**First Draft: November 1995**
**This Draft: April 1996**

# INSTITUTIONAL CHANGE, INFLATION TARGETS AND THE STABILITY OF INTEREST RATE REACTION FUNCTIONS IN OECD ECONOMIES

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## ABSTRACT

We estimate interest rate reaction functions for several OECD economies and examine their stability over the period 1972-96, with the aim of detecting changes in the response of monetary policy to various final and intermediate policy objectives. We obtain two key results. First, the generalised fall in inflation in the 1980s is attributable to various factors, both political and reputational, which are different from the institutional design emphasised in the monetary policy games literature. Second, despite major changes in the some countries' institutional arrangements in the early 1990s (e.g. inflation targeting), there is little evidence of change in our estimates.

**JEL Codes: E52, E58, E63**

(*) A preliminary version of this paper was presented at the Annual Conference of the Societa' Italiana degli Economisti, held in Florence, November 1995. We are grateful to all participants for useful comments received. The usual disclaimer applies.

## 1. Introduction

After the turbulence of the 1970's, inflation rates in the OECD countries have gradually fallen. There are three alternative, and complementary, explanations of this observation. First, the inflation fall may be the result of an improvement in the terms of trade during the 1980's (see De Grauwe, 1992). Second, others (see Goodhart, 1994, Posen, 1993) have emphasised the changing political influence of interest groups holding different views on the costs of inflation. Thus shifts in society's preferences might explain the fall of inflation[1]. Third, the literature on monetary policy games stresses the role played by the development of new institutional arrangements. The modern theory of macroeconomic policy regards inflation outcomes as the consequence of credibility constraints (Barro and Gordon, 1983)[2]. Within this class of models, output distortions[3] raise the incentive to generate monetary surprises, increasing the equilibrium time-consistent inflation rate. Thus reducing inflation may require particular institutional arrangements, such as policy delegation to a conservative central banker or the adoption of an exchange rate rule[4]. This tendency towards institutional reform has been observed in a number of high-inflation countries where measures have been taken to enhance the credibility of monetary policy. Gaining credibility may come at a cost: inflation averse institutions might implement distortionary monetary responses to unexpected supply shocks (see Rogoff, 1985, Lohmann, 1992)[5]. For instance nominal pegs limit the ability to repond to asymmetric shocks and force domestic policies to follow the "conservative" monetary stance implemented by the leader.

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[1] War of attrition-type models may explain this change in aggregate behaviour.
[2] For an alternative perspective, see Romer and Romer (1996).
[3] Cukierman (1992) examines three other possible causes which may generate an inflation bias: fiscal revenue, interest rate smoothing and balance of payments targets.
[4] Within Europe the exchange rate mechanism (ERM) of the European Monetary System (EMS) was seen as an institutional device to import the Bundesbank's credibility (see Giavazzi and Pagano, 1988).
[5] However, this depends critically on the nature of the delegation process (see Walsh, 1995a, Persson and Tabellini, 1993, Svensson, 1995, Muscatelli, 1995).

This implies that the relative importance of domestic objectives must fall. Since 1992 the partial break-up of the EMS has led some countries to seek alternative mechanisms to pursue anti-inflation policies, such as a formalisation of inflation targets (see Leiderman and Svensson, 1995). Other non-EMS countries have followed a similar route (Canada and New Zealand). New research in this field (see Svensson, 1995, Muscatelli, 1995, Herrendorf and Lockwood, 1996) has shown that, if the appropriate commitment technology were to be available, inflation targets should enable the central bank to implement the socially optimal response to supply shocks, attaining credibility gains at no cost. Thus inflation targeting models suggest that central banks who formerly "tied their hands" by committing to an exchange rate rule or to a foreign interest rate peg and recently announced inflation targets might have re-gained the ability to implement the socially optimal stabilization policy without suffering from an increase in the inflation bias[6].

This paper attempts to discriminate between alternative explanations of the inflation fall by looking at the statistical linkages which exist between monetary policy instruments and objective variables such as output, inflation and exchange rates, in a number of OECD economies. We focus on the G7 economies, and in addition we look at the experience of New Zealand, given the prominence which its reforms have been given in the literature on contracts and targets[7]. The intention is to focus on the constancy of estimated interest rate reaction functions for the post-Bretton Woods period, and to examine whether one can characterise, *ex post*, the in-sample properties of the estimated reaction functions in terms of policy regime

[6] Although it should be recognised that inflation targets as analysed in Svensson (1995), Muscatelli (1995) and Herrendorf and Lockwood (1996), have the undesirable property that they are not achieved on average by central banks. In practice, monetary authorities seem to employ inflation targets differently, as a means of co-ordinating inflationary expectations on lower levels of inflation as part as a reputation-building mechanism (see Lockwood, Miller and Zhang, 1995). For a critical view of inflation targeting proposals see McCallum (1995).

[7] Moreover, the New Zealand Reserve Bank Act has been a focus of discussion on monetary policy reform in a number of countries in the '90s (Fischer, 1995, Walsh, 1995b).

shifts. We try to detect whether changes in monetary policy behaviour have occurred and to assess whether these are matched by institutional innovations and announced shifts of policy regime. Evidence of policy shifts would obviously undermine the relevance of the terms-of-trade hypothesis. On the other hand, observed policy changes in the absence of institutional adjustments would favour the view that changing attitudes towards inflation (i.e. changes in social preferences reflected through the political majority) have played an important role[8]. Finally, the announcement of credible inflation targets should have freed central banks from the constraints of suboptimal rules, leaving room for greater flexibility in the face of domestic shocks.

This type of empirical investigation complements previous work which analysed the impact of institutional changes on the formation of inflationary expectations (see for instance Giavazzi and Giovannini, 1987). Recent attempts to estimate reaction functions for the monetary authorities have tended to follow a variety of approaches. One popular route has been to focus on the domestic creation of monetary base in order to gauge the extent to which monetary base growth is linked to changes in domestic objectives, and (in fixed exchange rate regimes) the extent to which foreign-exchange intervention is sterilised (see for example Herring and Marston, 1977, Obstfeld, 1983, Tullio and Ronci, 1994). The implicit assumption in such studies is that the authorities use the monetary base as an instrument of monetary policy, or at the very least that monetary base is an important intermediate objective which they target. To the extent that some countries do not have an explicit monetary base objective (as is the case for the G7), or allow the monetary base to fluctuate in response to shocks in the demand

[8] However, finding that policy changes have coincided with institutional innovations is not necessarily an indictment of this view: as Posen has forcefully argued, the establishment of an independent "conservative" central bank may be the consequence of a shift in social preferences towards greater monetary stability.

for money and the demand for bank reserves, monetary base growth reaction functions are at best an imprecise indicator of the monetary authorities intentions. Certainly these models yield useful information regarding the sterilisation issue, and the operation of fixed-exchange rate systems. But they give little insight into the weight of various domestic policy objectives in determining monetary policy.

There has also been a growing literature on the co-ordination of monetary policies between countries, especially in the ERM. Thus, Weber (1991) shows that monetary shocks in the ERM have become more symmetric over time. On the interest-rate front, various studies have explored the relationship between interest rates in different countries[9]. Tests of the German  dominance hypothesis within the EMS, advanced in, *inter alia*, Giavazzi and Giovannini (1987). Fratianni and Von Hagen (1990a,b) examine the independence of the monetary instruments (testing both base money growth and changes in monthly money market interest rates) of the main ERM countries over the period 1979-1988 from the monetary instruments of Germany. Once again, as in the case of tests for sterilisation operations, domestic policy objectives such as output growth and inflation enter these equations. However, the focus is not explicitly on testing for the significance of each target or the stability of the reaction function. The sole purpose of including output growth and inflation as additional explanatory variables is to reduce the problem of picking up spurious correlations between interest rates in different countries.

Our key results are the following. We find that monetary policy in the G3 countries has been remarkably stable, implying that both targets and policy preferences have remained constant, with the notable exception of the monetary

[9] In addition to the studies cited below, there have also been attempts to test for the causal linkages between interest rates in different countries on high frequency data, both within the ERM (see Russo and Tullio, 1988, Henry and Weidmann, 1994) and for the Gold Standard (see Eichengreen, 1987, Giovannini, 1989). However, there are dangers in inferring monetary policy dominance from econometric causality tests. Indeed, the factors affecting the timing of interest rate movements may be a classic example of the pitfalls of causality tests.

base targeting experiment in the USA between 1979-82. Turning to the other G7 countries, we find that by the 1980s a new and stable pattern emerged. Monetary policy increasingly responded to external objectives (the exchange rate and foreign interest rates). A further interesting result is that the announcement of inflation targets in the early 1990s in a number of the countries in our sample did not result in a shift in the estimated coefficients[10]. Despite the movement to more flexible exchange arrangements in Europe, external objectives continued to play an important part, much as they had in the 1980s.

The rest of this paper is structured as follows. In Section 2 we provide an outline of the changes in policy regimes for each of the countries in our study and in Section 3 we provide a discussion of the ways in which different policy instruments are employed. The estimation methods are outlined in Section 4, and the empirical results are reported in Section 5. A brief conclusion follows.

## 2. Institutional innovations, shifts in political majorities and changing techniques of monetary control.

Before proceeding to the formal estimation, we provide a thumbnail sketch of how the rules of the monetary policy game have changed during the sample period. This will allow us to interpret the empirical results reported below.

A variety of factors may generate shifts in monetary policy reaction functions. The consequences of some of them, such as institutional and political innovations are the direct concern of the paper. Others, such as the demise of

[10] These results are consistent with those obtained in related work by Groeneveld *et al.* (1996), who reject the hypothesis of a structural break following the switch to inflation targeting in Canada, New Zealand and the United Kingdom. However, their models are estimated on quarterly data, use mainly domestic target variables, and focus solely on the overall stability of the fitted reaction functions during the early 1990s. Our modelling approach in this paper examines the stability of the model parameters over the full sample. There are alternative approaches in the literature. For instance, Freeman and Willis (1995), and King (1995) examine credibility effects on the yield curve.

monetary aggregates due to the instability of demand for money functions, are not. Nonetheless, the timing of changes in techniques of monetary control - as opposed to policy changes - should be clarified in advance, since such changes will clearly show up in our results.

There are important differences within the group of countries analysed here. Monetary institutions in the G3 (the U.S., Germany and Japan) present some common features. No significant institutional innovations have been observed during the sample period: i.e., the relationship between the political system and monetary institutions has not changed[11]. In these countries, especially in the U.S. and Germany, the central bank enjoys a relatively high degree of independence (see Cukierman 1992, Grilli *et al.*, 1991). A major "technical" change occurred in the U.S. between 1979 and 1982. In this period the Fed switched from interest rate targeting to monetary base targeting, which implied complete flexibility of money market rates. Outwith this period the Fed has opted for the targeting of money market (federal funds) rates[12]. In Germany, after the breakdown of the Bretton Woods system, the Bundesbank has set target ranges for the growth of broad monetary aggregates. Over the last fifteen years actual growth rates often exceeded (fell short of) the upper (lower) limit of the targeted band[13].

For most of the sample period, the central banks of the remaining G7 countries have been credited with far lower independence in the conduct of monetary policy than their fellow institutions in the G3 group (see Cukierman, 1992, Grilli *et al.*, 1991). However important institutional innovations and political changes have occurred in these countries. The increasing rigidity of the ERM limited the

[11] Since 1979, EMS membership might have constrained the Bundesbank's ability to retain control of monetary policy. Most discussions on the Deutchmark role in the EMS have concluded that the Bundesbank largely retained her independence (see Fratianni and Von Hagen, 1990).
[12] For a detailed description of how techniques of monetary control have evolved in the U.S. see Lombra (1993).
[13] See Von Hagen (1993).

scope for discretionary policies in France (after the 1983 crisis) and in Italy[14] (from 1987 onwards). Moreover, the Bank of Italy has gradually gained a substantial degree of legal independence[15], whereas the Bank of France has gained full legal independence in 1993, as required by the Maastricht Treaty. After September 1992 the Lira has floated. The Government has announced year-to-year inflation targets, but the Bank of Italy is not held accountable for achieving them.

In the UK the Central Bank has never been granted formal independence. However, the election of the Thatcher government in 1979 signalled a long-lasting shift in the collective attitude towards inflation[16]. Instead of adopting an institutional approach the government has since tried to build a reputation for this commitment to low inflation policies. The Medium-Term Financial Strategy envisaged a 5-year sequence of gradually decelerating growth targets for £M3. However, the unstable relationship between this monetary aggregate and the final policy objectives quickly led to the demise of formal monetary targets. Since then the authorities have taken a more eclectic approach to targeting (see Minford, 1993). Within this, although ERM membership was delayed until 1990, the exchange rate assumed greater importance as an indicator of monetary conditions (see Bowen 1995). After the exit from ERM in 1992, the government has opted for a new monetary policy framework involving the announcement of formal inflation targets[17].

The central bank of Canada enjoyed only a limited degree of independence until the end of the 1980s (see Grilli *et al.*, 1991, Cukierman, 1992). M1 was the

[14] For a detailed account of the historical evolution of monetary policy in these two countries see Melitz (1993) and Spinelli and Tirelli (1993) respectively.
[15] Starting with the 1981 law wich freed the Bank from the obligation to finance the Treasury.
[16] Alogoskoufis *et al.* (1992) find convincing evidence of a spectacular reversal in the political business cycle after Mrs. Thatcher came to power. For a more descriptive analysis see Minford (1993).
[17] The UK government has chosen not to delegate the implementation of monetary policy to an independent and accountable central bank. Instead the government's own reputation is the ultimate guarantee of the policy commitment. However, the Central Bank plays the key role of publicly assessing the overall consistency of the policy stance. For a detailed account see Bowen (1995), Briault *et al.* (1995).

intermediate policy target between 1975 and 1982 (Freedman,1995) when it was officially abandoned due to developments in the financial sector. Between 1982 and 1991 the Bank of Canada reiterated the long-term goal of price stability, but did not commit to any pre-determined policy pattern. In 1991 the Government and the Bank set a sequence of year-to-year target bands for the inflation rate, so as to bring about a gradual reduction in inflation. However, the Bank was not granted a legislative mandate to achieve these inflation targets and a procedure was not established by which the Bank would be held accountable for missing the targets.

Finally, we turn to the evolution of the monetary regime in New Zealand, which has switched to inflation targeting during the '90s. Historically, the Central Bank of New Zealand's degree of independence ranked lowest amongst OECD countries (see Grilli *et al.*, 1991, Cukierman, 1992). Correspondingly, the inflation rate was well above the OECD average. Up until the mid-1980s monetary policy relied on regulation and administrative controls of capital markets. From 1985 the Bank turned to a market-oriented approach, and based her policy on a variety of indicators, such as the exchange rate, the term structure of interest rates, monetary aggregates and output (see Fischer, 1995). The Reserve Bank Act, introduced in 1990 to establish a legislative commitment to price stability, gave the Government and the Central Bank Governor the mandate to agree on inflation targets, and explicitly contemplated the possibility of the Governor's dismissal if targets were not met.

## 3. The Choice of Monetary Policy Instruments

This section clarifies the reasons underlying our choice of the relevant policy variables. This has to be an instrument which the authorities control. The growth in base money is unlikely to be an appropriate candidate, as with very few exceptions

(e.g. the United States, following the change in operating procedures in the Volcker-led Federal Reserve during the period 1979-82) central banks have not sought to exercise close control of base money. In general, central banks are better characterised as relying on short-term interest rates. Even where explicit money supply targets are set (e.g. Germany[18]), central banks typically react to movements in intermediate and final objectives by first deciding whether such movements are significant enough to trigger a change in the stance of monetary policy or whether a 'wait and see' attitude should be adopted; and, second, if a change in monetary policy stance is called for, by adjusting the price at which bank reserves are supplied.

Thus, we focus our analysis on short-term money market rates. Even this raises some difficulties. One could use short-term money market rates, such as the one-month rates used in many of the empirical studies cited above, or even shorter-term rates such as call money rates. Money market rates will entirely reflect policy intentions if the authorities peg the short-term money market interest rate at a level consistent with their policy goals and are willing to adjust the supply of reserves to demand shocks at such a rate. However, the operating procedures of many central banks in the 1970s and 1980s were such that shocks to the demand for reserves were not totally accommodated, but would trigger off an increase in the price of borrowed reserves. Thus money market rates such as call money rates have moved in response to demand conditions in money markets as well as in consequence of attempts to control policy targets. A more appropriate measure of the policy stance of the monetary authorities would then seem to be an interest rate related to central bank operations, for instance the rate at which the banking system can borrow from the central bank (typically the discount rate). It might be tempting to conclude that

[18] See Clarida and Gertler (1996) for a detailed analysis of how the German monetary authorities manipulate short-term interest rates.

discount rates (or equivalently administered borrowing rates) are a better measure of the central bank's policy intentions than money market rates which reflect temporary fluctuations in the demand for reserves. However, such a conclusion would be incorrect for some countries, because much depends on the extent to which the central bank relies on open market operations rather than direct discount borrowing. In a number of the countries in our sample, discount rates changes tend to lag changes in money market rates. Furthermore, in many countries, there has been a greater emphasis in signalling monetary policy changes through rates on (re)purchase operations on short-term paper rather by changes in rates on discount rate borrowing[19].

Thus, in estimating interest rate reaction functions for the G7 economies, we focus on short-term money market rates. These have the disadvantage of combining relevant information about central bank strategy with some noisy short-run fluctuations due to changes in the demand for reserves which the authorities do not fully accommodate, but which do not trigger a change in policy stance. In Appendix I we outline which money market rates reflect the authorities' policy intentions.

**4. Estimation Methods**

In the case of money market rates, which adjust continuously over time in response to reserve demand and supply conditions, the estimation procedure followed is similar to that in other recent studies of interest rate determination (see e.g. Fratianni and Von Hagen, 1990a,b). Thus we estimate an autoregressive distributed lag (ADL) model of the following type:

$$\Delta R_t = c + A(L)\Delta R_{t-1} + \mathbf{B(L)}\Delta\mathbf{X_t} + \mathbf{C(L)}\Delta\mathbf{W_t} + \varepsilon_t \qquad (1)$$

[19] In a related paper (Muscatelli and Tirelli, 1996) we examine the econometric problems involved in estimating reaction functions for discount rates, where movements in these rates are discontinuous.

where c is a constant term, the A(L) is a lag polynomial and B(L) and C(L) are matrices of lag polynomials, X is a vector of domestic final or intermediate objective variables, and W is a vector of foreign variables which might affect domestic interest rate movements. The series used for each country are detailed in Appendix I.

There are two key points to note about these models. First, in common with similar studies (see Groenveld *et al.*, 1996), we do not impose any long-run restrictions on the interest rate *levels* relative to the *levels* of at least some of the target variables. We did experiment with specifications which imposed a long-run relationship between interest rates levels and inflation, but there was no evidence of the existence of a cointegrating relationship in levels between nominal interest rates and inflation. This is not altogether surprising, since over the sample used in our study (monthly data over the period 1973-1996)[20], real interest rates tend to have a general upward trend in most OECD economies. Thus, whilst on theoretical grounds it would be preferable to specify a model with some long-run anchor for the real interest rate[21], the key point for our purposes is that there seems to be no important long-run information lost by omitting the levels variables, especially given that we are focusing on short-run stabilisation policies.

Second, by including contemporaneous lags of the objective variables we might encounter possible simultaneity problems. Where relevant we examined the possible impact of simultaneity effects by choosing appropriate instruments for the regressor in question. In no cases did the results deviate markedly from the OLS results, and so we report only the latter. What is striking about the estimates reported below is that all the target variable parameters are correctly signed.

[20] Differences in the availability of consistent series mean that the sample periods vary slightly between countries. In addition, for New Zealand we use quarterly data from 1980(1) onwards, rather than monthly data.

[21] Thus, if the real interest rate had proved to be stationary, or if adequate explanatory variables could be found to model the trend in real interest rates, this could provide a long-run cointegrating vector around which cyclical monetary policy shifts could be modelled.

Our focus is on the aggregate effect of the variables in X and W on the $\Delta R$ variable. We begun our specification search from a general model in which we included a number of potential objective variables, and then eliminated insignificant lags and variables which proved not to add significantly to the model, as measured by various goodness-of-fit and information statistics.

The variables included in the $\Delta X$ vector are consumer price inflation, growth in output measured using industrial production indices, growth in narrow (M1 or M0-type) or broad money[22] (M3 or M4-type), changes in the unemployment rate. For the $\Delta W$ vector we experimented with interest rate changes in other G-3 countries, and with variations in key single or effective nominal exchange rates.

We identify an appropriate specification over the sample up to 1994(1), and leave aside 24 observations for *ex ante* forecasts. We then estimate each equation recursively up to 1994(1) to check for model non-constancy which could indicate major changes in policy strategy, and to verify the coincidence of such models with the timing of policy announcements. The model's stability is assessed using variants of the Chow test (see Hendry, 1993), as well as by examining the changes in the estimated coefficients over time using recursive least squares. Finally, we use each model to provide *ex ante* forecasts for the period 1994(1)-1996(1). These out-of-sample forecasts are an additional check on the robustness of our estimated models[23].

[22] We chose the monetary aggregate which seemed to give the best results. In those countries where a significant effect is found, it was generally obtained by using the central bank's declared preferred monetary objective/indicator.

[23] The point here is to show that the dynamic structure of the fitted models has not been designed to ensure *ad hoc* model constancy over the 1980s, as this is a central part of our conclusions.

## 5. Econometric Results

In Table 1 we report the static (steady-state) long-run solution to the estimated ADL equations[24]. This shows the total response of interest rates to various target variables, together with the asymptotic standard error for each long-run coefficient. For each estimated ADL model we report a number of diagnostic tests for serial correlation, ARCH, normality, and a nonlinearity RESET test. We should stress at the outset that the main aim of our empirical evidence is not to find a stable reaction function for each country. Indeed, the central purpose of this exercise is to examine the timing of any structural breaks. Thus, since each diagnostic test has some power against a range of alternatives, we would only expect the misspecification tests to accept the null hypothesis in the small number of cases where a substantially stable reaction function could be found.

In addition to the diagnostic tests, for each estimated reaction function we display some recursive estimation graphics, which we use to detect shifts in the reaction functions[25]. These include a recursive plot of the estimated coefficient for the main explanatory variables, the t-ratios corresponding to each explanatory variable, the 1-step residuals, 1-step Chow tests, and N-downstep Chow tests for structural breaks (which yield similar results to CUMSUM-squared statistics), and N-step forecast Chow tests.

*The USA*.

The key explanatory variables are the monthly growth in industrial production (DIIP), the monthly acceleration in inflation (DINF), the growth rate in the M1

[24] For reasons of space, we do not report the estimated ADL models. These are available from the authors on request. Their properties are discussed in the recursive estimates and diagnostic tests reported.

[25] For most of our models, one lagged regressor was found to be significant for each explanatory variable. Where more than one lag was found to be significant, the estimated coefficients were similar, and the recursive plots focus on one of the estimated coefficients for that explanatory variable.

definition of the money supply (DM1), and the change in the unemployment rate (DU). We detected major instability during the years 1979-1982 when estimating the federal funds rate reaction function for the full sample. This is due to a marked instability in money market rates at the time of the Federal Reserve's experiment with tighter monetary targeting in the late 1970s-early 1980s, which we discussed above. The results obtained by estimating our preferred equation using recursive least squares (RLS) are shown in Figures 1(a)-(c).

**Figures 1(a)-(c) near here**

At first sight, the equation seems to perform poorly, with both the normality and ARCH test detecting potential misspecification problems. However, as can be gauged from the Chow tests in Figure 1(c), these diagnostic tests are essentially picking up the extremely large outliers during the period 1979-82. The structural break shown in the N-step Chow tests disappear once one excludes these critical years[26].

Re-estimating the model over sub-samples up to 1979 and after 1982 yields normal and white noise residuals. More importantly, the results reported in Table 1 are largely confirmed over these two sub-samples[27]. These results require an interpretation of the 1979-82 crisis. Goodfriend (1995) argues that in this period the Fed fought to establish a reputation for commitment to a low inflation policy after the second oil shock. It is striking, however, to discover that the Fed policies before and after that episode look rather similar.

[26] Indeed, for most of our models, the normality hypothesis is rejected. This is not surprising, as even very occasional unpredictable large changes in money market rates will cause the null hypothesis of normally distributed residuals to be rejected. Whilst this might be serious if it were to imply an underlying non-normal distribution for the disturbance term, in practice it is a symptom of an inability to capture a small number of large outliers. This was confirmed by eliminating these outliers via individual period dummy variables, which did not affect the estimated reaction function parameters. These results are discussed in detail in Appendix 2.

[27] There is some evidence that the 1970s sub-sample should contain the dollar-mark exchange rate, DGER (DM per $), which is significant at the 15% level, whilst the inflation effect (DINF) is more significant in the 1980s. However, the model is reasonably robust between the 1970s and 1980s sub-samples. These results are not reported here for reasons of space, but are available from the authors on request.

The t-ratios in Figure 1(b) are also of interest. In recursive estimates, one would expect these to increase (in absolute value) with the sample size. However, there are some interesting variations. For instance, it appears that the significance of the money supply variable (DM1) peaks in the mid-1980s, and the results confirm that it has become much less important since 1985. The role of the unemployment variable is also mixed, with a reduction in significance in the period 1983-87, which is only partially reversed later.

Overall, the results suggest a reasonably stable feedback policy reaction to output changes and inflation changes, with these two final objectives becoming increasingly significant in the post-1982 phase when strict monetary base targeting was abandoned. The federal funds equation shows considerable robustness post-1983, suggesting no major changes in policy objectives in the 1980s, except for a progressive de-emphasis of monetary targeting. Furthermore, the models seem to confirm the greater significance of the inflation variable in the 1980s compared to the 1970s, which corresponds to the view expressed in most descriptive accounts of US monetary policy.

*Germany*

As one might expect, the German interest rate reaction function is remarkably stable over the sample period. Absolutely no signs of instability emerge from the one-step residuals and Chow tests shown in Figure 2(c).

**Figures 2(a)-(c) near here**

Variations in the unemployment rate (DU) and in the inflation rate (captured as a 4-quarter change in inflation, D3INF ($INF_t$ -$INF_{t-3}$) seem to be the main driving forces, with variations in the US interest rate (DFFR) and in the DM/$ exchange rate (DER$) acquiring significance in the 1980s (see Figures 2(a)-(b)). It is not suprising

that German monetary policy seems to have been influenced to a greater extent from external events in the mid-1980s, such as the volatility in the Dollar-DM rate. Instead, no role could be found for monetary growth, either using the Bundesbank's preferred broad money definition or using narrow money (which in any case is not a target variable) [28]. This is perhaps surprising, although descriptive accounts of German monetary policy point out that the Bundesbank repeatedly allowed monetary aggregates to overshoot (undershoot) the announced target bands.

The main points to note from the German case are: first, the relative stability of the estimated call money rate equations, suggesting stable underlying policy objectives, although the credibility of the overall policy thrust could not originate from the announced money supply targets. Second, in contrast to some exaggerated views of the dedication of the Bundesbank to inflation control, monetary policy also tends to react systematically to shifts in real variables such as unemployment. It is important to note, however, that the response to unemployment seems to have declined as the latter rose sharply in the 1980s (see Figure 2(a)).

*Japan*

As in the case of Germany, our estimated reaction function for Japanese interest rates shows considerable stability over the sample period (see Figure 3(c)). There are some signs of instability around 1986 from the one-step Chow tests, but the N-step tests show that this is an outlier.

**Figures 3(a)-(c) near here**

Another striking similarity with the German case is the long-run response of interest rates to changes in unemployment (DU) and 4-quarter changes in inflation (D3INF). There are also some interesting contrasts, though. It appears that whilst

[28] Collinearity with the other objective variables is not a problem, since we experimented with the M3 objective in the absence of competing variables without success.

the significance of the inflation variable and variations in US interest rates (DFFR) increases with the size of the sample, the significance of the unemployment and output (DIIP) variables tends to decline sharply post-1989 (see Figures 3(a)-(b)). This suggests that Japanese monetary policy has become less responsive to the output cycle, probably as a result of the tight anti-inflationary policy in 1989-91.

*France*

There are a number of interesting points to note. First, over the whole sample, a greater role is found for external variables such as German interest rates (DG3MR) and the FF-DM exchange rate (DMER) than for domestic variables. Indeed, the domestic inflation variable is not significant and does not appear, and the output growth variable (DIIP) is only significant at the 10% level over the full sample.

Our recursive estimates and the Chow tests (see Figures 4(a)-(c)) capture most of the policy regime shifts one would expect from descriptive accounts. After the turbulence of the '70s, monetary policy in France turned more "conservative", showing increasing commitment to the fixed exchange rate policy. Figure 4(a) and (b) show the changing pattern over time. The DIIP variable, as one would expect, is larger and much more significant in the pre-ERM period in the 1970s, and declines relative to the external objectives in the 1980s. In contrast, the significance of DMER and DG3MR rises steadily over time as more observations are added with the significant exception[29] of the Mitterrand expansionary policy 'experiment' in 1980-3. The Chow tests obviously detect instability in correspondence to the ERM crises in 1992 and 1993.

**Figure 4(a)-(c) near here**

[29] As is apparent from the Chow tests in Figure 5(c).

*United Kingdom*

External objectives such as the Sterling effective exchange rate[30] (D2ER, defined as $ER_t - ER_{t-2}$) are significant over the whole sample. Over the whole sample, German interest rates (DG3MR) only seem to have a temporary effect, and are insignificant in the long-run solution (see Table 1). However, turning to the estimated recursive coefficients in Figures 5(a)-(b), it is apparent that from 1982 onwards the importance of German interest rates (at least in the short-run) increases suddenly, and the related coefficient becomes strongly significant. It is also striking to note that, after the first Thatcher government, when policy was clearly oriented to reputation building, the unemployment coefficient ($D3U=U_t - U_{t-3}$) becomes steadily more significant. This is especially the case post-1987, signalling what was a change towards a more active stabilisation policy, in spite of ERM membership. The significance of the exchange rate variable diminishes post-1992, with the UK's exit from the ERM. However, the data suggest that, even after the announcement of inflation targets, the overall policy thrust has remained substantially similar to the one prevailing in the former years.

Although we have identified some of the explanatory variables for UK short-term interest rates, the goodness-of-fit for this equation is not as good. The large number of outliers shown in Figure 5(c) are largely explainable in terms of recurrent short-term Sterling crises[31] (e.g. 1985 and the exit from ERM in 1992), and the N-step Chow tests do not show signs of any major structural break (see Figure 5(c)).

**Figures 5(a)-(c) near here**

[30] An increase in the Sterling effective exchange rate index corresponds to an apprectiation.
[31] Although the exchange rate enters the reaction function and is significant, arguably a linear relationship is not appropriate to capture the interest rate response to short-term exchange rate crises.

*Italy*

In the case of Italy, we can again identify the importance of external objectives in the 1980s. German interest rates (DG3MR) and the DM exchange rate (DMER) are two key explanatory variables. In addition, output growth captured as D3IIP ($IIP_t$-$IIP_{t-3}$) and inflation, which enters as D4INF ($INF_t$-$INF_{t-4}$) have some effect. The former is significant at the 10% level, whilst the latter only at the 15% level over the full sample period.

**Figures 6(a)-(c) here**

As can be seen from Figures 6(a)-(b), the significance of the exchange rate variable becomes much greater in the 1980s, after Italy's ERM entry. In contrast, and within this external constraint, D3IIP only acquires greater significance in the period 1981-88. It may seem paradoxical to find that domestic variables gained importance after joining the EMS. But one should bear in mind that the Bank of Italy was freed from the obligaton to finance the structural public deficit only in 1981, and was able to use monetary policy for stabilisation purposes. Moreover, a focus on domestic objectives was not inconsistent with EMS membership due to the wide bands and to a number of realignments. In fact, recursive estimates show that after the adoption of narrow bands in 1990 the significance of the output coefficient fell markedly.

As in the cases of France and the UK, even after the EMS crisis, foreign variables retain their importance. The significance of the German exchange rate variable dips temporarily in 1992 following the Lira's exit from the ERM, but it is notable that since then DMER once agains becomes a significant explanatory variable for short-term interest rates. German interest rates on the other hand have only become more significant post-1992, as they were in the late 1970s, suggesting that the abandonment of a formal nominal exchange rate target in Italy's case

means even a stronger link to other European, and especially German, short-term interest rates.

*Canada*

The estimated model for the full sample shows some role for external variables, such as the C$/US$ exchange rate (D$ER), and the US Federal Funds Rate (D3FFR=$FFR_t$ - $FFR_{t-3}$), as well as a much lesser role for domestic targets, such as DIIP and growth in M1 (DM1). Indeed, the money supply variable is only significant at the 10% level. We could find no role for domestic inflation. This is rather surprising, as descriptive accounts of Canadian monetary policy emphasize the announcement of inflation targets as from the early '90s.

What is apparent from the turbulence of the 1970s in Figures 7(a)-(b) is that stabilisation of output (DIIP) seems to have played a much greater role in the '70s, whereas from 1980 onwards the estimated coefficient is not significant. Conversely, as an anti-inflation strategy was gradually put in place from the mid-1980s (see Freedman, 1995), the significance of the two external variables increases with the size of the sample- the importance of DFFR is seen to grow especially rapidly in the 1980s. Even the money supply variable becomes much more significant. In contrast, our estimated reaction function for Canada displays considerable instability until the early 1980s, but post-1987 does not tend to display any major structural breaks (see Figures 7(a)-(c)).

**Figures 7(a)-(c) here**

*New Zealand*

In the case of New Zealand, data availability constrains our estimation to quarterly data, over the 1980s. The estimated model contains the rate of change in the effective exchange rate (DER), the growth in M1 (DM1), and the yearly growth

rate in GDP ($D4Y=Y_t-Y_{t-4}$). The striking aspect of the estimates for New Zealand is their stability in the late 1980s and early 1990s, even after the Reserve Bank Act came into force (see Figures 8(a)-(c)). If there are any signs of instability, they appear in 1987-8, after which the output variable declines in importance. This confirms the arguments of other commentators (see for instance Dowd and Baker, 1994), and supports the view that the institutional reform may have merely consolidated an existing change in policy stance, supported by a change in social preferences against inflation. In other words, it tends to support the notion of inflation targets as a co-ordination device to lower inflationary expectations, rather than as a disciplining device on the policymaker, in contrast with the usual perspective in the literature on targets and contracts.

**Figures 8(a)-(c) here**

*Out-of-sample Forecasts*

The performance of each estimated reaction function is shown in Table 2, which reports Chow and forecast $\chi^2$ tests. These show that all the models are stable over the period 1994(1)-1996(1). Together with the constancy of the models shown by the recursive estimates over the latter part of the 1980s and the early 1990s, this suggests that the announcement of inflation targets in Canada, Italy, the UK and New Zealand have not substantially altered the behaviour of monetary policy.

## 6. Conclusions

The G3 countries have been characterised by a stable institutional environment, and thus it would be obvious to look for policy shifts as the explanation of the inflation fall. In the U.S and in Germany monetary policy has responded significantly to domestic real variables such as unemployment or output. Our

recursive estimates confirm that policy changes did occur, but were merely technical adjustments. For instance, in the U.S. monetary aggregates lost relevance in favour of direct control of domestic objective, unemployment was gradually replaced with the production index. In the case of Germany there is no evidence of policy shifts over the sample period. In the US, the instability found in 1979-82 supports the argument in Goodfriend (1995) that this was a period of 'reputation-building' for the Fed, but that since 1982 the authorities' reaction function appears similar to that observed prior to 1979. Only in Japan's case did we detect signs of increasing "conservativeness" over the sample, as the unemployment coefficient lost significance in the '90s.

Our results suggest that the generalised inflation fall of the 1980s in the remaining G7 countries is due to a variety of reasons. For instance, neither Canada nor the UK relied on institutional innovations in these years, whilst both France and Italy opted for an exchange rate rule. However, all four countries seem to have reacted to external variables - both exchange rates and interest rates. With the exception of the UK, these countries reduced the emphasis on domestic real variables as the commitment (implicit or explicit) to foreign variables became paramount. Our recursive estimates suggest that the UK government, following a period of reputation building in the early 1980s, was able to implement stabilisation policies.

The 1990s data suggest another striking result. The estimated reaction functions in Canada, the UK, and Italy remain stable, and despite the currency float and the announcement of inflation targets, interest rates still react to exchange rate and foreign interest rate variables. Domestic policy objectives do not appear to have gained greater weight. Thus the potential benefits from inflation targeting - that is the ability of implementing a discretionary stabilisation policy without suffering from

a loss of credibility - apparently remain beyond reach, as external constraints still bind. This might be explained by the absence of an appropriate incentive structure, i.e. that the central bank is not yet fully accountable to society for achieving the target. However, the reaction function estimated for New Zealand exhibits a similar pattern. This suggests that inflation targeting may have played a different role from the one envisaged in the literature on Walsh contracts and Svensson targets: i.e. as a highly visible and transparent yardstick against which to assess the monetary authorities' attempts to build a reputation and to co-ordinate inflationary expectations (see Lockwood *et al.*, 1996, Visco, 1995, Briault *et al.*, 1996).

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## APPENDIX 1: Data Series Employed

*Target Variables*
For all countries we employed monthly index of industrial production series, except for New Zealand, where quarterly GDP was used. The inflation series were constructed using consumer price index series. Exchange rates used were US Dollar rates for Japan, Germany and Canada, the nominal effective exchange rate index for the UK and New Zealand, and the D-Mark exchange rate for France and Italy. The US Federal Funds Rate was used as the foreign interest rate variable for Japan, Germany, Canada, and New Zealand. German 3-month rates were used as the relevant foreign rate for Italy, France and the UK.
*Data* Sources: OECD, Datastream.

*Monetary Policy Instruments*
In what follows we briefly point out which money market rates reflect the authorities' policy intentions.

**U.S.** During the sample period the policy instrument has been the Federal Funds rate (FFR), which we model. A number of studies support the view that even during the 1979-1982 period a great deal of the FFR volatility was the result of deliberate Central Bank actions (Goodfriend, 1995).
**Japan.** The Central Bank has chosen to affect the interbank rate by regulating the supply of bank reserves. Money market rates are closely under the authorities' control and for data availability reasons we have chosen to use a 3-month inter-bank rate.
**Germany.** The supply price of monetary base in Germany depends mainly on the Discount, Lombard and REPO rates, each relating to a specific channel of supply of monetary base. As a scalar measure of the base supply price the Bundesbank uses the call-money rate (see Neumann and Von Hagen, 1993), which we model.
**France.** The Bank sets two prices for the supply of reserves. The first is announced weekly, following a call for closed bids. The second is quoted continuously. The interbank call money rate which we use usually falls between these two, occasionally wandering either below the lower rate or above the higher one.
**UK** The Bank of England affects conditions in money markets through operations in eligible bills. Since 1981 there have been periods when an administered rate (MLR then Base Rate) has been announced to give guidance to markets, and periods when no explicit announcement was made on Base Rates. Generally, however, despite some minor changes in operating procedures, the Bank has been able and willing to control rates at the short-end in money markets. Hence we employ a call money rate.
**Italy.** Since 1975 the 3-month T-Bill rate has been the Bank instrument. As from 1988 the Bank has shown increasing reliance on the call-money rate, but this closely shadows the T-Bill rate, hence for continuity we use the latter.
**Canada.** Open market operations mainly aim to affect the overnight interest rate (see Howitt, 1993 p.474), which we model.
**New Zealand.** Since 1985, a target has been set for settlement balances held at the Reserve Bank. The Reserve Bank supplies further reserves by discounting Reserve Bank bills, imposing a 1.5% penalty above market rates (Fischer, 1995 p.35). We employ 3-month rates in our study.

## APPENDIX 2: Outliers in Estimated Reaction Functions

**USA**

The normality test statistic of the residuals falls to 2.90 if one excludes the monetary base targeting period between 1979:10-1982:10 when money market rates became very volatile on a month-by-month basis, and three outliers in 1973:7, 1974:7 and 1987:1.

**Germany**

The normality test falls to 0.04 if one includes only the residuals over the period 1982:1-1994:1, and to 5.43 if one considers the residuals over the period 1976:1-1978:12. This suggests that the large outliers in the periods 1973-5 and 1979-1981 were due to an attempt to maintain a reputation in the face of the two oil shocks.

**Japan**

The normality test falls to 6.83 if one excludes five outliers in the period 1980-1, and three outliers between 1985:11-1987:11. The earlier outliers are probably also due to an attempt to react to the oil shock.

**Canada**

In this case, the normality test statistic falls to 4.40 if one considers the residuals afer 1982:1, and excludes two outliers in 1986. This confirms the results from the stability analysis in the paper where the estimated reaction function is stable in the 1980s, but shows considerable instability in the 1970s.

**France, UK, Italy**

These three countries have experienced a number of speculative attacks on their exchange rates both in the 1970s, and to a much lesser extent (especially in the case of France, and Italy) since 1982, with the exception of the ERM crises in 1992-3. In the UK, there is a greater number of outliers in the 1980s, but this is not suprising as it did not join the ERM, and Italy and France also maintained capital controls into the 1980s. As pointed out in the text, there are difficulties in modelling reaction functions as a linear response of interest rates to exchange rates during speculative attacks, and this explains the presence of these isolated outliers. As we stress in the main text, this does not impair the overall stability of the estimated reaction functions. In the case of France, if one considers the residuals between 1974:8-1981:4, the normality test falls to 6.73; if one considers the residuals between 1982:4-1992:8, it falls to 8.25. In the case of Italy and the UK, removing the periods of exchange rate crisis lowers the test statistic to 5.75 and 1.76 respectively.

## Table 1: Solved Static Long-Run Equation and Diagnostic Tests from ADL Interest Rate Reaction Functions

USA - Sample 1972(8)-1994(1)

Solved Static Long Run equation

DFFR = -0.002 + 0.279 DIIP + 0.389 DINF + 0.315 DM1 - 0.006 DU
(0.0008) (0.067) (0.181) (0.116) (0.003)

$R^2$= 0.348, σ = 0.0065, DW = 2.01, AR (7, 243) = 1.39, ARCH (7, 236) = 11.41*,
Norm(2)= 342.9*, RESET F( 1, 249) = 1.77

Germany - Sample 1973(1)-1994(1)

Solved Static Long Run equation

DGCMR = 0.0005 + 0.020 DER$ + 0.209 D3INF + 0.094 DFFR - 0.012 DU
(0.0003) (0.011) (0.087) (0.040) (0.003)

$R^2$= 0.355, σ = 0.0096, DW = 1.99, AR (7, 247) = 1.46, ARCH (7, 240) = 1.55,
Norm(2)= 361.5*, RESET F( 1, 253) = 0.02

Japan - Sample 1979(10)-1994(1)

Solved Static Long Run equation

D3MR = -0.037 + 0.142 DIIP + 0.160 D3INF + 0.369 DFFR - 0.013 DU
(0.064) (0.053) (0.084) (0.119) (0.007)

$R^2$= 0.390, σ = 0.0031, DW = 1.96, AR (7, 149) = 0.27, ARCH (7, 149) = 1.45,
Norm(2)= 199.5*, RESET F( 1, 162) = 1.22

France - Sample 1972(5)-1994(1)

Solved Static Long Run equation

DFCMR= -0.0003 + 0.041 DIIP + 0.112 DMER + 0.007 DG3MR
(0.0004) (0.024) (0.033) (0.001)

$R^2$= 0.253, σ = 0.006, DW = 1.91, AR (7, 247) = 1.99, ARCH (7, 240) = 6.55*,
Norm(2)= 87.3*, RESET F( 1, 253) = 2.19

UK - Sample 1975(5)-1994(1)

Solved Static Long Run equation

DUKCR = -0.001 - 0.405 D3U - 6.670 D2ER + 0.192 DG3MR
(0.065) (0.168) (2.018) (0.198)

$R^2$= 0.119, σ = 0.0111, DW = 2.01, AR (7, 212) = 0.56, ARCH (7, 205) = 1.20,
Norm(2)= 17.4*, RESET F( 1, 218) = 0.12

Italy - Sample 1974(6)-1994(1)

Solved Static Long Run equation

D3TB = -0.001 + 0.023 D3IIP + 0.107 D4INF + 0.197 DMER + 0.006 DG3MR
(0.0004) (0.013) (0.068) (0.034) (0.001)

$R^2$= 0.226, σ = 0.006, DW = 2.04, AR (7, 231) = 0.57, ARCH (7, 224) = 0.08,
Norm(2)= 95.1*, RESET F( 1, 237) = 14.3*

## Table 1: Solved Static Long-Run Equation and Diagnostic Tests from ADL Interest Rate Reaction Functions (Contd.)

Canada - Sample 1975(6)-1994(1)

Solved Static Long Run equation

DFFR = -0.058 + 0.052 DIIP + 0.053 DM1 + 0.154 D$ER + 0.289 D3FFR
(0.045) (0.038) (0.032) (0.042) (0.026)

$R^2$= 0.423, $\sigma$ = 0.0115, DW = 2.04, AR (7, 210) = 0.48, ARCH (7, 203) = 6.45*,
Norm(2)= 121.8*, RESET F( 1, 249) = 17.4*

New Zealand - Sample 1981(2)-1993(4)

Solved Static Long Run Equation

DR3M = -1.327 - 0.357 DER + 0.136 DM1 + 0.259 D4Y
(0.243) (0.073) (0.042) (0.065)

$R^2$= 0.642, $\sigma$ = 0.0190, DW = 1.95, AR (4, 39) = 0.95, ARCH (4, 35) = 1.03,
Norm(2)= 2.85, RESET F( 1, 42) = 1.05

*Notes: A (*) denotes a test statistic which is significant at the 5% significance level. All diagnostic tests reported are distributed as F(n,m) statistics under the null, except the Normality test, which is distributed as a $\chi^2$ variate.*

## Table 2: Out of Sample Forecasts for Estimated Reaction Functions

| Country | Forecast Test | Chow Forecast Test |
|---|---|---|
| USA | $\chi^2(24)=10.29$ | F(24,251)=0.31 |
| Japan | $\chi^2(24)=8.65$ | F(24,165)=0.32 |
| Germany | $\chi^2(24)=5.41$ | F(8,43)=0.20 |
| France | $\chi^2(24)=16.13$ | F(24,254)=0.67 |
| UK | $\chi^2(24)=6.70$ | F(24,219)=0.25 |
| Italy | $\chi^2(23)=9.00$ | F(23,227)=0.34 |
| Canada | $\chi^2(24)=16.74$ | F(24,217)=0.63 |
| New Zealand | $\chi^2(8)=6.74$ | F(8,43)=0.62 |

*Note: None of the reported test statistics are significant at the 10% significance level.*