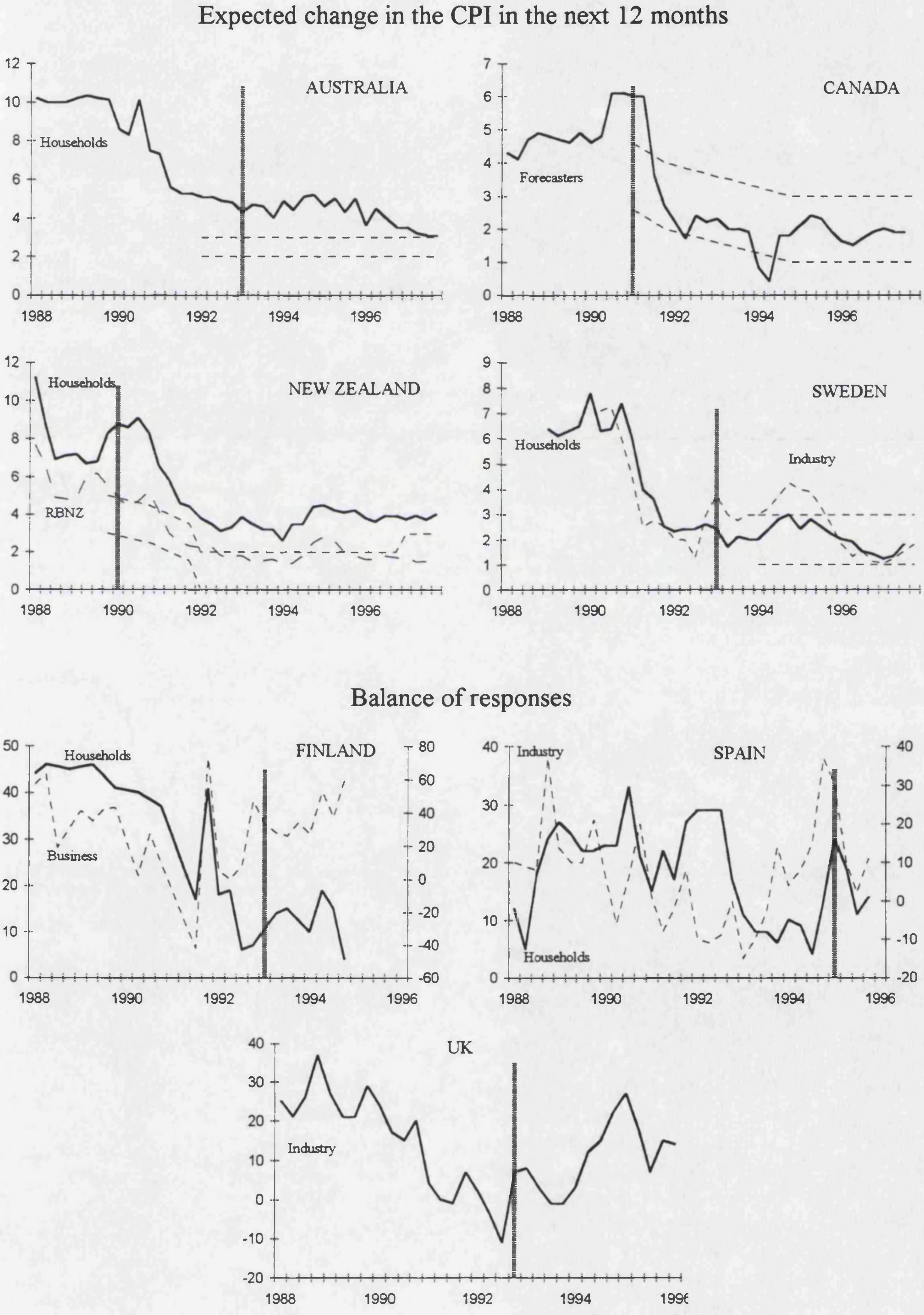
Notes: see footnote 63 in main text.

Figure 5.3: Inflation targets and inflation outcomes



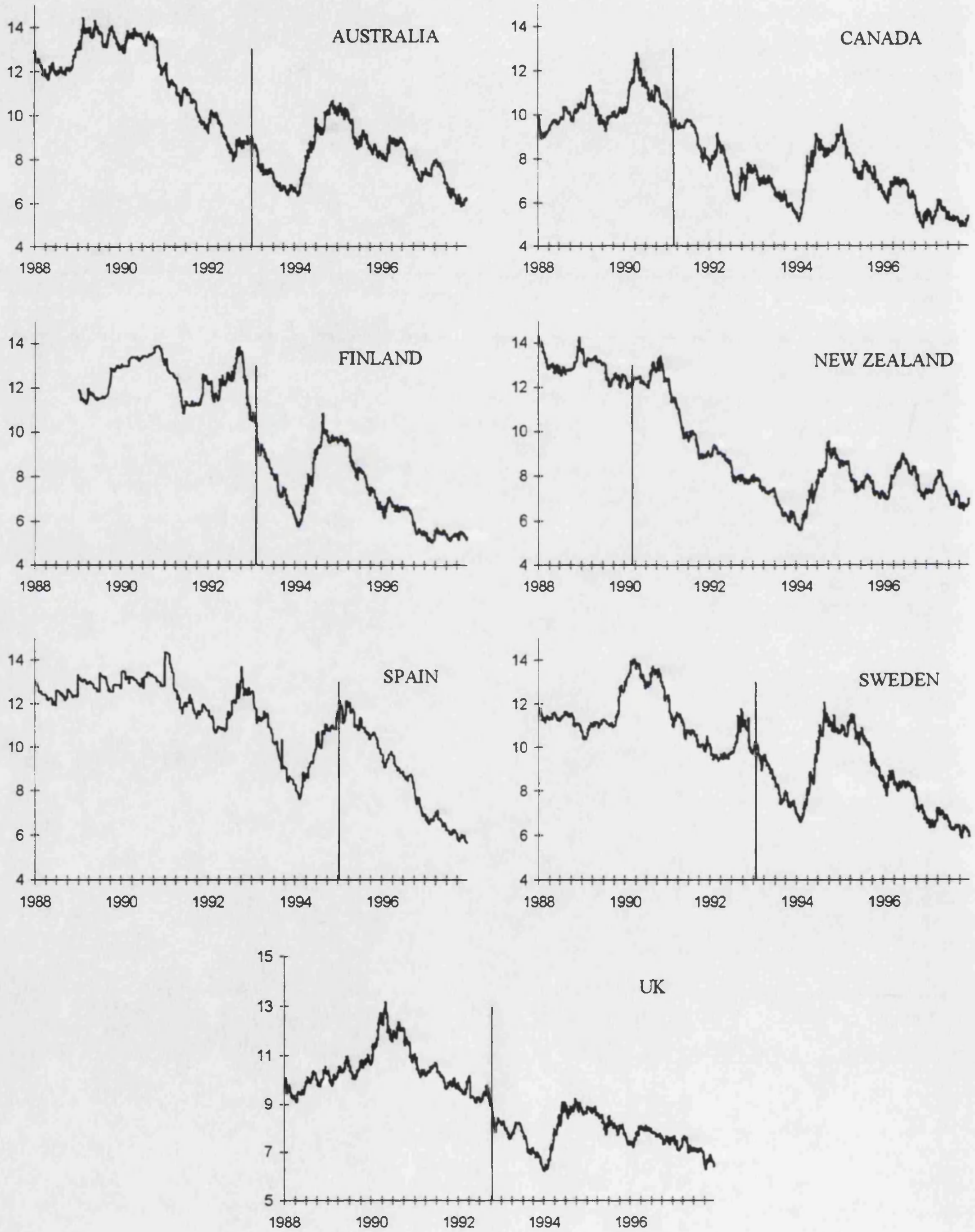
Notes: see footnote 74 in main text.

Figure 5.4: Households' and businesses' inflation expectations



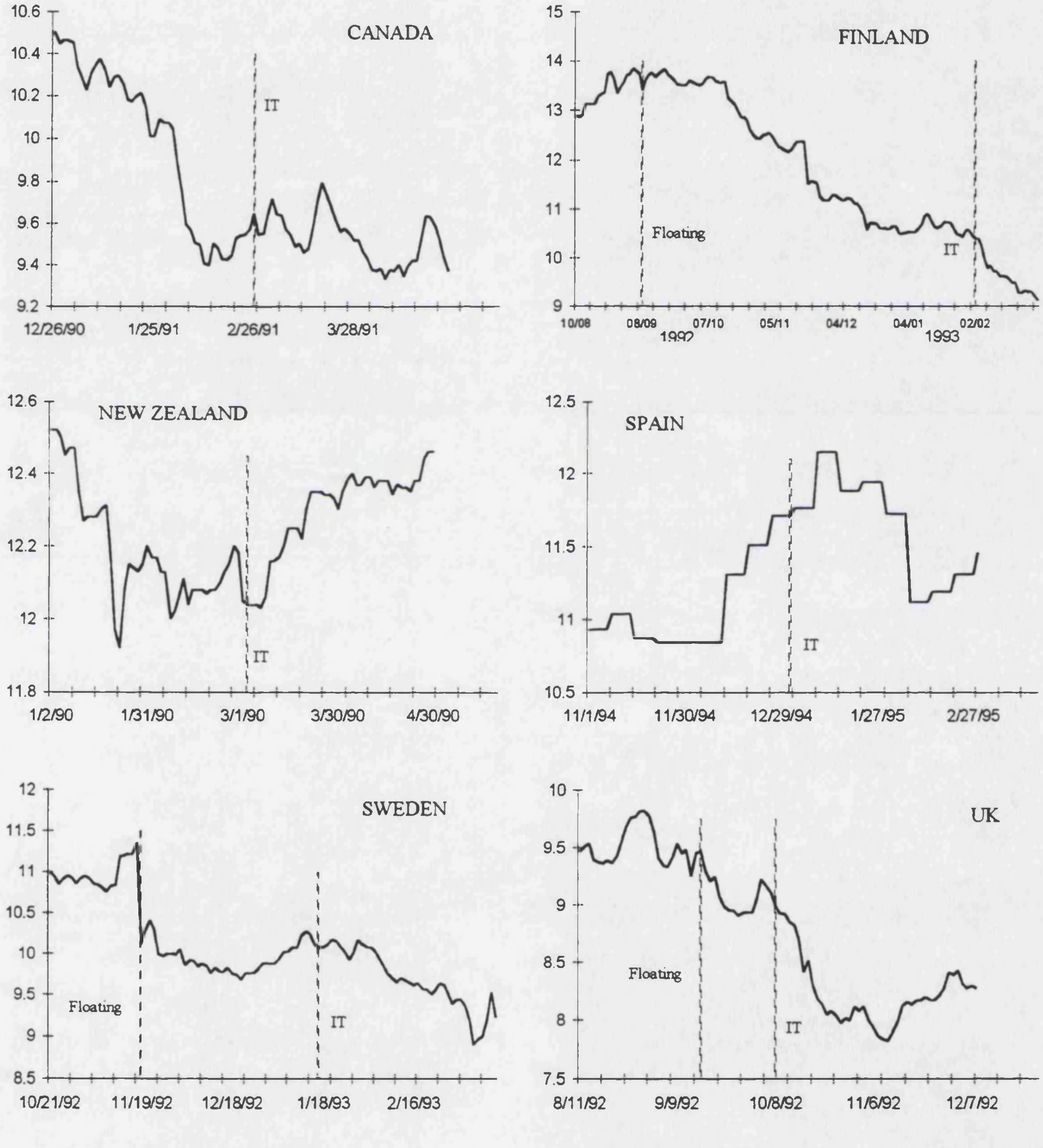
Notes: see pages 223-224 in main text.

Figure 5.5: Long term government bond yield



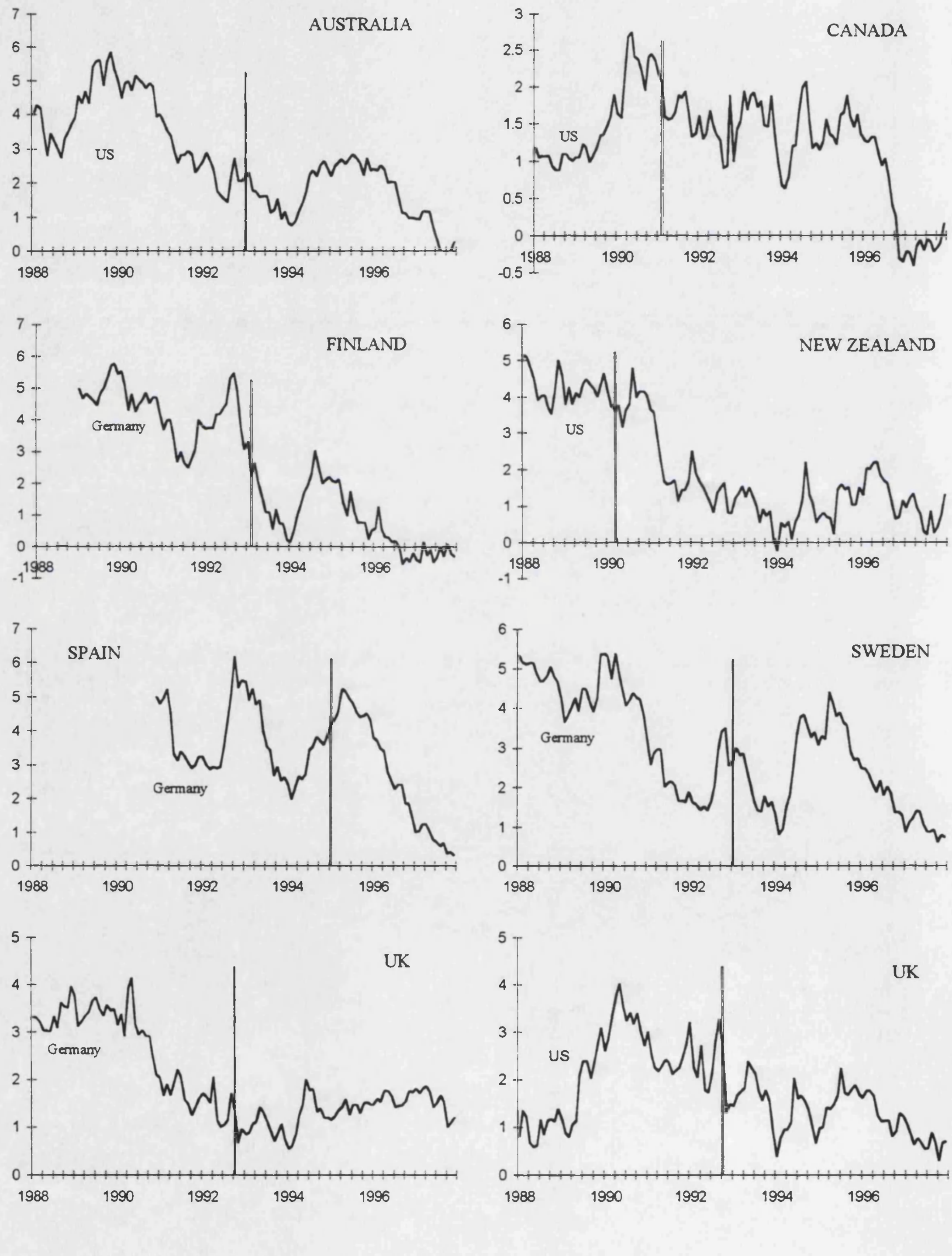
Notes: see page 225 in main text.

Figure 5.6: Long term government bond yield, around IT announcement



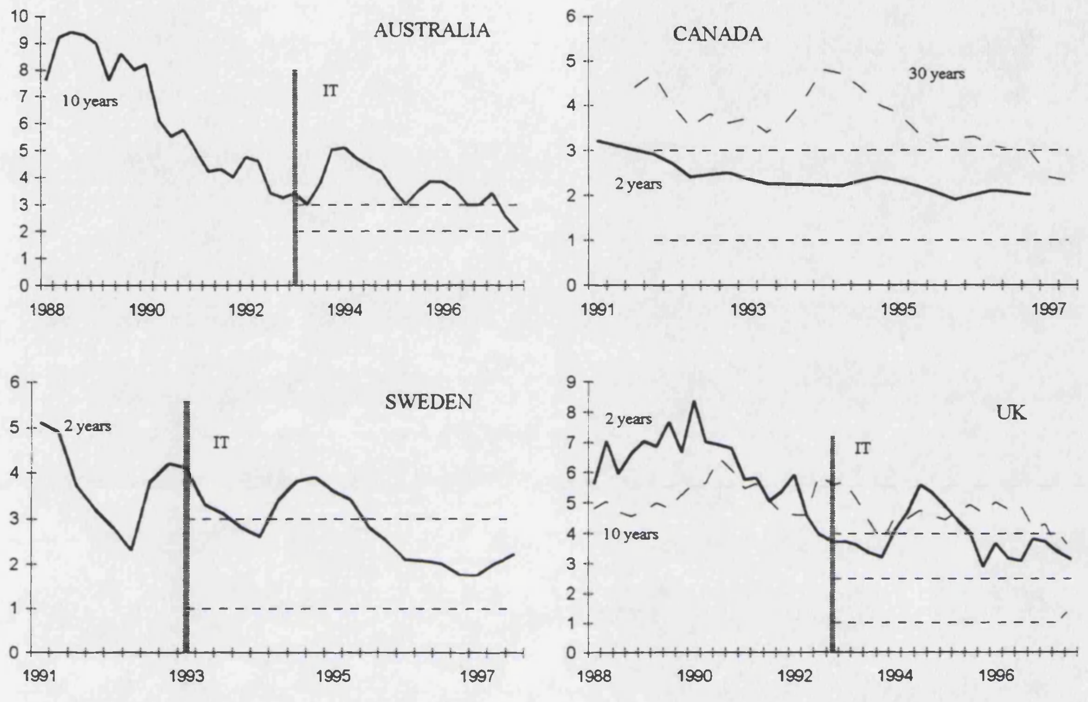
Notes: see pages 225-226 in main text.

Figure 5.7: Long term government bond yield, differential to Germany or the US



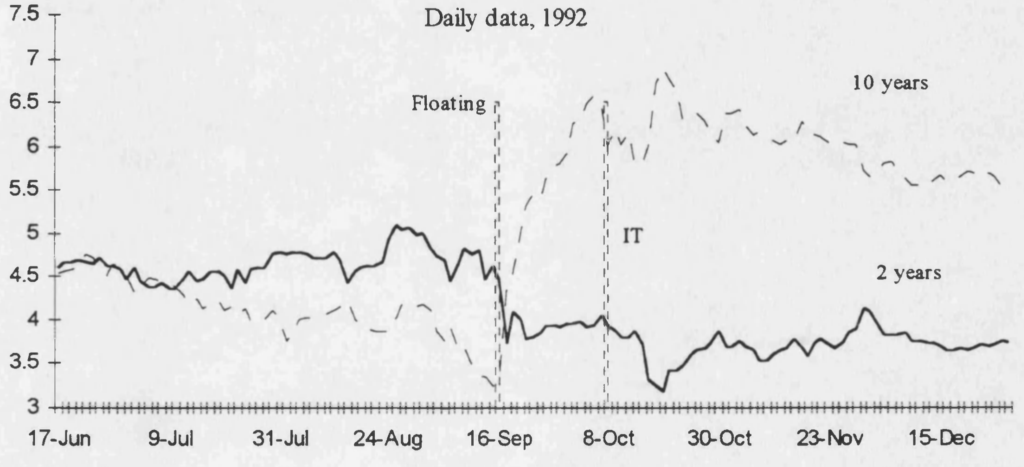
Notes: see pages 226-227 in main text.

Figure 5.8: Bond market inflation expectations



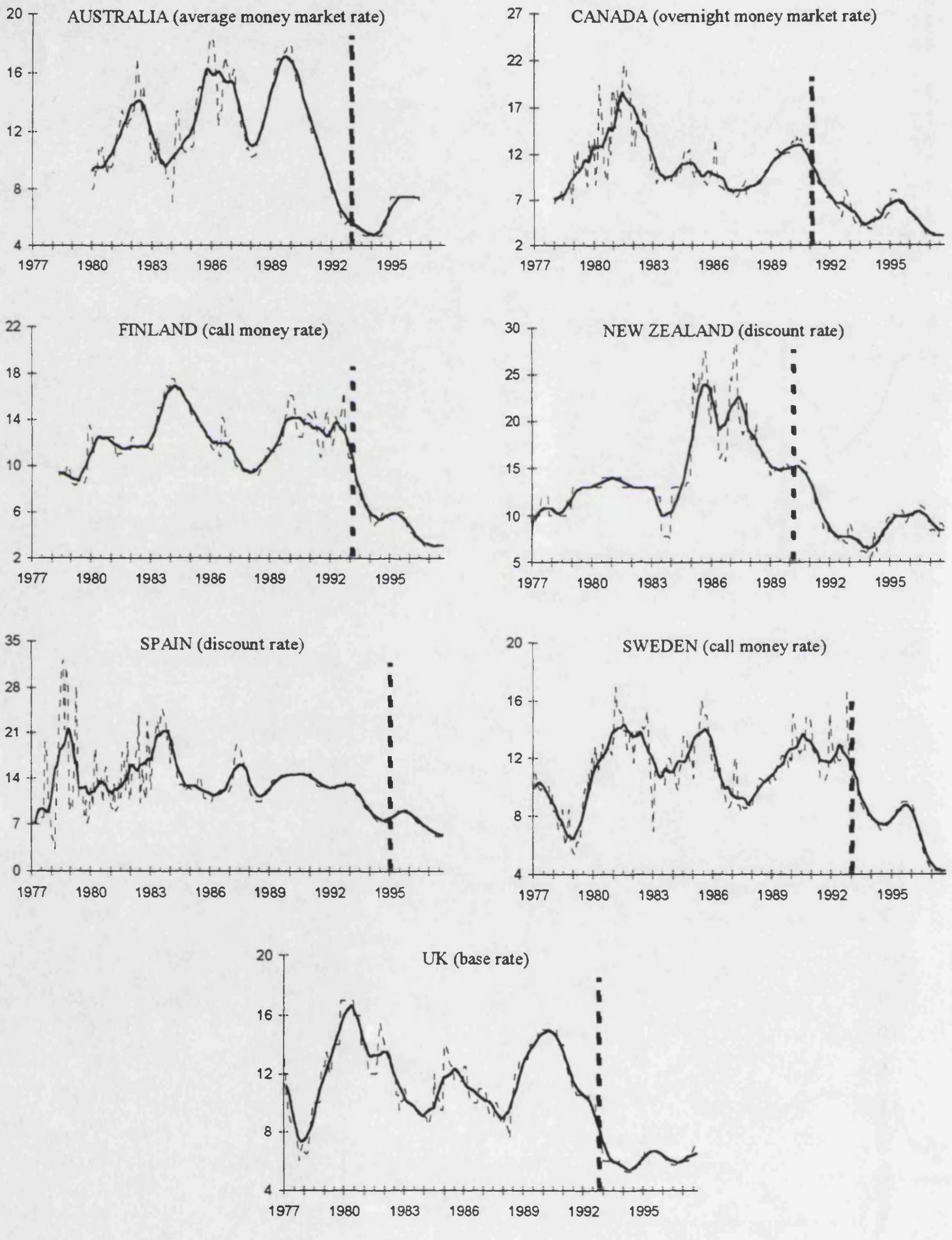
Notes: see page 227 in main text.

Figure 5.9: UK bond yield implied inflation



Notes: see page 228 in main text.

Figure 5.10: Short term interest rates (monthly)



Notes: see Appendix 5.B.

Chapter 6

Monetary Policy Targets and Instability in Financial Markets

Economists and central bankers have long debated the merits of alternative strategies for the conduct of monetary policy. One of the most widely researched features of these strategies is the question of whether monetary policy should be guided by stable rules, or central banks should be given the discretion to decide what is the optimal policy at each moment in time. The concept of a monetary policy rule is usually straightforward in the context of the theoretical models used in academic research, but it is less clear when it comes to practical application to the behaviour of actual central banks. There is considerable agreement among economists that a policy rule need not be interpreted narrowly as entailing fixed settings for the policy instruments (Taylor, 1993). The most common assertion of the practical application of a policy rule is the announcement by a central bank of a quantified target for some variable, together with the commitment to achieve this target (McCallum, 1997, Laidler, 1996). Although other variables have been proposed (e.g., nominal GDP, interest rates),[1] in practice, only the inflation rate, a monetary

[1] The concept of 'policy target' is being used here in the sense of an 'intermediate' or 'final' target, that the central bank sets for the medium term and commits to stick to it. It does not cover 'operating targets', which are frequently adjusted. Several central banks have used money market interest rates as 'operating targets', but not as 'policy targets', in this sense.

aggregate or the exchange rate have been used as policy targets.[2]

Should central banks announce quantitative targets, and if so, which of the above should they choose? This question has been the starting point of a large body of research in recent years. In the evaluation of monetary policy strategies, the most popular approach is to determine how well the various targets would perform in terms of yielding desirable values of postulated objective functions, with these pertaining primarily to root-mean-square deviations from desired values of variables such as inflation or real GDP relative to trend. The focus of these studies on inflation is a consequence of most central banks having price stability as their main policy objective. However, price stability is not the *only* objective of monetary policy. Central banks usually have a clear mission to secure stable financial systems, in addition to their macroeconomic objectives. The tension between the goals of macroeconomic and financial stability has been expressed by Folkerts-Landau and Garber (1992), in the context of the discussion around the design of the European Central Bank, in terms of the aphorism "A bank or a monetary policy rule?" More generally, many economists (namely Summers, 1991b, and Solow, 1982) have expressed doubts as to the compatibility of a strict monetary policy rule with central bank acceptance of lender-of-last-resort responsibilities.

The possibility of conflict between macro and microeconomic objectives suggests that the evaluation of alternative monetary policy targets will not be complete without an analysis of the implications of the adoption of a policy target to the stability of financial systems. The objective of this chapter is to provide a contribution to this discussion, by comparing the financial stability experienced under different monetary policy targets, using data for three financial assets (exchange rates, interest rates and stock prices) from a panel of 18 OECD countries, for the period 1972-1996. In this chapter, a stable financial market is defined as one with low risk and low uncertainty, with the definitions

2 The use of inflation targets has been reviewed in Chapter 5. Surveys of monetary and exchange rate targeting may be found in Goodhart (1989b), and Isard (1995), respectively. The issues involved in the choice of a monetary policy target are reviewed in Goodhart and Viñals (1994), McCallum (1997), Mishkin (1997), Cottarelli and Giannini (1997), and the survey by the Federal Reserve Bank of New York (1990).

of *risk* and *uncertainty* following Meltzer (1986). According to his definition, *risk* refers to events with known distributions of outcomes, either because people may know the probability of the event or because they may classify events based on experience or subjective belief. *Uncertainty* refers to events for which the distribution of outcomes is unknown and the basis for classification is tenuous; the timing, or even the occurrence, of these events cannot be predicted reliably. Here, *risk* in a financial market is associated with short-term price volatility. The main form of *uncertainty* in financial markets refers to the so called 'financial crises', periods of abrupt and very large changes in asset prices.

The chapter is organised as follows. Section 6.1 provides a brief review of the literature on empirical evaluation of alternative monetary policy strategies, and highlights the expected implications of the adoption of each policy target for financial stability. Section 6.2 discusses the actual policy targets used by central banks in OECD countries. Section 6.3 describes the data and methodology used in the two empirical exercises that constitute the core of the chapter: the analysis of short-term volatility of financial asset prices using a GARCH framework, and the study of the likelihood of financial crises under each policy target. Section 6.4 presents the results of these studies, and concluding comments are provided in Section 6.5.

6.1 Evaluating Alternative Monetary Policy Targets

The empirical evaluation of alternative policy strategies usually consists of analysing the performance of the various targets in terms of the behaviour of key economic variables. One of the most common approaches is to base the analysis on stochastic simulation of econometric models. Recent examples are McCallum (1994), Feldstein and Stock (1994), Haldane and Salmon (1995), Stevens and Debelle (1995), and the individual authors in Bryant, Hooper, and Mann (1993). Alternatively, one may analyse a country, or a period in time, that experienced different policy strategies, and observe the behaviour of the relevant economic variables under each strategy. Examples of time-series analysis of policy strategies are the studies of US monetary regimes in Meltzer (1986), the operating procedures of the Federal Reserve in Lastrapes (1989), and the exchange rate regime in the UK in Mills and Wood (1993). Cross-section analyses are the norm in empirical studies of central bank independence, such as Alesina and Summers (1993) and Grilli, Masciandaro, and Tabellini (1991). Panel studies of the performance of a number of macroeconomic variables under different monetary policy regimes can be found in Bordo and Schwartz (1997) and Ghosh *et al.* (1995), the latter covering nominal exchange rate regimes only.

Most of these studies have focused on the behaviour of inflation and growth (or employment), although some them also analysed the implications of the policy strategy for the volatility of some financial variables, usually a (short- or long-term) interest rate and the exchange rate. The main exception is McCallum (1994), who focused on financial stability, and analysed the compatibility of a strict monetary policy rule with central bank acceptance of lender-of-last-resort responsibilities. He studied this problem in terms of whether it would be possible for the central bank to provide lender-of-last-resort assistance through open-market operations with high-frequency smoothing of movements of a money market interest rate, and still be able to hit lower-frequency (e.g., quarterly average) intermediate money targets conforming to a monetary policy rule designed to yield macroeconomic stability. Using counterfactual simulations for the US economy, during two sample periods (1974-79 and 1988-91), of an empirically based weekly model of monetary base determination (consistent with a quarterly policy rule) together with a Federal Funds rate that entails weekly smoothing, he finds that quarterly base targets could be achieved rather accurately while practising some form of interest rate smoothing, although it still involved more interest rate volatility than had been experienced in the US.

This chapter is concerned with the impact on financial stability of alternative monetary policy targets. The focus is on the four basic targeting strategies that central banks in OECD countries have used in the last thirty years: exchange rate targets (ET), money targets (MT), inflation targets (IT), and a strategy in which the central bank does not announce a target, that will be designated as *discretion* (DS).[3] From the literature mentioned above, what are the expected implications of each of these alternative targets for the stability of financial markets? In most cases, the answer is not clear-cut. The results from stochastic simulation studies depend significantly on the nature of the shocks hitting the economy and/or on the model used in the analysis. Evidence from time-series analysis is country specific, and not prone to generalisations. The following paragraphs attempt to summarise the main results in the literature concerning the volatility of interest rates and exchange rates.

Under an ET, the authorities stabilise the exchange rate, at least if there are no significant problems of monetary control. Some authors (e.g., Mills and Wood, 1993) argue that intervention by the authorities can not eliminate volatility in the economy, only shift it from one market to another. If the central bank reduces exchange rate volatility by pursuing an ET, this volatility will show up in another market, most likely the money market: in order to keep the exchange rate stable, the central bank will have to manipulate short term interest rates more actively. However, the results in BHM (Bryant, Hooper, and Mann, 1993)[4] suggest the opposite: short term interest rates are less volatile under ET than under any other strategy. The logic here is that under fixed exchange rates and free capital movements, domestic interest rates must follow interest rates in the anchor country. If interest rates are stable in this country, they will also be stable in the countries fixing their exchange rates to it.

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[3] If the central bank announces a target but it accepts misses on a discretionary basis, it will be classified as having *announced* a rule, but as a discretionary central bank *in practice* (because it is not committed to follow the target it set). See below for a discussion on the distinction between *actual* and *announced* targets.

[4] The research in Bryant, Hooper, and Mann (1993) examines the stabilisation properties of four alternative monetary policy strategies, in eight different multicountry econometric models. The four strategies are exchange rate, monetary, and nominal GDP targeting, and a strategy in which the central bank targets the sum of real GDP growth and inflation. While the first two strategies have an obvious correspondence to the ones used in this chapter, and the third has no counterpart, the fourth strategy could be seen as a simplification of the behaviour of most central banks in this sample that are classified as discretionary. For instance, Taylor (1993) claims that the US Federal Reserve (classified as a discretionary central bank after 1986) implicitly follows such a rule. The BHM research did not cover pure inflation targeting.

The ranking of the other strategies is not clear either, since it depends on the nature of the shocks affecting the economy. The results in BHM suggest that for domestic money demand shocks DS may produce better results than MT. The basic rationale for this result is similar to Poole's (1970) argument: the optimal response to a money demand shock is to keep interest rates fixed, since in this case all markets but the money market will be isolated from the shock. This is possible under every strategy except MT, where the policy response will be to increase interest rates to reduce money demand to its original level.

For aggregate demand or aggregate supply shocks, the ranking is inverted: MT should lead to lower interest rate volatility than DS. For the case of an increase in the demand for goods, the rationale can be simplisticly described as follows.[5] The increased demand for goods will imply an increased demand for money. Under MT, the policy response will be to raise interest rates, which will lower output and prices, but not enough to return them to their initial level; the final result will be an unchanged money demand, with higher interest rates, output and prices. Under the BHM strategy equivalent to DS (targeting real GDP plus inflation), output and prices must be restored back to their original levels; this would imply a larger interest rate increase than in the MT case, because under MT the adjustment is spread over three variables, while under DS it is concentrated on the policy instrument, interest rates.

The ranking of interest rate volatility under MT and DS will then depend on which type of shock is more likely in the economy. Haldane and Salmon (1995) found that for the type of shocks that hit the UK economy in the last 40 years, MT would deliver lower interest rate volatility than DS. However, the differences are small, and did not hold across all range of parameter values. Moreover, these results for DS are likely to be specific to the kind of formalised rule used in the BHM and Haldane and Salmon (1995) studies. More general definitions of DS could lead to lower interest rate volatility than MT. This could be the case, for example, if the central bank has a strong preference for interest rate smoothing. The lack of the constraint imposed by an announced target,

[5] A more detailed theoretical analysis of the topic may be found in Henderson and McKibbin (1993).

would give the authorities more freedom to implement the amount of interest rate smoothing they desire.

The BHM study did not include IT as a possible strategy, but Haldane and Salmon (1995) did. They concluded that interest rate volatility is higher under IT than under any other strategy. Theoretically, interest rate volatility should be the same under IT and the strategy of a mixed real GDP and inflation targeting (which is the equivalent of DS in the two studies referenced above) for all type of shocks, except supply shocks. In the event of a negative supply shock, under IT interest rates will have to rise sufficiently to return inflation to its original level, while under DS the supply shock would be accommodated, possibly without any change in interest rates. The result in Haldane and Salmon (1995) thus suggests the UK economy is more susceptible to supply shocks.

The volatility of exchange rates should be lower under ET than under any other strategy, abstracting from problems of monetary control. Not surprisingly, this is what the research in BHM has found. The ranking of the other strategies is less clear. Lastrapes (1989) found that in the US exchange rate volatility was higher during the MT period (1979-82), than in the previous and posterior DS periods. A strict MT implies endogeneity of interest rates and exchange rates, so these will tend to be more volatile under MT. However, this was not what the research in BHM found. As was explained above, in the BHM studies exchange rate volatility is positively associated with interest rate volatility. This implies that the ranking for exchange rate volatility is the same as for interest rate volatility, and the discussion in the preceding paragraphs applies. In most circumstances DS will be associated with higher exchange rate volatility than MT, and an extension of the results in Haldane and Salmon (1995) would suggest IT would be associated with higher exchange rate volatility than DS. However, the analysis in Chapter 5 (subsection 5.2.4) suggests that exchange rate volatility should be lower under IT than under DS, since the existence of a clear target could reduce the uncertainty faced by market participants regarding the future stance of monetary policy.

6.2 Monetary Policy Targets in OECD Countries

The discussion in Section 6.1 shows that the implications for financial stability of each policy target are not clear. The existing empirical literature only provides results that are model or country specific. One form of overcoming this problem is to analyse historical data from a panel that includes a sufficiently large number of countries, and a wide variety of strategies. This is the first contribution of this chapter. It covers the experience of 18 OECD countries,[6] all the countries in the OECD with a sufficiently long history of 'tolerably liberalised' financial markets,[7] for a period of 25 years, long enough to include all the strategies under analysis in this chapter.

The first step in the research is to identify the targets in use by each central bank at each moment in time. As in the rules and discretion problem, although in theory the distinction between the different targets is clear, it becomes less obvious when one has to classify the strategies followed by actual central banks. For example, some central banks do not announce any targets, even though policy decisions are based on one (and this may be widely recognised by private agents).[8] Others announce a target, but policy decisions are not guided by that variable, or they may even announce more than one target. Because one of the rationales for adopting a target is its effect on (private sectors') expectations, it is important whether or not the target is announced. But talk is cheap, and announcing a target does not force the central bank to take policy actions consistent with its attainment. What determines policy outcomes is the target that drives policy decisions, not the announced one. Thus, both the *actual* and the *announced* targets are important, since both will have an effect on the outcome of the strategy, and

[6] The countries in the sample are Australia, Austria, Belgium, Canada, Denmark, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the UK, and the US.

[7] The expression 'tolerably liberalised' is used here in the sense of a financial market that may be restricted by regulatory constraints, but these constraints are not enough to render prices meaningless. Note that not all countries in the sample fulfilled this condition throughout the whole sample period.

[8] An example was the Austrian Central Bank, that before 1995 had an unpublished target for the schilling/DEM exchange rate.

potentially on the stability of financial markets. This chapter analyses monetary policy strategies from both points of view. Appendix 6.A describes the policy targets used by the central banks in the sample, including the discussion of whether the announced target was the actual target.[9] This appendix is the second contribution of this chapter: it provides a systematic and detailed classification of the monetary policy strategies used by OECD central banks since the collapse of the Bretton-Woods system.[10]

The use of an exchange rate target does not imply that the exchange rate is fixed. Exchange rate targets are usually formulated in terms of a central parity, with associated fluctuation bands. As long as the width of the band is strictly positive, the exchange rate will not be fixed. Also, the central parity may be changed; in some ET strategies these changes follow a pre-announced schedule (e.g., crawling peg), while in others they occur in irregular occasions and amounts. Different widths of the fluctuation bands and different arrangements for changes in the central parity are likely to be associated with different levels of stability in financial markets, so this chapter considers several ET strategies independently. In particular, multilateral exchange rate agreements, like the Smithsonian agreement (BW), the European 'snake' (SK), and the ERM, are treated separately from unilateral exchange rate targets (XT). In addition, the original ERM arrangement (OR), with fluctuation bands of ±2.25% (±6% for some countries), is distinguished from the ERM with 'wide bands' (fluctuation margins of ±15%) that emerged after August 1993 (WR).[11]

[9] Some of the sources of information used are official (e.g., central banks, IMF), others are not. It was assumed that the target described in the official sources was the announced one, and that the target described in the non-official sources was the actual target, when different. Some of latter descriptions might represent subjective ex-post opinions of the authors, but it was assumed that they represent the contemporaneous view of private market agents.

[10] After the first draft of this chapter was completed, I become aware of Cottarelli and Giannini (1997), who also provide a systematic classification of monetary policy strategies. Their database covers a wider range of countries but is less detailed than the one in Appendix 6.A. As far as it was possible, the two databases were compared and no contradiction was found between the two.

[11] The classification OR was also used when the *actual* target was an exchange rate peg with the DEM or the ECU, even if the country did not participate formally in the ERM mechanism (e.g., Austria).

6.3 Data and Methodology

The goal of the chapter is to study the stability of financial markets under different monetary policy targets. The analysis covers the concept of stability from the point of view of low risk and low uncertainty. *Risk* is defined as short-term price volatility, and its analysis is based on a GARCH-type model, using monthly data, described in subsection 6.3.2. *Uncertainty* is associated with the occurrence of financial crises, when asset prices change suddenly and by very large amounts. The study of this kind of instability is important because the economic impact of these crises tends to be higher than the consequences of a higher average volatility. For instance, derivatives prices are less likely to account for financial crises, that tend to be unexpected, than for higher average volatility, and thus those crises may cause large losses (and gains) for institutions trading in these markets, that may lead to the failure of some of them. Subsection 6.3.3 describes the methodology used in the study of financial crises.

6.3.1 Data

For the GARCH analysis, the financial asset prices series are monthly data for the period 1972:1-1996:12, obtained from the *IMF International Financial Statistics* and *OECD* historical databases. The sample starts after the end of the Bretton-Woods regime, because previously the countries in the sample had their choice of monetary policy strategy seriously restricted by the constraints imposed by the regime.[12] The exchange rate data are *IFS*'s nominal effective exchange rate indices. Bilateral exchange rates are influenced by factors originating in the two countries involved, and the use of effective

[12] Note that before 1971 the US, as the anchor country, and Canada, during the periods when the Canadian dollar was floating (before May 1962 and after May 1970), were able to pursue independent monetary policies. Also, exchange controls and limited capital mobility allowed for considerable discretion on domestic policies, even for the other countries. Nevertheless, the policy strategy was basically set by the regime's constraints.

exchange rate indices reduces the influence of external elements in the analysis. Domestic factors, like the monetary policy targets analysed in this chapter, are more closely related to the effective exchange rate than to any bilateral exchange rate, which also depends on other factors unrelated to domestic conditions, like, for example, the strategy adopted by the central bank of the other country.[13] On the other hand, variations in the effective exchange rate are the best measure of foreign exchange market risk faced by domestic agents, which is the focus of this chapter, given that they represent an average of the variability of individual currencies, weighted by their importance to domestic agents. Interest rates are money market call rates, and the share price data are market indices. The full description of the data may be found in Appendix 6.B.

The study of uncertainty in financial markets was based on the same monthly data used in the GARCH analysis, complemented by analogue series of daily data that allowed for the construction of daily and weekly price changes. The sample period was the same as in the previous exercise, and the data were obtained from *Datastream*. The exchange rate data are mainly the Bank of England's trade weighted currency movement indices (see Appendix 6.B for a more precise description of the data). The interest rate data are (2 days notice) euro-currency rates in London, when available, or some short-term interbank or treasury bill rate, in the other cases. Share price data are *Datastream* national stock price indices.

6.3.2 Financial markets' risk

Financial market risk was measured by the short term volatility of financial asset prices, modelled in a GARCH framework. The first stage of the analysis consisted in a preliminary statistical treatment of the monthly data. In a GARCH model, any price change contributes to higher volatility. However, not all price changes represent short term risk,

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[13] Since effective exchange rate indices are weighted averages of changes in individual currencies, they are not immune to external factors, in particular those influencing the currencies with the larger weights in the index. However, their influence is smaller than in any bilateral exchange rate.

which is the concept one is trying to measure. To give an extreme example, there is no risk if a currency is depreciating at a constant rate of 3% per month, but this would translate in an unconditional volatility of 3% in the GARCH framework. In order to avoid this problem, (the log of) exchange rates and share prices were previously de-trended using the Hodrick-Prescott filter.[14] Then, the asset price change in period t for country i, c_{it}, was computed as the first difference of the (de-trended) log of the asset prices, p_{it},

$$c_{it} = (p_{it} - p_{i,t-1}) \times 100 \tag{6.1}$$

corresponding to the (continuously compounded) percentage short term change in the asset price. Finally, ARMA models were fitted to the c_{it} series, and their residuals used as the basic asset price variable, r_{it}.[15]

The second stage consisted of modelling r_{it} as a GARCH(1,1) process, following a substantial body of literature that has described the behaviour of foreign exchange rates under Bollerslev's (1986) GARCH framework.[16] The model used in this exercise assumes that for each country the r_{it} series follows a GARCH(1,1) process, and the constant term of the conditional variance includes a country-specific and a monetary policy target-specific term, with the latter assumed to be the same across countries. The full model is

$$r_{it} = \mu_i + \varepsilon_{it} \tag{6.2}$$

$$\varepsilon_{it} \;/\; \psi_{t-1} \sim D(0, h_{it}) \tag{6.3}$$

$$h_{it} = \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \left(1 + \sum_m \phi^m S_{it}^m\right) \tag{6.4}$$

where D is a conditional density function, $S^m{}_{it}$ is a variable taking the value 1 if country i uses target m in period t, and μ_i, α_i, β_i, γ_i, and ϕ^m are parameters to be estimated.[17] Each

[14] The problems caused by the existence of a trend in prices are less severe for the interest rate series, so these were not de-trended.

[15] In the case of the share price model, the r_{it} series was constructed as the residuals from a transfer function that included a dummy variable for the October 1987 crash. All the subsequent GARCH analysis will therefore not include the effects of this crash.

[16] For references on applications of the GARCH framework to financial prices see Bollerslev, Chou, and Kroner (1992).

[17] For the conditional variance in equation 6.4 to be well defined, α, β and $\gamma(1+\phi)$ must be all positive. In some models, some of the β_i estimates were found to be negative. When this was the case, the

parameter ϕ^m measures the percentage increase in volatility associated with the use of target *m*, relative to the base target. The model in equations 6.2 to 6.4 is estimated by quasi-maximum likelihood (QML). Although financial asset prices tend to exhibit a higher degree of leptokurtosis than that induced by a normal *D*, the QML estimates obtained by maximising the conditional normal likelihood function are consistent and asymptotically normal (see Bollerslev, Engle and Nelson, 1994). The large number of observations involved in the estimation (300 periods x 18 countries) provides the justification for the use of asymptotic results, and tests on restrictions on the ϕ parameter vector can thus be carried out using conventional likelihood ratio statistics.

6.3.3 Uncertainty in financial markets

In this chapter, *uncertainty* in financial markets is associated with the occurrence of 'financial crises', periods of abrupt and very large changes (positive or negative) in asset prices, so large and abrupt that its occurrence is highly unlikely and potentially disruptive of the stability of the financial system. Obviously, the first stage in this analysis is the identification of these financial crises. The basic idea at this stage is to consider as a financial crisis any price change that is 'very large' relative to the past history of price changes for that asset, as measured by the ratio of the forecast error of a rolling ARMA model over its standard deviation. Since the change has to be 'abrupt', price changes were measured over relatively short periods, using monthly, weekly and daily data.[18]

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conditional variance was alternatively modelled as following an ARCH(1) process, i.e., the parameter β_i was restricted to zero. Also, the model is covariance stationary only if $\alpha_i+\beta_i<1$. For some countries, this condition was not verified initially. Estimates of $\alpha_i+\beta_i>1$ are sometimes caused by the existence in the sample of very large outliers, like those caused by point devaluations. Accounting for those observations using dummy variables in equation 6.4, usually provides estimates of $\alpha_i+\beta_i$ that are smaller than 1. This solution was used in some of the models estimated.

[18] Even though large asset price changes occurring gradually over the medium term may have a serious impact on the economy, they are less likely to cause significant disruption in financial markets. Financial institutions tend to hold liabilities with shorter maturities than their assets. Abrupt changes in asset prices (occurring in less than a couple of weeks) may cause a mismatch between the cost of the liabilities and the return on the assets, serious enough to lead to the collapse of the institution. If the change in asset prices occurs over the medium term, financial institutions can gradually adjust their portfolios, such that the mismatch between the cost of the liabilities and the return on the assets does not reach dangerous levels. This is why the analysis is based in daily and weekly changes, and extended to

The basic asset price variable in this exercise was the (continuously compounded) percentage short term change in the asset price, r_{it}, measured by the first difference of the log of the asset price, P_{it}, multiplied by 100,

$$r_{it} = (\log P_{it} - \log P_{i,t-1}) \times 100 \qquad 6.5$$

ARMA models, chosen according to the Schwarz criterion, were then fitted to each of the r_i series. Subsequently, rolling ARMA models were estimated using data for the previous 2 years (3 years for the monthly data), and a forecast based on the estimated model, f_{it}, was computed for each period. The indicator used to identify financial crises, TF_{it}, was computed as the ratio of the forecast given by the rolling ARMA model and its standard deviation

$$TF_{it} = f_{it} / \textit{standard deviation } (f_{it}) \qquad 6.6$$

If the indicator TF_{it} was larger than 5.0, 6.3 or 8.3 (for the monthly, weekly and daily data, respectively), it would identify a crisis in financial market i in period t.[19] When two or more very large price changes were identified inside two consecutive calendar months (irrespectively of whether these were identified using monthly, weekly or daily data), it was assumed that these refer to the same financial crisis.[20]

Having identified the financial crises in the first stage, the second stage consists on the analysis of the relationship between the occurrence of a crisis and the policy target the central bank was using when the crisis erupted, using a logit model of the type [21]

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monthly changes to capture those changes that extend for more than a week but not much longer.

[19] These values were chosen such that the total number of crises identified in the sample would be around 90, which corresponds roughly to the occurrence of a crisis every 5 years in each country.

[20] This restriction results from the nature of the monthly data used, that does not permit the separation of two crises occurring in consecutive calendar months, when using monthly data. The *IFS*'s nominal effective exchange rates are computed using the *average* exchange rate for each calendar month. This implies that the exchange rate change from month t to month $t+1$ is affected by any event occurring in the period from the first day of month t to the last day of month $t+1$. I.e., if a crisis is identified in month $t+1$ from monthly data, this could have happened at any time in the calendar months t and $t+1$.

[21] The logit model was preferred to the probit model because the logistic distribution has fatter tails than the normal distribution, and thus is more appropriate to describe the data under analysis. Nevertheless, estimates of probit models were also calculated, and it was found that all the qualitative results were similar to the ones presented here (details of the estimations may be obtained from the author). Both models produce similar results when the estimated probabilities are close to 50%, but the results may differ widely across models when the estimated probabilities are very large or very small (Greene, 1993,

$$CR_{it} = l\left(\gamma + \sum_m \beta_m S_{it}^m\right) \qquad 6.7$$

where CR_{it} is a dummy variable taking the value 1 if a crisis occurs in country i in period t, $S^m{}_{it}$ are variables taking the value 1 if country i follows strategy m in period t, γ and β_m are parameters to be estimated, and $l(.)$ denotes the logistic distribution. This model was estimated independently for each of the 3 types of financial assets under analysis (exchange rates, interest rates and share prices), using a quarterly periodicity.[22]

6.4 Results

6.4.1 Short term volatility in a GARCH framework

Table 6.1 presents the results from the estimation of the GARCH model in equations 6.2 to 6.4, using exchange rates and the announced policy targets. The top panel shows the estimates for the policy target parameters in equation 6.4 (ϕ^m), which are common across countries, and the bottom panel shows the remaining parameters, which are country-specific. The estimates for the country-specific parameters in equation 6.4 denote substantial differences in the volatility process. The average volatility (measured by the unconditional volatility under the base strategy, UV_{BWi}) varies from 0.16 in Canada to 1.43 in Australia. The degree of persistence in volatility (measured by $\alpha_i+\beta_i$) also varies substantially, from very low levels of persistence in Sweden (0.15) to very high levels in Australia (0.99). These large differences between volatility processes justify the use of country-specific parameters in equation 6.4, as estimation of a single set of volatility

p. 638). In this exercise the estimated probabilities were small, but still the results were similar with both models.

[22] The choice of a quarterly periodicity is a consequence of the procedure used, that does not identify two crises occurring on two consecutive calendar months. This rules out the use of a monthly periodicity. Note that much care was taken to ensure that the occurrence of a crisis was associated with the target in place when the crisis started.

Table 6.1 **GARCH model for exchange rates, with announced targets**

Monetary policy target parameters (ϕ^m)

MT	IT	DS	XT	OR	WR	SK
4.213	4.711	4.332	0.720	0.500	0.328	1.792
(0.727)	*(0.990)*	*(0.783)*	*(0.277)*	*(0.231)*	*(0.255)*	*(0.468)*

Country specific parameters

	μ_i	γ_i	α_i	β_i	UV_{BWi}	$\alpha_i+\beta_i$
Austria	-0.010	0.100	0.448		0.181	0.448
	(0.029)	*(0.019)*	*(0.075)*			
Australia	-0.046	0.010	0.054	0.939	1.429	0.993
	(0.131)	*(0.004)*	*(0.022)*	*(0.025)*		
Belgium	-0.008	0.146	0.478	0.105	0.350	0.583
	(0.036)	*(0.040)*	*(0.057)*	*(0.113)*		
Canada	0.003	0.126	0.199	0.030	0.163	0.229
	(0.050)	*(0.048)*	*(0.099)*	*(0.289)*		
Denmark	0.001	0.281	0.224		0.362	0.224
	(0.040)	*(0.046)*	*(0.057)*			
France	-0.030	0.047	0.209	0.689	0.461	0.898
	(0.037)	*(0.017)*	*(0.052)*	*(0.067)*		
Germany	-0.028	0.051	0.135	0.593	0.188	0.728
	(0.055)	*(0.022)*	*(0.052)*	*(0.132)*		
Ireland	0.052	0.158	0.089	0.570	0.463	0.659
	(0.054)	*(0.051)*	*(0.041)*	*(0.100)*		
Italy	0.021	0.126	0.154	0.425	0.299	0.579
	(0.044)	*(0.032)*	*(0.057)*	*(0.095)*		
Japan	-0.034	0.662	0.189		0.816	0.189
	(0.122)	*(0.112)*	*(0.096)*			
Netherlands	-0.016	0.196	0.144	0.062	0.247	0.206
	(0.038)	*(0.106)*	*(0.065)*	*(0.451)*		
New Zealand	0.127	0.145	0.387	0.411	0.718	0.798
	(0.084)	*(0.046)*	*(0.105)*	*(0.078)*		
Norway	-0.004	0.109	0.097	0.530	0.292	0.627
	(0.052)	*(0.084)*	*(0.038)*	*(0.323)*		
Spain	0.157	0.506	0.507		1.026	0.507
	(0.071)	*(0.070)*	*(0.112)*			
Sweden	0.107	0.203	0.143	0.009	0.239	0.152
	(0.042)	*(0.043)*	*(0.099)*	*(0.161)*		
Switzerland	0.018	0.152	0.221	0.362	0.365	0.583
	(0.070)	*(0.065)*	*(0.094)*	*(0.204)*		
UK	0.063	0.173	0.266	0.444	0.597	0.710
	(0.080)	*(0.053)*	*(0.060)*	*(0.093)*		
US	0.045	0.207	0.017	0.562	0.492	0.579
	(0.091)	*(0.056)*	*(0.054)*	*(0.131)*		

	IR	IT	NZ	SD
Devaluation dummies	13.764	52.661	25.500	56.077
	(9.221)	*(72.805)*	*(20.774)*	*(71.912)*

Notes: The table presents the estimated parameters of the model in equations 6.2 to 6.4. Figures in parenthesis are standard errors. UV_{BWi} is the estimated unconditional volatility for country i, under the base strategy, BW.

parameters for the pooled exchange rates would be likely to deliver meaningless estimates. Note that, conversely, almost all of the mean returns (μ_i in equation 6.2) are close to zero. These two broad patterns (substantial differences in the volatility processes and μ_i close to zero) are extensive to all the GARCH models estimated.[23]

Table 6.2 presents the estimates for the policy target parameters in equation 6.4, using exchange rate, interest rate and share price data, and both the *actual* and the *announced* monetary policy targets.[24] The base strategy set in the interest rate and the share price models was discretion, but for the exchange rate models BW was used instead. BW has much lower exchange rate volatility than the other strategies, and not using BW as the base could lead to negative parameters so large that they would imply negative estimated variance. The estimates in Table 6.2, and the tests in Table 6.3, show that there are significant differences across policy targets in the short term price volatility of the three financial assets, including, surprisingly, share prices. There are no important differences between the results obtained with the announced targets, and the ones from the models using the actual targets. Nevertheless, the models with actual targets tend to have likelihood ratio statistics of higher magnitudes, denoting more significant differences in volatility across strategies. This suggests that for the volatility of financial assets it is more important what central banks do, than what they say. As it was extensively documented before (e.g., in Chapter 5), it is unlikely that announcements alone affect significantly the behaviour of private agents, and thus, what should be relevant for the behaviour of financial variables is the actual strategy followed by central banks. For this reason, all the subsequent analysis will focus on the models with actual targets.

[23] The country-specific parameters are essential to produce precise estimates of the model, but in themselves are of minor importance to this study. For this reason, and to save space, for the other models, only the policy target parameters are presented. The estimates of the country-specific parameters are not reproduced here, but may be obtained from the author.

[24] The exchange rate had to be modelled as an ARCH(1) process, instead of GARCH(1,1), for the cases of Austria, Denmark, Japan, and Spain, and dummies accounting for specific point devaluations had to be used for Ireland, Italy, New Zealand, and Sweden. In the interest rate model a dummy had to be used for a specific event in Sweden. Finally, share prices were modelled as ARCH(1) for the cases of Denmark, the Netherlands, Spain, and the US.

Table 6.2 **GARCH models - estimates of monetary policy target parameters**

Model	*Exchange rates*		*Interest rates*		*Share prices*	
Target	*Announced*	*Actual*	*Announced*	*Actual*	*Announced*	*Actual*
Discretion	4.332	4.855				
	(0.783)	*(0.871)*				
Money	4.213	4.521	1.396	-0.434	-0.037	-0.143
	(0.727)	*(0.750)*	*(0.274)*	*(0.094)*	*(0.076)*	*(0.076)*
Inflation	4.711	3.284	-0.589	-0.638	-0.669	-0.634
	(0.990)	*(0.712)*	*(0.099)*	*(0.092)*	*(0.051)*	*(0.051)*
XT	0.720	0.418	2.014	1.316	-0.093	-0.019
	(0.277)	*(0.220)*	*(0.428)*	*(0.237)*	*(0.114)*	*(0.110)*
ERM	0.500	0.458	0.170	0.106	-0.269	-0.294
	(0.231)	*(0.227)*	*(0.145)*	*(0.109)*	*(0.081)*	*(0.078)*
Wide ERM	0.328	1.059	0.564	0.647	-0.598	-0.476
	(0.255)	*(0.465)*	*(0.215)*	*(0.125)*	*(0.065)*	*(0.085)*
Snake	1.792	1.505	12.337	10.460	-0.157	-0.027
	(0.468)	*(0.421)*	*(2.075)*	*(1.371)*	*(0.108)*	*(0.127)*
BW			24.740	2.142	0.047	0.051
			(4.446)	*(0.321)*	*(0.171)*	*(0.169)*

Notes: The table presents estimates for the policy target parameters of the model in equations 6.2 to 6.4. The models estimated also included a full set of country specific parameters, as in Table 6.1, but these are not presented here to save space. Full results may be obtained from the author. Figures in parenthesis are standard errors.

In the exchange rates model, all the coefficients are positive, denoting that the base strategy BW is the one with lower exchange rate volatility. As expected, volatility is lower under exchange rate targeting (ET) strategies. Since under these strategies the main goal of the central bank is to stabilise the exchange rate, any other result would only be possible if there were serious shortcomings in the capacity to implement monetary policy. However, there are also significant differences (at least at the 10% level) in exchange rate volatility among strategies inside the two main groups, ET and non-ET, as the results for joint tests 1 and 2 in Table 6.3 demonstrate. Apart from BW, the ET strategies with lowest volatility levels are unilateral exchange rate targets (XT), and the 'original' ERM (OR), both with volatility about 40% higher than BW, followed by the 'wide band' ERM (WR), and the European 'snake' (SK), which has volatility 180% higher than under BW. This ranking could be explained by the width of the fluctuation bands in each of the strategies: the wider the bands, the higher the exchange rate volatility.[25]

[25] XT includes a wide range of exchange rate targeting arrangements, with many different band widths. Nevertheless, the large majority of the arrangements had bands similar to the ones in OR (±2.25% for the core currencies), and much smaller than the ±15% of WR. The bands in SK were also narrow, but

The non-ET strategies are associated with exchange rate volatility more than 300% higher than under BW, with inflation targeting (IT) being associated with the lowest volatility in this group, followed by money targeting (MT) and discretion (with almost 500% more volatility than BW). This results seems to contradict the previous findings of Haldane and Salmon (1995), and to some extent Bryant, Hooper, and Mann (1993), but the rankings are not clear in their work (see Section 6.1), nor in Table 6.3: the null in test 1 (no difference among non-ET strategies) is only rejected at the 10% significance level.

Table 6.3 **GARCH models - hypothesis tests on policy targets**

	Exchange rates		*Interest rates*		*Share prices*	
	Announced	*Actual*	*Announced*	*Actual*	*Announced*	*Actual*
Tests on individual parameters: $\chi(1)$						
DS = 0	25.24	35.71				
MT = 0	104.28	121.80	39.95	6.08	0.07	0.61
IT = 0	16.22	21.01	4.55	10.60	21.55	22.91
XT = 0	0.41	4.67	29.52	55.20	0.05	0.05
OR = 0	3.80	4.21	0.01	0.41	2.12	2.15
WR = 0	0.98	0.01	1.30	8.38	11.76	7.63
SK = 0	9.24	7.60	105.42	135.56	1.41	0.01
BW = 0			347.45	178.02	0.29	0.24
Joint tests						
1. No difference among non-exchange rate targeting (ET) strategies						
$\chi(2)$	1.12	4.76	42.08	16.26	23.44	24.49
2. No difference among non-ET strategies and no difference among ERM and XT strategies						
$\chi(4)$	1.26	10.07	57.36	47.27	35.81	24.80
3. Significance of the model (all ϕ^m=0)						
$\chi(7)$	114.96	136.76	316.08	377.47	37.17	35.71

Notes: The table presents the likelihood ratio statistics for the restrictions described. The unrestricted regression corresponds to the models with all policy target variables, partially presented in Table 6.2. Full results for the restricted models may be obtained from the author. The critical values for the likelihood ratio statistics at the 5% (10%) level are 3.84 (2.71), 5.99 (4.61), 9.49 (7.78), and 14.07 (12.02), for 1, 2, 4 and 7 degrees of freedom, respectively. The title of each joint test describes the null hypothesis. Test 1 is performed by imposing the restriction *MT=IT=DS* in the exchange rate models, and the restriction *MT=IT=0* in the other models. Test 2 adds the restriction *XT=OR=WR* to the restrictions in test 1.

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the frequency of the realignments rendered the bands meaningless.

The main conclusion from the estimation of the interest rate model is that ET strategies have higher interest rate volatility than non-ET strategies. The coefficients for ET strategies are all positive, showing that these strategies have higher volatility than discretion (the base strategy), while IT and MT have lower volatility. These differences, which are significant in almost all the cases, suggest that there is a trade-off between exchange rate and interest rate volatility: if central banks want to stabilise the exchange rate, they have to accept less stable interest rates. This would support the Mills and Wood (1993) argument that central bank intervention can not eliminate volatility, only shift it from one market to the other.

However, it seems that there is no trade-off inside the two main groups of strategies. Among the ET strategies, OR has both low exchange rate and low interest rate volatility. This might be explained by the fact that in countries committed to the ERM discipline, monetary policy is constrained by the behaviour of the Bundesbank, one of the most notorious interest rate smoothers.[26] A similar result is found for the non-ET strategies, which have the same ranking for exchange rate and interest rate volatility. Again, this is likely to be caused by different patterns of interest rate smoothing.[27] The policy lag (the period between the use of the instrument and its effect on the target) is shorter under MT than under IT. This implies that in the event of a shock, the adjustment needs to be more rapid and vigorous under MT, because IT allows for gradual adjustments, and thus interest rate smoothing. The higher volatility under discretion is probably associated with the increased uncertainty caused by the lack of a clear medium-term reference for monetary policy, such as that provided by the adoption of a policy target.

The results for share prices also reveal surprisingly significant differences among policy targets. However, the differences do not seem to be associated with the exchange rate regime, as it was the case in the previous models: tests 1 and 2 have high likelihood ratio statistics relatively to test 3, suggesting that the differences inside the main groups (ET

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[26] Goodhart (1996) provides evidence on the interest rate smoothing behaviour of some central banks, including the Bundesbank.

[27] With free capital movements, stable interest rates should be associated with stable exchange rates, as explained in Section 6.1. This is also consistent with the results in Chapter 2, Section 2.3, where it was shown that news about interest rates have a substantial impact on exchange rate volatility.

and non-ET) are more important than the differences between the groups. The strategies with higher volatility are BW and discretion, and the ones with (significantly) lower volatility are IT and WR. The low volatility for IT and WR could be a sign that stock markets tend to be less volatile when monetary policy is clearly aimed at price stability.[28]

6.4.2 Financial crises

Table 6.4 presents the financial crises identified using the procedure described in subsection 6.3.3, in the foreign exchange markets, money markets and stock exchanges. In the foreign exchange market a total of 97 crises were identified, with Germany and the Netherlands being the countries with fewest crises (only one in each, both in 1973 in the early stages of the generalised floating) and New Zealand and the US the countries with most crises (9 and 11, respectively, all of them occurring before the end of 1985). In the money market, the total number of crises identified was 86, ranging from 1 in New Zealand and Norway (both in the 1990's) to 8 in the UK (all in the 1970's). Finally, 55 crises in the stock markets were identified, ranging from 0 in Sweden to 12 in Austria.[29] Sixteen out of these 55 crises correspond to the crash of October 1987 (the procedure used identified a crisis in this period in every country in the sample except for Sweden and Italy). Since this crash is unlikely to be associated with the policy strategy in use in each of the central banks in the sample,[30] the analysis was conducted both including and excluding the October 1987 observations.

[28] Price stability is the overriding objective of monetary policy in Germany, the anchor country in the ERM, and was one of the criteria to participate in the European Monetary Union. For these reasons, price stability may be seen as the main policy objective under the WR strategy, especially because the exchange rate does not seem to impose a major constraint, given the wide bands of the arrangement.

[29] The number of crises identified in the Austrian stock market is abnormally large (the second country with most crisis in the stock market is Ireland, with 5). It is unlikely that this result arises from some data deficiency, since these crises are identified both by the monthly and the daily data, which are from different sources. I am not aware of any reason that justifies this result. Since this is a relatively large proportion of the total number of crisis identified, the logit model was also estimated without these observations (see Table 6.7).

[30] In almost every country in the sample, the October 1987 crisis represented the repercussion on the domestic market of the international crash. If this crash is associated with monetary policy, it should be, one might assume, only with the US policy, where the crash appears to have originated, and not with other countries' policies.

Table 6.4 **Crises in financial markets**

Country	Foreign exchange market #	Foreign exchange market Dates	Money market #	Money market Dates	Stock market #	Stock market Dates
Austria	4	73:07, 73:12, 78:11, 88:09	7	73:10, 78:05, 80:04, 90:01, 92:04, 93:08, 94:04	12	85:02, 85:08, 85:11, 86:04, 87:02, 87:07, 87:10, 89:10, 90:01, 90:08, 91:01, 91:08
Australia	7	72:12, 73:09, 74:09, 76:11, 83:03, 85:02, 93:12	2	82:12, 83:12	2	73:09, 87:10
Belgium	4	74:02, 81:12, 82:02, 83:03	5	79:02, 81:03, 81:08, 81:10, 83:03	4	73:12, 81:06, 81:12, 87:10
Canada	2	76:11, 86:02	6	79:10, 80:02, 80:04, 80:12, 92:09, 92:11	3	80:03, 82:11, 87:10
Denmark	3	72:09, 79:11, 93:08	7	75:08, 86:12, 87:09, 89:10, 92:11, 93:02, 93:08	3	74:11, 80:07, 87:10
France	7	72:08, 76:03, 78:03, 81:08, 81:10, 82:06, 83:03	6	79:01, 81:06, 82:03, 82:06, 82:10, 83:03	2	75:01, 87:10
Germany	1	73:06	6	73:03, 80:12, 81:02, 81:09, 86:12, 90:12	4	80:02, 87:10, 89:10, 91:08
Ireland	7	72:07, 73:07, 76:03, 76:09, 83:03, 86:08, 93:02	5	86:02, 86:07, 92:09, 92:11, 93:01	5	73:12, 74:10, 75:01, 87:10, 89:10
Italy	8	73:01, 73:06, 74:01, 74:10, 76:01, 85:07, 92:09, 95:03	4	72:12, 76:03, 80:07, 81:06	2	77:06, 81:07
Japan	3	73:02, 74:01, 80:05	4	78:08, 78:11, 80:06, 95:09	4	87:10, 90:04, 90:10, 92:08
Netherl.	1	73:10	5	72:03, 72:05, 72:10, 76:08, 78:09	1	87:10
NZ	9	73:02, 73:05, 73:09, 74:09, 75:08, 79:06, 83:03, 84:07, 85:12	1	93:01	1	87:11
Norway	5	72:06, 78:02, 82:08, 86:05, 92:11	1	95:12	3	87:10, 89:10, 90:12
Spain	8	72:01, 73:08, 74:02, 76:02, 77:07, 82:12, 92:09, 93:05	5	92:09, 92:12, 93:05, 93:07, 93:11	2	80:04, 87:10
Sweden	8	73:12, 74:04, 75:07, 77:04, 77:08, 81:09, 82:10, 92:11	5	73:07, 74:01, 90:02, 91:12, 92:09	0	
Switzer.	4	73:02, 74:02, 78:01, 78:10	3	78:10, 79:06, 81:06	3	87:10, 89:10, 91:08
UK	5	72:07, 73:07, 76:03, 76:10, 92:09	8	73:04, 73:08, 74:02, 76:03, 76:06, 77:02, 77:08, 78:04	2	75:01, 87:10
US	11	72:06, 73:02, 73:07, 73:11, 74:01, 78:01, 78:11, 80:05, 82:06, 85:03, 85:09	6	73:07, 79:10, 80:02, 80:04, 85:12, 86:12	2	73:07, 87:10
Total	97		86		55	

The logit models explaining the likelihood of crises as a function of the policy target adopted by the central bank when the crisis was declared (equation 6.7) were estimated using, alternatively, the actual and the announced targets, and in both cases 'discretion' was set as the base strategy.[31] Table 6.5 presents the estimates of the logit parameters, while Table 6.6 provides some statistical analysis of the results. As in the previous subsection, the significance levels tend to be higher for the model with actual policy targets, and thus the discussion will focus on these models.

Table 6.5 **Policy targets and financial crises - estimates of logit models**

Model	*Exchange rates*		*Interest rates*		*Share prices*	
Target	*Announced*	*Actual*	*Announced*	*Actual*	*Announced*	*Actual*
γ	-2.951	-2.527	-3.534	-2.848	-3.580	-3.514
	-10.77	*-12.64*	*-9.85*	*-12.38*	*-10.59*	*-12.00*
β (MT)	-0.199	-0.578	0.712	-0.039	0.184	-0.094
	-0.55	*-1.67*	*1.73*	*-0.11*	*0.43*	*-0.20*
β (IT)	-1.730	-2.483	-0.031	-1.051		-1.497
	-1.66	*-2.43*	*-0.04*	*-1.68*		*-1.43*
β (XT)	0.497	-0.189	0.211	-0.275	0.886	0.755
	1.44	*-0.66*	*0.45*	*-0.81*	*2.16*	*2.10*
β (OR)	-0.093	-0.820	0.940	-0.019	-0.014	-0.129
	-0.25	*-2.31*	*2.28*	*-0.06*	*-0.03*	*-0.29*
β (WR)		-1.323				
		-1.28				
β (SK)	0.577	0.046	0.848	0.148	-0.661	-0.621
	1.42	*0.12*	*1.71*	*0.34*	*-0.84*	*-0.81*
β (BW)	1.566	1.141	0.356	-0.330		
	3.50	*2.81*	*0.44*	*-0.44*		

Notes: The table presents the estimates of the parameters in the logit model given by equation 6.7, using 'discretion' as the base strategy. The dependent variable is a dummy variable taking the value 1 if a crisis in the financial market (named in the heading of the column) of country i=1 to 18 occurred in quarter t=1972:1 to 1996:4. The explanatory variables are alternatively, the announced or the actual policy targets. Values in italics are t-statistics; at the 5% (10%) level, the critical value for the t-statistics is 1.96 (1.67). Since the estimation procedure does not converge when the dependent variable always takes the value 0 when one of the explanatory variables takes the value 1, some models had to be estimated without the observations corresponding to the targets that fulfilled this condition.

The model for the foreign exchange market is highly significant, showing that there are significant differences in the probability of an exchange rate crisis associated with different policy targets. These differences are not just a consequence of differences between the two main groups of strategies, ET and non-ET, as may be inferred from the rejection

[31] I.e., $l(\gamma)$ is the estimated probability that a crisis will occur under discretion, while $l(\gamma+\beta_m)$ ($m\neq$ discretion) is the estimated probability that a crisis will occur when the central bank is using target m.

of the null hypotheses in the joint tests 1 and 2, and from the rejection of some of the tests of equality of coefficients, in Table 6.6. Exchange rate crises are least likely to of the null hypotheses in the joint tests 1 and 2, and from the rejection of some of the

Table 6.6 **Statistical inference from logit models of targets and crises**

	Exchange rates		*Interest rates*		*Share prices*	
	Announced	*Actual*	*Announced*	*Actual*	*Announced*	*Actual*
Predicted probabilities						
Discretion	0.050	0.074	0.028	0.055	0.027	0.029
	(0.004)	*(0.003)*	*(0.004)*	*(0.003)*	*(0.003)*	*(0.002)*
Money	0.041	0.043	0.056	0.053	0.032	0.026
	(0.009)	*(0.012)*	*(0.011)*	*(0.013)*	*(0.008)*	*(0.009)*
Inflation	0.009	0.007	0.028	0.020	0	0.007
	(0.009)	*(0.007)*	*(0.016)*	*(0.011)*		*(0.007)*
XT	0.079	0.062	0.035	0.042	0.063	0.060
	(0.015)	*(0.012)*	*(0.010)*	*(0.010)*	*(0.014)*	*(0.012)*
ERM	0.045	0.034	0.070	0.054	0.027	0.026
	(0.011)	*(0.010)*	*(0.013)*	*(0.012)*	*(0.008)*	*(0.008)*
Wide ERM	0	0.021	0	0	0	0
		(0.021)				
Snake	0.085	0.071	0.064	0.063	0.014	0.016
	(0.024)	*(0.023)*	*(0.021)*	*(0.022)*	*(0.010)*	*(0.011)*
BW	0.200	0.200	0.040	0.040	0	0
	(0.057)	*(0.057)*	*(0.028)*	*(0.028)*		
Joint tests						
1. No difference among non-exchange rate targeting (ET) strategies						
$\chi(2)$	2.8	7.9	3.9	2.9		2.1
2. No difference among non-ET strategies and no difference among ERM and XT strategies						
$\chi(.)$	$\chi(3) = 6.1$	$\chi(4) = 11.8$	$\chi(3) = 7.8$	$\chi(3) = 3.4$	$\chi(2) = 5.4$	$\chi(3) = 7.0$
3. Significance of the model (all $\beta(m)=0$)						
$\chi(.)$	$\chi(6) = 27.1$	$\chi(7) = 32.2$	$\chi(6) = 10.0$	$\chi(6) = 5.0$	$\chi(4) = 10.0$	$\chi(5) = 14.8$
Tests of equality of coefficients (rejections of the null)						
5%	MB,IB,BX BO,BS,MX MS,IX,IS	MB,IB,BX BO,BW,BS IX,IS	XO		MX,XS,XO	MX,IX, XO
10%	XO,OS	MI,XO,OS		IS		XS

Notes: the results in this table are based on the estimated logit models presented in Table 6.5. 'Predicted probabilities' are given by $l(\gamma)$ for 'discretion', and $l(\gamma+\beta(m))$ for the other targets, where $l(.)$ is the logistic distribution. Figures in parenthesis are standard errors for the predicted probabilities. At the 5% (10%) level, the critical value for the χ^2 statistics are 5.99 (4.61), 7.82 (6.25), 9.49 (7.78), 11.07 (9.24), 12.59 (10.64) and 14.07 (12.02), for 2 to 7 degrees of freedom, respectively. The lines for the 'test of equality of coefficients' present target pairs (identified by the first letter of each target) for which the null of the two coefficients being equal was rejected at the significance level displayed in the first column. The title of each joint test describes the null hypothesis. Test 1 is performed by imposing the restriction $\beta(MT)=\beta(IT)=0$. Test 2 adds to the restriction in test 1, the restriction $\beta(XF)=\beta(EF)=\beta(WF)$.

tests of equality of coefficients, in Table 6.6. Exchange rate crises are least likely to occur under IT, followed by WR, OR, MT, XT, DS, SK and BW. The higher likelihood of crisis under BW (the Smithsonian agreement) was expected, since the data period for this strategy corresponds to the collapse of the Bretton-Woods regime, when crises in the foreign exchange markets were frequent.

Perhaps more interesting is the significantly lower likelihood of a crisis under IT. With a credible inflation target there is less uncertainty on the future direction of monetary policy, and thus less uncertainty regarding exchange rates, reducing the potential for exchange rate crises. Another interesting result is that, contrary to what happened with short term volatility, there is no clear ranking between ET and non-ET strategies. The former tend to have higher likelihood of crises, consistent with the common view that they are more prone to speculative attacks, but, for instance, the ERM strategies have lower volatility than MT or discretion. It would seem that the strong discipline of a multilateral arrangement could be a better deterrent to speculation than the (soft) domestic constraint of a money target.

The likelihood of a crisis occurring in the money markets or in the stock exchanges does not seem to be related to the policy target. None of the logit models estimated using the data for interest rate crisis are significant. The stock market models seem to be significant, but this is just a consequence of the large number of stock market crises in Austria, that causes XT to have a significantly higher likelihood of crisis. If one excludes the Austrian observations, and accounts for the effect of the October 1987 crash, the significance of all the target variables disappears, either individually or jointly, as may be seen in Table 6.7.

Table 6.7 **Stock exchange crises, excluding October 1987 and Austria**

Logit model			*Predicted probabilities*		
Parameter	*Announced*	*Actual*	*Target*	*Announced*	*Actual*
γ	-4.080	-3.743	Discretion	0.016	0.023
	-9.02	*-10.86*		*(0.003)*	*(0.003)*
β (MT)	0.404	-0.268	Money	0.025	0.018
	0.75	*-0.49*		*(0.007)*	*(0.007)*
β (IT)		-1.268	Inflation		0.007
		-1.19			*(0.007)*
β (XT)	0.346	0.034	XR	0.023	0.024
	0.55	*0.07*		*(0.010)*	*(0.009)*
β (OR)	-0.228	-0.692	ERM	0.013	0.012
	-0.37	*-1.18*		*(0.006)*	*(0.006)*
β (SK)	-0.161	-0.392	Snake	0.014	0.016
	-0.19	*-0.49*		*(0.010)*	*(0.011)*
β (D87)	6.066	6.081	Oct. 87	0.879	0.912
	7.63	*7.61*		*(0.089)*	*(0.068)*

Hypothesis tests

1. No difference among non-ET strategies			*2. (1) and no difference among XT and ERM*		
$\chi(2)$		1.5	$\chi(.)$	$\chi(2) = 1.4$	$\chi(3) = 3.0$
3. Significance of the model			*4. Significance of target variables (exc.D87)*		
	$\chi(5)$=101.9	$\chi(6)$=105.7	all $\beta(m)$=0	$\chi(4) = 2.0$	$\chi(5) = 3.1$

5. Tests of equality of coefficients (exc. D87) : no rejections of null

Notes: See Tables 6.5 and 6.6. D87 is a dummy variable taking the value 1 in 1987:4.

6.5 Conclusions

This chapter examined the differences in instability in the foreign exchange, money, and stock markets, associated with the use of alternative monetary policy targets, based on data from a panel of 18 OECD countries, for the period 1972-1996. The investigation was centered on the analysis of short-term volatility of financial asset prices, and on the study of the likelihood of financial crises under different policy targets.

The main conclusion to be drawn is that the choice of monetary policy strategy will significantly affect stability in financial markets. Both short term price volatility of financial assets, and the likelihood of crises in foreign exchange markets, differ significantly when central banks are using alternative policy targets. The evidence provided in this chapter suggests that there is a trade-off between stabilising interest rates or stabilising exchange rates: central banks that have chosen to target exchange rates faced higher interest rate volatility.

Some strategies appear to be unambiguously preferable from the financial stability perspective. Among the exchange rate targeting strategies, the strict discipline of a multilateral arrangement, with narrow fluctuation bands such as the original ERM, seems to be associated with lower interest and exchange rate volatility. On the other side, inflation targeting seems to be the floating exchange rate strategy that delivers lowest volatility in financial markets. Since the use of inflation targets also reduces the likelihood of crises in the foreign exchange market (relative to *any* other strategy), the evidence in this chapter suggests that a central bank concerned with financial stability should adopt this strategy.

Financial stability ranks high on the list of concerns of the typical central bank, but it is seldom on top of that list. It is more likely that the monetary policy strategy will be chosen according to its effect on inflation (and employment) than on financial stability. Nevertheless, existing research on this area suggests that no strategy clearly outperforms the others. If the effects of different strategies on macroeconomic variables do not differ significantly, the choice should be made on the basis of their impact on financial stability. The evidence provided in this chapter could provide pertinent guidelines for those situations.

Appendix 6.A: Monetary Policy Targets in Selected OECD Countries

This appendix lists the monetary policy targets used by the central banks in this sample of OECD countries, during the period 1972-96. Additionally, it also includes information regarding the existence of exchange controls. Unmarked text describes the official target announced by the central bank. Text in square brackets refers to the actual (unofficial) target, as described in the sources consulted. Each policy strategy period starts in the beginning of the 'start date' (i.e., if the start date is '1985' the period is assumed to start on 1/1/85), and ends immediately before the beginning of the 'start date' of the following period. In each period, the policy target is classified with a 2 letter code. The first letter refers to the officially announced target, and the second letter to the actual (unofficial) target. The letter code is as follows:

b - multilateral exchange rate target, 'Smithsonian' agreement;
d - discretionary policy, with no explicit policy target;
o - multilateral exchange rate target, original ERM (before August 1993);
i - inflation target;
m - monetary target;
s - multilateral exchange rate target, European 'snake';
w - multilateral exchange rate target, 'wide' ERM (after August 1993);
x - unilateral exchange rate target.

Start date	*Code*	*Comments*
AUSTRALIA		
1971, Dec 18	xx	USD peg; par value changed 23/12/72, 12/2/73, 9/9/73; exchange controls for capital account transactions;
1974, Sep 25	xx	effective XR peg; constant trade-weighted exchange rate index;
1976, Nov 29	md	fixed XR target abandoned for managed floating; M targets (or 'conditional projections') adopted [but these were never elevated to the centre piece of monetary policy];
1983, Dec 12	md	managed floating ends; exchange controls end;
1986	dd	M targets abandoned; no intermediate targets adopted (discretion);
1993	ii	IT adopted.

AUSTRIA

1971, Aug 15	xx	USD peg abandoned; CB pledged to 'maintain XR stability against main European currencies, especially of the large industrialised neighbours' [implicit DEM peg]; exchange controls for current and capital account transactions;
1973, Jul 1	xx	exchange controls for current account transactions end;
1981	xx	[implicit DEM peg becomes more restrictive, with smaller XR fluctuations allowed]
1991, Nov 4	xx	exchange controls end;
1995, Jan 9	wo	ERM membership.

BELGIUM

1971, Dec 18	bb	Smithsonian agreement; narrower margins of fluctuation (1%) with Dutch guilder; 'official' market only for current account transactions; no exchange controls in the 'free' market;
1972, Apr 24	ss	Snake participation;
1979, Mar 13	oo	ERM membership;
1990, Jun 1	oo	[implicit DEM peg];
1993, Aug 2	wo	ERM margins widened to 15% [but implicit DEM peg maintained].

CANADA

1970, May 31	dx	floating XR [but the authorities main concern was XR stability]; no exchange controls;
1975, Nov 6	mm	M targets announced;
1978, 4th qrt	mx	[worries about monetarism; M targets continue to be announced, but XR stabilisation becomes the main concern; implicit effective XR peg];
1982, Nov	dx	M targets formally abandoned; no intermediate target adopted;
1984, 2nd qrt	dd	[implicit effective XR peg abandoned];
1988, Jan	di	price stability becomes primary objective;
1991, Feb 26	ii	IT adopted.

DENMARK

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1972, May 1	ss	Snake participation;
1972, Jun 23	bb	Snake participation abandoned;
1972, Oct 10	ss	Snake participation rejoined;
1979, Mar 13	oo	ERM membership;
1988, Oct 1	oo	exchange controls end;
1993, Aug 2	ww	ERM margins widened to 15%.

FRANCE

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1972, May 1	sd	Snake participation [but policy was discretionary, geared towards domestic objectives, with equilibrium assured by XR adjustments];
1974, Jan 19	dd	Snake participation abandoned;
1975, Jul 10	sd	Snake participation rejoined [but policy remained discretionary];
1976, Mar 15	mm	Snake participation abandoned; M2 target announced;
1979, Mar 13	od	ERM membership [M2 targets retained, but these were frequently missed; policy was discretionary, with XR stability defended through capital controls and frequent parity adjustments];
1984, 4th qtr	oo	[XR stability becomes primary concern; program of gradual financial deregulation and liberalisation of exchange controls];
1990, Jan 1	oo	exchange controls end;
1993, Aug 2	ww	ERM margins widened to 15%.

GERMANY

1971, Dec 18	bb	Smithsonian agreement; no exchange controls;
1973, Mar 19	dm	USD peg abandoned; Snake participation [but participation in European XR agreements was never a binding constraint for German monetary policy]; [M targeting attempted, but not announced];
1974, Dec	mm	M target announced.

IRELAND

1971, Dec 18	xx	1:1 parity with GBP; exchange controls for capital account transactions;
1978, Dec 18	dx	GBP parity formally abandoned [but maintained in practice];
1979, Mar 13	oo	ERM membership;
1992, Dec 31	oo	exchange controls end;
1993, Aug 2	wo	ERM margins widened to 15% [but policy is still aimed at maintaining the DEM peg].

ITALY

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1972, May 1	sd	Snake participation [but interest rate policy was not consistent with XR commitments; instead the CB resorted to capital controls and a 2-tier XR system];
1973, Feb 12	dd	Snake participation abandoned;
1974, Mar 22	md	exchange controls for current account transactions introduced; Total Domestic Credit expansion adopted as intermediate target [under pressure from the IMF; in practice, targets were not observed];
1979, Mar 13	od	ERM membership [but interest rate policy was still inconsistent with XR commitments; it is arguable whether ERM membership was a serious constraint on policy];
1982, Feb 1	od	exchange controls for current account transactions end;
1984	om	M2 target adopted [but TDC target not abandoned; conflict with XR target settled with the imposition of capital controls];
1987	oo	[policy aimed first and foremost at maintaining XR stability; M2 targets not abandoned, but were not pursued rigidly];
1990, May 14	oo	exchange controls end;
1992, Sep 17	mw	ERM participation suspended; M2 becomes intermediate target [but XR is also monitored closely];
1996, Nov 24	ww	ERM participation resumed.

JAPAN

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1973, Feb 12	dd	USD peg abandoned [no explicit policy target adopted];
1975, Jul	dm	[M2 used as intermediate target, but not announced];
1978, Jul	mm	M2 'forecasts' announced [these were not 'targets', but represented the movements in M2 the CB was willing to accept];
1980, Dec	mm	exchange controls end;
1990	dx	[CB allowed for increased variability of M growth]; no intermediate targets; CB pays attention to international financial conditions and the maintenance of an adequate XR.

NETHERLANDS

1971, Dec 18	bb	Smithsonian agreement; narrower margins of fluctuation (1%) with Belgium franc; exchange controls for capital account transactions;
1972, Apr 24	ss	Snake participation;
1977, Sep 1	ss	exchange controls end;

1979, Mar 13	oo	ERM membership;
1984	oo	[unpublished DEM target of 1.12/1.13 NLG/DEM];
1993, Aug 2	oo	ERM margins widened to 15%, but not for the NLG/DEM [unpublished DEM target is not affected].

NEW ZEALAND

1971, Dec 18	bb	Smithsonian agreement; exchange controls for current and capital account transactions;
1973, Jul 9	xx	effective XR fixed peg adopted; exchange controls for current account transactions end;
1979, Jun	xx	effective XR crawling peg adopted;
1982, Jun 22	xx	effective XR fixed peg adopted;
1984, Nov 21	xx	exchange controls end;
1985, Mar 4	dd	effective XR peg abandoned [no explicit target adopted; checklist approach in conducting monetary policy];
1988, Jun 1	di	price stability becomes primary objective;
1990, Feb 1	ii	IT adopted.

NORWAY

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1972, May 23	ss	Snake participation;
1978, Dec 12	xx	end of Snake participation; effective XR peg adopted;
1990, Oct 19	xo	ECU peg, with fluctuation bands of ±2.25%;
1992, Dec 10	dx	ECU peg abandoned; policy aimed at a broadly stable XR;
1994, Jan 14	dx	exchange controls end.

SPAIN

1971, Dec 18	bb	Smithsonian agreement; exchange controls for current and capital account transactions;
1974, Jan 22	dm	USD peg abandoned; [explicit use of M3 intermediate target, but targets are not made public];
1977, May 2	mm	exchange controls for current account transactions end; M3 targets announced;
1984	mx	change to liquid assets targeting [importance of M targets gradually downgraded; concern for XR gradually increasing; initially concern was for effective XR (1984-85), then for index of EEC countries' XR (1986-87), finally for DEM/ESP (1988-89)];
1989, Jun 19	oo	ERM membership, with fluctuation margins of ±6% [liquid assets targets were not abandoned, but XR target took precedence];
1992, Jul 1	oo	exchange controls end;
1993, Aug 2	ww	ERM margins widened to 15%;
1995, Jan 1	ii	IT adopted.

SWEDEN

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1973, Mar 19	ss	Snake participation;
1977, Aug 29	xx	Snake participation abandoned; effective XR peg adopted;
1991, May 17	xo	ECU peg adopted, with fluctuation margins of ±1.5%;
1992, Nov 19	dd	ECU peg abandoned; no target adopted;
1993, Jan 15	ii	exchange controls end (Jan 1); IT adopted.

SWITZERLAND

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1973, Jan 23	dd	USD peg abandoned;
1975	mm	M1 target adopted [but the XR is an important concern, and in periods of large pressures in forex markets, the XR goal may take precedence over the M target];
1978, Oct 1	xx	DEM target announced, M1 target suspended;
1979, Jun 25	xx	[return to M targeting, but not announced; XR concerns still dominate policy];
1980	mx	return to announced M targets, but target changed to M0 [XR concerns still dominate policy];
1982, Jan 3	mm	[return to domestic concerns; importance of XR downgraded];
1986, Oct 1	mm	exchange controls end;
1988, Jan 6	md	definition of M0 changed [M target followed less rigidly];
1991	di	M0 target for 1991 not announced; CB emphasises the XR oriented nature of policy, but refrained from defining targets; policy set to be consistent with 1% inflation rate [implicit IT].

UNITED KINGDOM

1971, Dec 18	bb	Smithsonian agreement; exchange controls for capital account transactions;
1972, Jun 23	dd	USD peg abandoned [discretionary policy]; [Snake participation from 1/5/72 to 23/6/72];
1973, 4th qtr	dm	[informal M3 target adopted];
1976, July	md	M target announced [under IMF pressure; targets were not taken as a serious constraint on policy, and were consistently overshot];
1979, June 12	mm	[new government more committed to £M3 targets];
1979, Oct	mm	exchange controls end;
1982, Mar	md	£M3 target de-emphasised; targets for M1 and PSL2 also adopted [discretionary policy in practice];
1985	dd	£M3 target suspended;
1987, Mar	dx	[unpublished DEM target adopted];
1988, Mar	dd	[unpublished DEM target abandoned];
1990, Oct 8	oo	ERM membership, with fluctuation margins of ±6%;
1992, Sep 17	ii	ERM membership abandoned; IT adopted (Oct 8).

UNITED STATES

1971, Dec 18	bb	Smithsonian agreement; no exchange controls; [discretionary policy oriented to domestic conditions, based on Fed Funds rate targeting; weekly money targets were more 'forecasts' than 'targets' (desired)];
1973, Feb 12	dd	major currencies abandon peg to USD; [M targets become real objectives, instead of mere forecasts];
1975, April	md	M1 target announced [targets were quarterly revised and frequently overshot; policy still based on Fed Funds rate targeting];
1979, Oct 6	mm	non borrowed reserves targeting announced; [greater weight on M targets];
1982, Oct	md	borrowed reserves targeting [M targets de-emphasised];
1986	dd	[abandon of M targets; concern for financial asset prices].

Sources: General: IMF *Annual Report on Exchange Arrangements and Exchange Restrictions*, OECD *Economic Surveys*, Bernanke and Mishkin (1992), Goodhart and Viñals (1994); Australia: Stevens and Debelle (1995); Canada: Freedman (1995a), Howitt (1993); France: Mélitz (1993); Germany: Bernanke and Mihov (1997), Clarida and Gertler (1996), Kloten (1992), Neumann and von Hagen (1993), von Hagen (1995); Italy: Spinelli and Tirelli (1993), Visco (1995); Japan: Ichimura (1993), Tamura (1992); New Zealand: Fischer (1995); Spain: Ayuso and Escrivá (1997); Sweden: Svensson (1995); Switzerland: Wasserfallen and Kursteiner (1994); UK: Artis and Lewis (1991), Bowen (1995b), Goodhart (1992a), Minford (1993); US: Mayer (1992), Meulendyke (1990).

Appendix 6.B: Financial Asset Prices Data

MONTHLY DATA

EFFECTIVE EXCHANGE RATE:
Source: International Financial Statistics, Nominal Effective Exchange Rate Index NADJ (line NEUF).
Sample: 1972:1/1996:12, except: Australia (1979:1/1996:12); New Zealand (1979:1/1996:12).

MONEY MARKET INTEREST RATE:
Source: International Financial Statistics, Money Market Call Rate (line 60B), except: Canada (IFS, Treasury Bill rate, line 60C); Ireland (OECD, Interest Rate on Call Money, end period); New Zealand (OECD, 90 Day Bank Bill Rate); Spain (OECD, Interest Rate on Call Money, end period); Switzerland (Datastream, Interest Rate on 3 Month Swiss Franc Deposits in London, end period); UK (OECD, Overnight Interbank Min).
Sample: 1972:1/1996:12, except: Spain (73:6/96:12); New Zealand (73:12/96:12).

SHARE PRICES:
Source: International Financial Statistics, Share Prices (line 62), except: Denmark (IFS, Share Prices: Industrial, line 62A); Germany (OECD, Share Price Index, CDAX, monthly average).
Sample: 1972:1/1996:12, except: Australia (1979:1/1996:12); New Zealand (1979:1/1996:12).

DAILY DATA

EFFECTIVE EXCHANGE RATE:
Source: Bank of England's trade weighted currency movement indices, rebased at 1990=100.
Sample: 1975:1:1/1996:12:31.

Identification of exchange rate crisis during the 1972-74 period was based on USD exchange rates:[32]
Source: WM/Reuters closing spot rates.
Sample: 1972:1:1/1974:12:31.

MONEY MARKET INTEREST RATE:
Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Switzerland, UK, US: eurocurrency interest rates, London, 2 days notice; Sample: 1975:1:1/1996:12:31, except: Belgium (78:6:1/96:12:31); Denmark (85:6:1/96:12:31); Italy (78:6:1/96:12:31); Japan (77:6:1/96:12:31).
Austria: 1 month VIBOR, middle rate (72:3:15/88:12:31); Overnight VIBOR, offered rate (89:1:1/96:31:12).
Australia: 3 month treasury bill, middle rate (80:12:31/96:12:31).
Ireland: Eire money overnight, middle rate (84:1:20/96:12:31).
New Zealand: 1 month interbank, middle rate (86:4:1/96:12:31).
Norway: deposit middle rate (93:5:4/96:12:31).
Spain: interbank weighted average overnight, middle rate (88:9:1/96:12:31).
Sweden: 270 day treasury bill, middle rate (89:4:25/96:12:31).

SHARE PRICES:
Source: Datastream Global Indices - stock prices - national.
Sample: 1973:1:1/1996:12:31, except: New Zealand (1988:1:1/1996:12:31); Norway (1980:1:1/1996:12:31); Spain (1987:3:1/1996:12:31); Sweden (1982:1:1/1996:12:31).

[32] The decision on whether to assign an identified crisis to the domestic currency or the USD was based on the following criteria: if a crisis was identified simultaneously in more than 5 countries, this was assumed to be an USD crisis; if the number of countries involved was 5 or less, this was assumed to be a crisis of the domestic currencies involved.

Chapter 7

Conclusions

and Suggestions for Further Work

There is no well established explanation of what determines exchange rate movements, even though a large body of literature in applied economics has been dedicated to this theme. One of the most productive lines of research in this field has been concentrated on the relationship between exchange rates and monetary policy. The collection of studies contained in the previous chapters contributes to this area by providing a number of examinations of the effects of monetary policy on the behaviour of exchange rates. The main topics covered are the effect of monetary policy and other macroeconomic announcements on exchange rates, the objectives of monetary policy, and the use of targets in its implementation. In this concluding chapter the results of the preceding studies are summarised and directions for further work are indicated.

The main implication of the evidence provided in the previous chapters is that monetary policy is an important determinant of exchange rate behaviour. It was shown that, directly and indirectly, the actions of central banks significantly affect the mean, as well as the variance, of nominal exchange rates: 'news' about key interest rates have a strong impact on the level and volatility of exchange rates; the reaction of exchange rates to macroeconomic news is a function of the anticipated policy reaction by the monetary authorities; and the choice of monetary policy target affects the volatility of the exchange rate, and the likelihood of crises in the foreign exchange market. Thus, monetary policy may be an important source of risk to world investors, and central banks should be concerned with minimising this risk when designing the policy strategy. In many instances throughout this thesis, it was shown that central banks can alter the effect of their policy decisions on exchange rates by the appropriate choice of some features of their strategy.

Furthermore, the link between monetary policy and exchange rates is two way. Monetary policy is a determinant of exchange rates, but is also constrained by exchange rate concerns. For instance, the nominal exchange rate regime is one of the most important elements of the monetary policy strategy, but many times this choice is imposed on the central bank, and on these cases it is usually dictated by concerns other than the efficiency of monetary policy. Some central banks have been forced to give foreign exchange guarantees, or to maintain unrealistic exchange rates to protect special economic interests, which hampered their ability to conduct monetary policy.

The recent availability of good databases of high frequency exchange rates induced a large number of empirical studies that explored the properties of these data. Chapters 2 and 3 belong to this strand of literature. Using a three year span of DEM/USD exchange rate quotes sampled at a five minute frequency, they investigate the impact on exchange rates of monetary policy signals and macroeconomic announcements. The first of these exercises is described in Chapter 2, which analyses monetary policy signals from the German Bundesbank and the US Federal Reserve. Results indicate that 'news' about monetary policy have a strong impact on exchange rates: large and significant changes in the exchange rate level and increases in its volatility were found to be associated with some specific information releases regarding German and US monetary policy. Chapter 3 examined announcements of German and US macroeconomic data, and found that macroeconomic 'news' have a strong and quick impact, with the exchange rate reflecting the anticipated policy reaction by the monetary authorities to the piece of news just released.

Monetary policy signals and macroeconomic news from Germany and the US were all found to have a significant impact on exchange rates, but the nature of these effects differed substantially. First, news from Germany tended to have a smaller impact than news from the US: the estimated exchange rate change caused by German 'news' was, on average, half of that for the US. Second, the effect of news varies across time: the same piece of news might have a different impact on the exchange rate at different moments in time, in some cases even implying opposite reactions. Third, the exchange rate reaction differs according to how the information reaches the market: exchange rates adjust faster when the news are released through scheduled announcements, or when policy signals are revealed through official statements (instead of open-market operations). Finally, the impact of macroeconomic 'news' is quantitatively smaller than the impact of monetary policy signals, and the overall effect of macroeconomic news on lower frequency exchange rate changes decays quite rapidly towards insignificance: the average exchange rate change caused by the most significant macroeconomic news is less than a quarter of that of policy signals; and the significance of the coefficients on macroeconomic news tended to disappear after a couple of hours, while the effects of policy news could usually still be felt after 12 hours.

The larger impact of monetary policy news, the fact that the markets' reaction to macroeconomic news seems to be driven by their interpretation of the central bank's reactions, and the fact that in Chapter 3 it was found that the effect of German macroeconomic news depends on the proximity to the next Bundesbank council meeting, all indicate that the monetary authorities' actions are one of the main factors driving exchange rates. This suggests that an interesting extension of the analysis above could be to study the effects on the high frequency behaviour of exchange rates of other central banks' actions, in particular interventions in the foreign exchange market. In the dataset used in Chapters 2 and 3, several episodes of direct intervention in foreign exchange markets by the Fed and other central banks could be identified, and an analysis of those episodes might deliver relevant results. Other possible extensions would be the analysis of the impact of statements by central bank officials, or the effects of other types of public information (e.g., political news). Finally, there is the obvious extension of these studies to other exchange rates, countries, and data periods, since the results were obtained for a specific sample. It would be interesting to examine the robustness of some of the results when the analysis is extended to other currencies, notably whether the dominant effect of US news is general, and whether it even affects cross-rates between currencies other than the USD.

Most of the research on monetary policy focus on the experience of central banks in larger and more advanced economies, facing fully developed financial markets. Yet, this is just a subset of the universe of central banks, and not even a representative one. Central banks in developing countries conduct monetary policy in an environment substantially different from that faced by central banks in more developed economies, as the evidence in Chapter 4 demonstrates. This chapter examined the monetary policy framework in a sample of 44 developing countries, and detected that there is a general acceptance of the benefits of price stability as the primary central bank objective. Nevertheless, the results suggest that in developing countries central banks give a lower priority to price stability than it is usually the case in more advanced economies. The weakness of other public administration institutions forces the government to rely on the central bank to pursue other objectives: central banks are expected to provide governments the revenue they cannot collect through the tax system, and to perform a range of quasi-fiscal activities, like providing implicit subsidies through credit or foreign exchange guarantees, or imposing restrictions on the financial system that will benefit the government; they are also expected to preserve the stability of the financial system. A central bank that is obliged to carry out a wide range of quasi-fiscal activities can hardly aspire to the same degree of independence from government as one which has not been required to assume such activities, and this lack of independence will jeopardise their ability to maintain price stability, as the results show.

The evidence in Chapter 4 emphasizes that central banks may have multiple objectives, and this has to be considered when designing a strategy for monetary policy. The analysis of a policy strategy should not be conducted *exclusively* in the light of its effects on inflation. This principle permeates the last two studies in this thesis. Chapter 5 provides an detailed analysis of the experience of seven countries that have adopted a monetary policy strategy based on inflation targeting. The chapter examines the inflation experience of these countries, but it also investigates several other aspects of central bank behaviour that may have been affected by the adoption of this strategy. Chapter 6 compares the performance of alternative monetary policy targets, from the point of view of financial stability, based on data on exchange rates, interest rates, and stock prices, from a panel of 18 OECD countries for the period 1972-96.

The study in Chapter 5 could not provide a definitive conclusion on whether the adoption of inflation targets had a significant impact on the behaviour of central banks. There are some signs of a positive impact, especially in the countries where it has been in force for a longer period (New Zealand and Canada), but most of these are country specific. The only area where there is clear evidence of a change in behaviour is in the nature of communications of central banks with both the public in general and government in particular, where there is a visible increase in transparency and accountability. Inflation targeting countries have been successful in lowering inflation, and then keeping it low, but then so equally were other OECD countries. The only advantage inflation targeting countries might have had was to achieve low inflation faster and at a lower cost in terms of output growth. On the other hand, inflation targeting countries have missed their own targets on several occasions, which suggests that the target ranges used might be too narrow.

Some of the evidence in Chapter 5 suggested that the adoption of inflation targets might have been instrumental in achieving increased stability in financial markets. A more detailed and extended analysis of this question in Chapter 6 confirmed that the use of inflation targets is associated with more stable financial markets. This chapter compared the degree of financial stability associated with different targeting strategies, and found that the choice of monetary policy strategy will significantly affect stability in financial markets. Both short term price volatility of financial assets, and the likelihood of crises in foreign exchange markets, differ significantly when central banks are using alternative policy targets. Results suggest the existence of a trade-off between stabilising interest rates or stabilising exchange rates, but they also indicate some strategies that appear to be preferable from the financial stability point of view, such as inflation targeting and multilateral exchange rate targeting arrangements with strong discipline (as the original ERM).

The research in Chapters 5 and 6 contributes to the extensive literature on the evaluation of monetary policy strategies. Although the existing work already covers many issues in this area, there are some possible extensions of the analysis in these chapters. First, the study in Chapter 5 should be revisited in some years, when a longer experience with inflation targeting is available. The analysis of the adoption of inflation targets was based on a small set of countries, and covered a short period of time, and this might have been one of the reasons why we could find few significant effects. Second, one of the sub-products of the analysis in Chapter 6 was the creation of a database of monetary policy strategies in OECD countries. This database, together with the database in Cottarelli and Giannini (1997), could be used to extend the analysis in Chapter 5 to other monetary policy strategies. One could examine differences in inflation performance, and in the credibility of polices, under alternative policy targets. This will be the focus of our future work.

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