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10 How the Bundesbank Conducts Monetary Policy

Richard Clarida and Mark Gertler

10.1 Introduction

Over the last decade there has been a growing belief among economists and policymakers that the primary objective of monetary policy should be to control inflation. Two kinds of arguments are cited. First, experience suggests that fine-tuning the economy is not a realistic option and that inflation is difficult to lower. By taking preemptive steps to avoid high inflation, a central bank can reduce the likelihood of having to engineer a costly disinflation. Second, a central bank that establishes a clear commitment to controlling inflation may be able to maintain low inflation for far less cost than if it did not have this reputation.

In this context German monetary policy is of great interest. From the breakup of Bretton Woods in 1973 until the year prior to reunification, 1989, average annual inflation in West Germany was lower than in any other Organization for Economic Cooperation and Development (OECD) country. Based in large part on this historical performance, the Deutsche Bundesbank is known for its commitment to fighting inflation, perhaps more than any other central bank. The institutions of German monetary policy, further, appear specifically geared toward controlling inflation. Each year since 1974 the Bundesbank has set targets for both inflation and monetary growth.

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This paper provides a broad-based description of German monetary policy. The goal is to learn about the mechanics of maintaining low inflation, and about the net benefits and costs of doing so. In the end we provide a description of how the Bundesbank conducts monetary policy that is based on both a reading of the historical evidence and a formal statistical analysis of the Bundesbank's policy rule.

What makes the general problem of evaluating Bundesbank policy challenging is that for much of the last fifteen years the performance of the real economy has been mixed. Unraveling the precise role of monetary policy in this performance is a complex issue, one that our analysis cannot fully resolve. By closely studying the record of monetary policy, however, we try to shed light on the matter.

Section 10.2 describes the institutions of German monetary policy. Here we outline the system of inflation and monetary targeting. As is commonly understood by close observers of the Bundesbank, the targets are meant as guidelines. In no sense do they define a strict policy rule. In terms of operating procedures, the Bundesbank chooses a path for short-term interest rates to meet its policy objectives, similar in spirit to the Federal Reserve Board.

Section 10.3 reviews the history of Bundesbank policy since the breakup of Bretton Woods. Here our objective is to obtain narrative evidence on how the Bundesbank operates in practice. As one might expect, we find that the Bundesbank is aggressive in managing short-term interest rates to dampen inflationary pressures, the exception being the period between the two major oil shocks, 1975 to early 1979. On the other hand, it clearly factors in the performance of the real economy in setting rates, though perhaps not explicitly. For example, it often cites exchange rate considerations to pursue what closely resembles a countercyclical policy. We also find, as have others, that curtailing inflation is not a costless process for the Bundesbank, despite its reputation.

Sections 10.4 and 10.5 supplement the narrative evidence with a formal statistical analysis of Bundesbank policy. Specifically, we attempt to identify a policy reaction function that characterizes how the Bundesbank sets the short-term interest rate. In general, estimating a policy reaction function involves a number of formidable identification issues, as we discuss. We take a two-step approach. We first obtain a reaction function by estimating a structural vector autoregression (VAR). This approach permits us to formally characterize how the Bundesbank adjusts short-term rates in response to different disturbances to the economy, using only a minimal set of identifying assumptions. As we show, the results are highly consistent with the narrative evidence. The disadvantage of this approach is that the reaction function is difficult to summarize intuitively because it is based on the entire information set in the VAR.

Section 10.5 presents the second step. We place additional structure on the model to obtain a more conventional-looking reaction function based on inflation and output objectives. We estimate a reaction function for the German short-term rate that is close in general form to the one developed by Taylor (1993) to characterize how the Federal Reserve Board has set the funds rate during the Greenspan era. In particular the central bank adjusts the short-term interest rate in response to the gaps between inflation and output and their respective targets. One key difference from Taylor is that under our rule the central bank is forward-looking in the sense that it responds to expected future inflation as opposed to lagged inflation. To form these expectations, our rule uses the information about the economy that is contained in the VAR model. Another key difference is that we allow for an asymmetric policy response to inflation; that is, we allow for the possibility that the Bundesbank may tighten more aggressively when expected inflation is above target than it eases when expected inflation is below target.

Overall, the estimated reaction function does a reasonably good job of characterizing the path of the German short-term rate over the post–Bretton Woods era. In addition the Bundesbank does appear to respond asymmetrically to the inflation gap. Finally, as we show, our modified "Taylor" rule provides a useful benchmark to gauge the position of policy at different critical junctures of the economy. Taken all together, our results suggest that Bundesbank policy since 1973 may be characterized as being reasonably similar to Federal Reserve policy under Alan Greenspan.

Section 10.6 offers concluding remarks.

10.2 Institutions of Bundesbank Policy

As is commonly presumed, the overriding objective of German monetary policy is to control inflation. The institutional design supports this goal in two main ways. First, formal legislation explicitly restricts political influence. Second, each year the Bundesbank clearly articulates an inflation objective and then establishes a target for the growth of a key monetary aggregate, based on this objective.

At the same time it is important to recognize that the system allows for flexibility. The monetary and inflation targets, for example, are only guidelines and not legal mandates. Events in the real economy can (and often do, as we will see) induce the Bundesbank to deviate from these guidelines, though not without some kind of official explanation.

With these general observations in mind, we proceed to characterize the institutional design of Bundesbank policy. Section 10.2.1 describes the organization and jurisdiction of the German central bank. Section 10.2.2 discusses the practice of monetary and inflation targeting. Section 10.2.3 describes the operating procedures for conducting monetary policy. Here we argue that, despite the focus on monetary aggregates, short-term interest rates provide a better overall indication of the thrust of policy than do the aggregates. In this respect there are some strong similarities with U.S. monetary policy.

10.2.1 Central Bank Design and Jurisdiction

Much as the experience of the Great Depression shaped the development of monetary and financial institutions in the United States, memories of the hyperinflation influenced the design of the German central bank. Article 3 of the Deutsche Bundesbank Act of 1957 empowers the German central bank to regulate the amount of currency and credit in circulation with the aim of safeguarding the currency. To ensure that this goal is feasible, legal mandates free monetary policy from the demands of fiscal policy. To avoid the mistakes of the hyperinflation, article 20 of the act prohibits the central bank from financing government deficits. Decisions on the course of monetary policy are made by a council that is independent of the federal government. Article 12 of the act makes this independence explicit.[1]

The formal body that sets monetary policy is the Central Bank Council, which closely resembles the federal Open Market Committee. It consists of the Bundesbank Board (analogous to the Federal Reserve Board) and the presidents of the German *Land* central banks (analogous to the presidents of the regional reserve banks). The Bundesbank Board consists of a president, vice president, and up to six other board members. The federal government nominates the board members, while the state governments nominate the presidents of the *Land* central banks. Terms are for eight years. Except for the constraint of mandatory retirement, council members typically are invited to serve a second term. The long terms are justified as a means to insulate the governing body from political pressures.

From the perspective of political independence, any differences between the institutional setup of the Bundesbank and the Federal Reserve are not dramatic. Grilli, Masciandaro, and Tabellini (1991) assign the German central bank a slightly higher independence rating than its U.S. counterpart because the Bundesbank president is guaranteed a longer term than is the Federal Reserve Board chair (eight years versus four years.)

Finally, the Bundesbank's jurisdiction is not completely independent of the federal government. The latter has discretion over exchange rate agreements. At least in practice, however, the government cannot force the Bundesbank to maintain agreements that threaten domestic price stability. Before Germany entered the European Monetary System (EMS), for example, the Bundesbank won a provision from the federal government that it could deviate from the exchange agreement if it was deemed necessary to do so in order to maintain low inflation (Neumann and Von Hagen 1993). In effect this meant that the Bundesbank assumed a clear leadership role in the EMS. At least for a period

1. Article 12 encourages the Bundesbank to cooperate with the economic objectives of the federal government, but not to the extent that doing so may conflict with the overriding goal of price stability. The article explicitly forbids the federal government to formally participate in monetary policy decisions.

of time, this was a suitable arrangement for the other countries involved. Because of its reputation the Bundesbank served as an informal nominal anchor. On numerous occasions other central banks simply followed the response of German interest rates to exogenous shocks.[2]

10.2.2 Monetary and Inflation Targeting

The Bundesbank is widely known for its practice of setting monetary targets. Perhaps its most distinctive feature, though, is its simultaneous practice of setting inflation targets. Inflation targeting is slowly increasing in popularity among central banks, and is currently a popular subject of academic discussion. It is perhaps not widely appreciated, however, that always underlying Germany's announced monetary target is an explicitly stated goal for inflation.[3] This contrasts with the United States, for example, where in the past monetary targets have been set without any explicit public rationalization.

Also not widely appreciated is the flexibility built into the policy rule. There is no blind commitment to hitting the monetary targets.[4] The view is that the monetary policy will be judged on its inflation scorecard, and it will not be penalized for missing monetary targets if inflation is under control. In addition there has not been a unilateral focus on inflation. As we show later, on a number of occasions, the Bundesbank has tolerated deviations from the targets in order to pursue what may be construed as a countercyclical policy.[5]

The Targeting Procedure

The practice of targeting began in 1975, after the breakup of Bretton Woods. The Bundesbank felt the need to maintain some kind of explicit nominal anchor to guide policy in the post–Bretton Woods era. The procedure works as follows: Each year the Bundesbank first establishes a goal for inflation. A target growth rate for a designated monetary aggregate is then established that is meant to be consistent with the inflation goal. In particular the money-growth

2. Uctum (1995), among others, provides some formal evidence for the Bundesbank's leadership role in the EMS. The paper identifies a clear causal relationship between German short-term interest rates and the short-term interest rates of other countries.

3. Bundesbank officials are resistant to equating their selection of an inflation goal with inflation targeting. They maintain that the ultimate target is price stability. Any deviation of the inflation goal from price stability is due to what they term "unavoidable" factors.

4. The notion that the targets serve as guidelines rather than as rigid mandates is a prominent theme in many studies of Bundesbank behavior. See, for example, Bernanke and Mishkin (1992); Kahn and Jacobson (1989); Trehan (1988); Von Hagen (1994). In addition, Bundesbank officials themselves are rather open about the flexibility inherent in the system. For example, to quote, Otmar Issing (1995, 5), the current head of the Bundesbank's research department, "Even in Germany, where a high degree of stability of financial relationships was observed, the central bank has never seen fit to transfer monetary targeting to an 'autopilot,' as it were."

5. Even in its official publications, the Bundesbank makes clear that circumstances may justify deviating from the targets. It states that, while the monetary targets "include a recognizable steadying element, they are not meant to preclude any reaction to the developments of economic activity, exchange rates, costs, and prices" (Deutsche Bundesbank 1989, 99).

target is backed out of a conventional quantity-theory equation that links money, velocity, prices, and output. As inputs into the equation, the Bundesbank uses the target rate of inflation and estimates of the trend growth of velocity and the trend growth of capacity output. The motive for using estimates of trend as opposed to near-term output and velocity growth in the calculation is to avoid trying to fine-tune inflation.[6] Instead, the objective is to maintain a low long-run average inflation rate. By clearly signaling its intent to gear policy toward achieving this long-term inflation goal, the Bundesbank seeks to influence private-sector wage and price adjustments.[7]

Originally, a fixed money target was announced. After two years, however, this was changed to a fixed range. The move to the range reflects the reality that the monetary aggregate is difficult to tightly regulate and that both output and velocity may deviate considerably from trend in the short run. Additional flexibility is provided by a midyear review of targets, which allows changing the targets in light of new information. The Bundesbank has made use of this option only once, however, during 1991, in the early stages of reunification. Finally, the targets are fixed for a fourth-quarter-to-fourth-quarter growth rate of a variable. Originally, they were from December to December, but the monthly pinpointing introduced too much transitory noise.

How does the Bundesbank set its inflation target? The official goal is to keep inflation from rising above its "unavoidable" level. Using this criteria, the Bundesbank has set a goal of 2% annual inflation for each year since 1986 (see table 10.1). The Bundesbank refrains from reducing the target to 0% because the official price index may overstate the true inflation rate since it tends to undercompensate for improvements in the quality of goods. Fixing the target at 2% ensures that measurement error in the price index will not inadvertently induce the Bundesbank to tighten (Issing 1995).

In the past the Bundesbank has also taken into account stabilization considerations in fixing the target inflation rate, at least implicitly. In the initial year of targeting, 1975, it set the inflation goal at 4.5%. This objective was picked with the aim of gradually reducing inflation over time. At the time, Germany (like the United States) was experiencing stagflation, due to the oil shocks of 1973 and 1974. The target was reduced to 2% gradually over time. The fact

6. Indeed, Bundesbank officials state explicitly that the central bank does not try to fine-tune either inflation or money growth in the short term. To quote Issing (1995, 8) again: "in the short term the relationship between the money stock and the overall domestic price level is obscured by a host of influencing factors. Any attempt at keeping the money stock on the desired growth path at all times would therefore inevitably spark off considerable interest rate and exchange rate fluctuations, provoke shocks to the trend of economic activity and hence cause unnecessary economic costs in the shape of adjustment on the part of economic agents. Accordingly, the Bundesbank has time and again pointed to the medium term nature of its strategy which is aimed at cyclical stabilization."

7. In particular the Bundesbank states that an important purpose of the targeting procedure is to "make the aims of monetary policy clearer to labor and management, whose cooperation is essential if inflation is to be brought under control without detrimental effects to employment" (Deutsche Bundesbank 1989, 97).

Table 10.1 History of Money-Growth Targets and Unavoidable Inflation

	Money Growth		Inflation	
Year	Target	Actual	Target	Actual
1975	8	10	4.5	5.6
1976	8	9	4.5	3.7
1977	8	9	3.5	3.3
1978	8	11	3.0	2.6
1979	6–9	6	3.0	5.4
1980	5–8	5	4.0	5.3
1981	4–7	4	3.8	6.7
1982	4–7	7	3.5	4.5
1983	4–7	7	3.5	2.6
1984	4–6	5	3.0	2.0
1985	3–5	4.5	2.5	1.6
1986	3.5–5.5	8	2.5	−1.0
1987	3–6	8	2.0	1.0
1988	3–6	6.7	2.0	1.9
1989	5	4.6	2.0	3.0
1990	4–6	5.6	2.0	2.7
1991	4–6	5.2	2.0	4.2
1992	3.5–5.5	9.4	2.0	3.7
1993	4.5–6.5	7.4	2.0	3.7

Sources: Kole and Meade 1994; Von Hagen 1994.

Notes: From 1975 to 1984 the Bundesbank announced a rate of "unavoidable" inflation as its input to the determination of money-growth targets. From 1985 to 1993 the objective was the rate of inflation consistent with "price stability."

that the target was not set lower initially suggests that, while controlling inflation may be its primary goal, the Bundesbank is not willing to do it at any cost.[8]

As further evidence of the Bundesbank's pragmatism, the previous year's performance of inflation relative to its target does not directly affect the current target choice. The targets are simply rebenchmarked, implying that the Bundesbank accommodates any overshooting in the previous year. It thus does not try to target a path for the price level. We return to this point in section 10.3, during the historical review of monetary policy.

Choice of a Monetary Aggregate

What determines the monetary aggregate that the Bundesbank targets? The desired aggregate must satisfy two conventional criteria. First, it should be reasonably controllable. Second, it should obey a relatively predictable relationship with nominal GDP. These criteria quickly eliminate narrow money

8. The Bundesbank officially acknowledges that the need for a gradualist approach to reducing inflation influenced its targeting decisions. It states that in setting the targets "it took account of the fact that price increases which have already entered the decisions of economic agents cannot be eliminated immediately, but only by degrees" (Deutsche Bundesbank 1989, 97).

aggregates like M1. Substitution between demand deposits and near-money substitutes (e.g., time and savings deposits) make this aggregate difficult to regulate. It also induces large fluctuations in M1 that are unrelated to the course of economic activity.

The Bundesbank originally settled on a construct it termed central bank money (CBM). The idea underlying the construct was to develop an aggregate that was a weighted average of all existing monetary instruments, where the weights reflect the relative "moneyness" of each instrument. The elements of CBM are, roughly speaking, the sum of currency held outside the banking system and the components of the broad aggregate M3 (which corresponds to M2 for the United States) weighted by the respective reserve requirement that existed in 1974. Thus, CBM is roughly the monetary base minus excess reserves. It differs by not including reserves against foreign deposits and by using the 1974 reserve requirements as opposed to the current ones. The rationale for using reserve requirements to weight the aggregates was that reserve requirements reasonably reflected the relative liquidity of each bank deposit liability.

In 1988 the Bundesbank switched to targeting the broader money aggregate M3. Strong currency growth in 1987 (due possibly to low interest rates) led to a rapid expansion of CBM. The Bundesbank felt that the broader aggregate was less susceptible than CBM to gyrations stemming from currency substitution (Trehan 1988). The decision to change the target aggregate is one of a number of pieces of evidence that the Bundesbank does not conduct policy on automatic pilot. New market developments can influence policy.

A number of studies have demonstrated that the relation between M3 and nominal GDP has been fairly stable over time (e.g., Trehan 1988). Some papers have argued that the early stages of reunification have not disrupted this relationship (e.g., Von Hagen 1994; Kole and Meade 1994). Very recently, however, there has been considerable financial innovation, patterned after what has occurred in the United States over the last five to ten years.[9] There is some possibility that this development may introduce the same kind of instability in M3 that the United States has experienced with its M2 aggregate. If this does occur, we should not be surprised to see a new target aggregate emerge.

10.2.3 Operating Procedures

Despite the public focus on monetary aggregates, the daily management of policy is concerned with the setting of short-term market interest rates. Like many other central banks, the Bundesbank translates its main policy goals (e.g., controlling inflation) into near-term interest rate objectives. It in turn supplies bank reserves to meet these objectives. Even in its official publications, the Bundesbank states (in its own oblique way) that, in the short run,

9. For a description of how recent financial innovation is affecting the monetary aggregates in Germany, see *German Economic Commentary* (Goldman Sachs), no. 42 (1994).

moderating market interest rate fluctuations takes precedence over meeting monetary targets.[10] In section 10.4 we present formal evidence that supports this contention.

Until the mid-1980s the Bundesbank manipulated short-term market interest rates (and bank reserves) via discount window lending to commercial banks. It made available two types of credit: discount and Lombard. Banks could receive discount credit at a preferred rate, up to a fixed quota. To meet short-term liquidity needs beyond the quota limit, they could obtain Lombard credit at a premium rate. Under normal circumstances Lombard credit was generally available in elastic supply. In periods of tightening, though, limits could also be placed on the use of this credit.

Both the discount and Lombard rates are posted rates. The market rate that discount window lending most directly affects is the rate in the interbank market for reserves, known as the day-to-day rate or the call money rate. As in the United States, reserve management policy is geared toward influencing the interbank rate.[11] Short-term variation in this rate therefore reflects the intention of monetary policy. As figure 10.1 indicates, the day-to-day rate tends to fluctuate in the band fixed by the discount and Lombard rates.

Since 1985 the Bundesbank has supplied banks with reserves mainly via repurchase agreements, which are essentially collateralized loans with a maturity of two to four weeks. Lombard credit has largely dried up. Nonetheless, the Bundesbank still posts a Lombard rate, mainly as a way to signal its intentions. Reserve management continues to directly influence the day-to-day rate, which still tends to fluctuate between the discount and Lombard rates, as figure 10.1 illustrates. Further, the day-to-day rate also tends to move closely with the rate on repurchase agreements, known as the repo rate. Despite the midstream change in operating procedures, therefore, it is still reasonable to view the day-to-day rate as the Bundesbank's policy instrument for the full post–Bretton Woods era.

10.3 A Narrative Description of Bundesbank Policy

In this section we provide a selective review of Bundesbank policy during the post–Bretton Woods era.[12] Our goal is to obtain narrative evidence on how the Bundesbank operates in practice.

It is useful to divide the review into four episodes: (1) 1973–78, the period

10. For example, the Bundesbank states that, because commercial banks' demand for reserves is "virtually inelastic" in the short run, it "has no choice but to meet the credit institutions' need for central bank balances in the short run. At times it may even have to provide more central bank balances than are strictly compatible with the growth in the money stock" (Deutsche Bundesbank 1989, 105).

11. Bernanke and Blinder (1992) propose treating the funds rate as the operating instrument for U.S. monetary policy. Bernanke and Mihov (1995) present evidence in support of this approach.

12. For additional information on the history of postwar Bundesbank policy, see Tsatsaronis (1993).

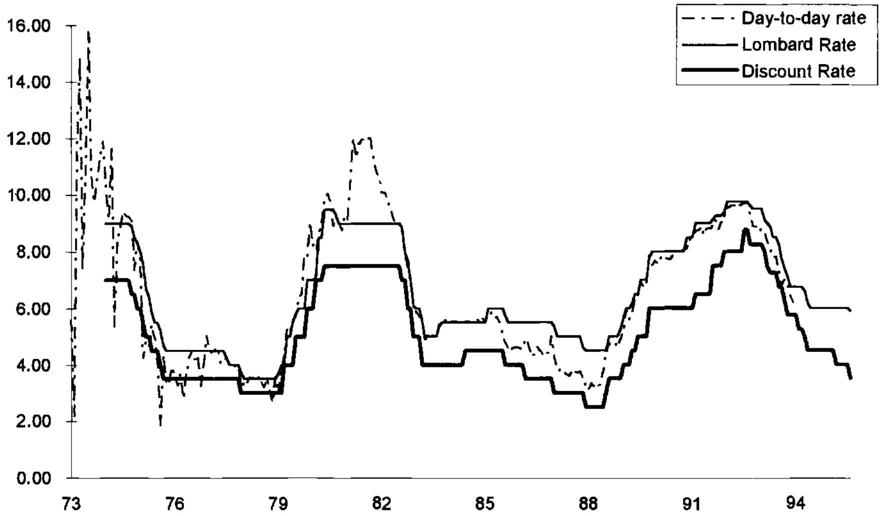

Fig. 10.1 German short-term interest rates

immediately after Bretton Woods was abandoned and after the first major oil shock occurred; (2) 1979–83, when the second major oil shock occurred and the United States tightened monetary policy; (3) 1983–89, the era of stagnation and late recovery in West Germany; (4) 1990–93, the early years of reunification. After a brief discussion of each episode, we summarize the key lessons about the conduct of Bundesbank policy.

To aid the discussion, we refer (often implicitly) to figure 10.2, which plots consumer price index (CPI) inflation, the growth rate of industrial production, and the day-to-day rate, all for West Germany. To provide a benchmark, the figure also plots the analogous variables for the U.S. economy. In addition figure 10.3 plots the behavior of both the real D-mark/dollar exchange rate, and the trade weighted exchange rate.

10.3.1 1973–1978

Shortly after it was freed from its obligations under Bretton Woods in early 1973, the Bundesbank raised short-term interest rates dramatically in order to curtail steadily rising inflation. On a number of occasions during this period it publicly announced a commitment to maintaining a tight monetary policy until inflation was under control (Tsatsaronis 1993). Unfortunately, later in the year came the first major oil shock. Thus, despite a restrictive policy through most of 1973, inflation climbed above 7% by the end of 1974. Though below the nearly double-digit level reached in the United States, this rate was clearly high by West German standards.

The Bundesbank continued to signal its intent to combat inflation. By the end of 1974, it had the system of inflation and monetary targeting intact. It announced a target rate of inflation for 1975 of 4.5% and a target rate of mone-

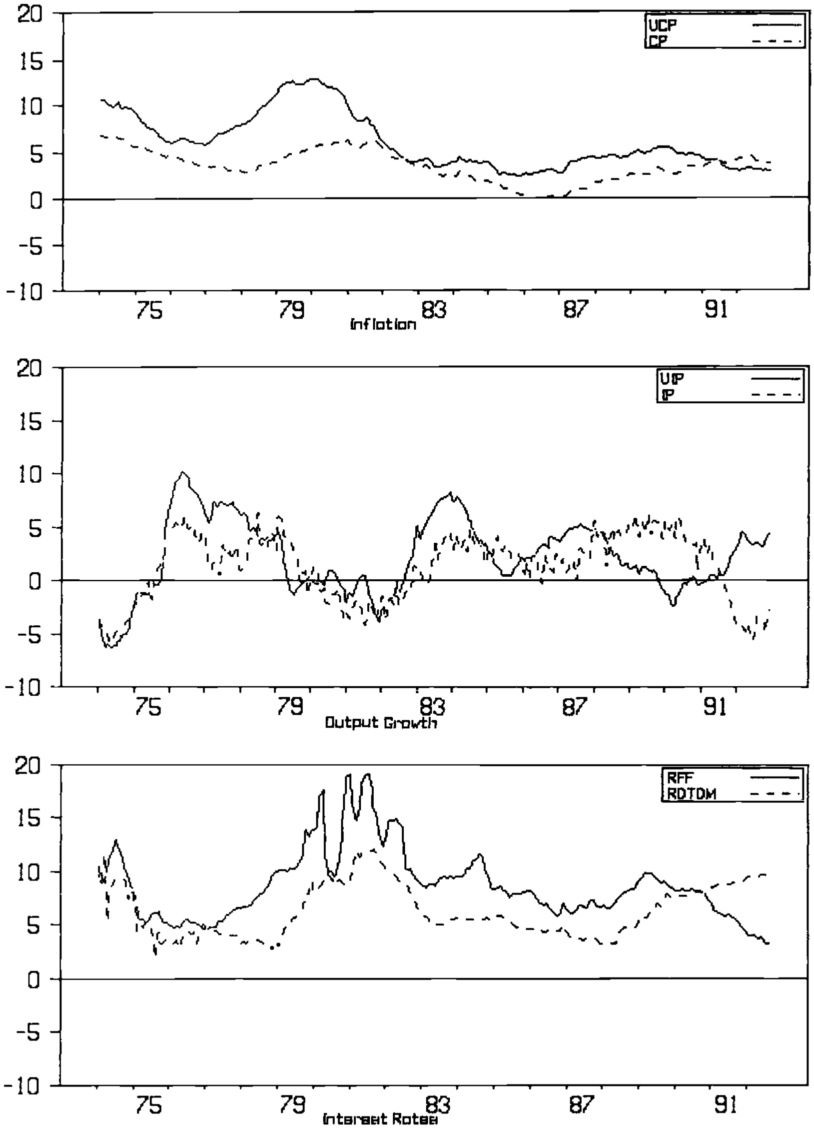

Fig. 10.2 Inflation, output growth, and interest rates: *UCPI,* U.S. consumer price index; *CPI,* German CPI; *UIP,* U.S. industrial production; *IP,* German industrial production; *RFF,* federal funds rate; *RDTDM,* day-to-day interest rate

tary growth of 8%. While these goals were ambitious, they nonetheless reflected a gradualist approach to reining in inflation.

As in the United States, the combined force of the oil shocks and a restrictive monetary policy forced the economy into a deep recession. The severe downturn induced the Bundesbank to ease, along with the Federal Reserve Board.

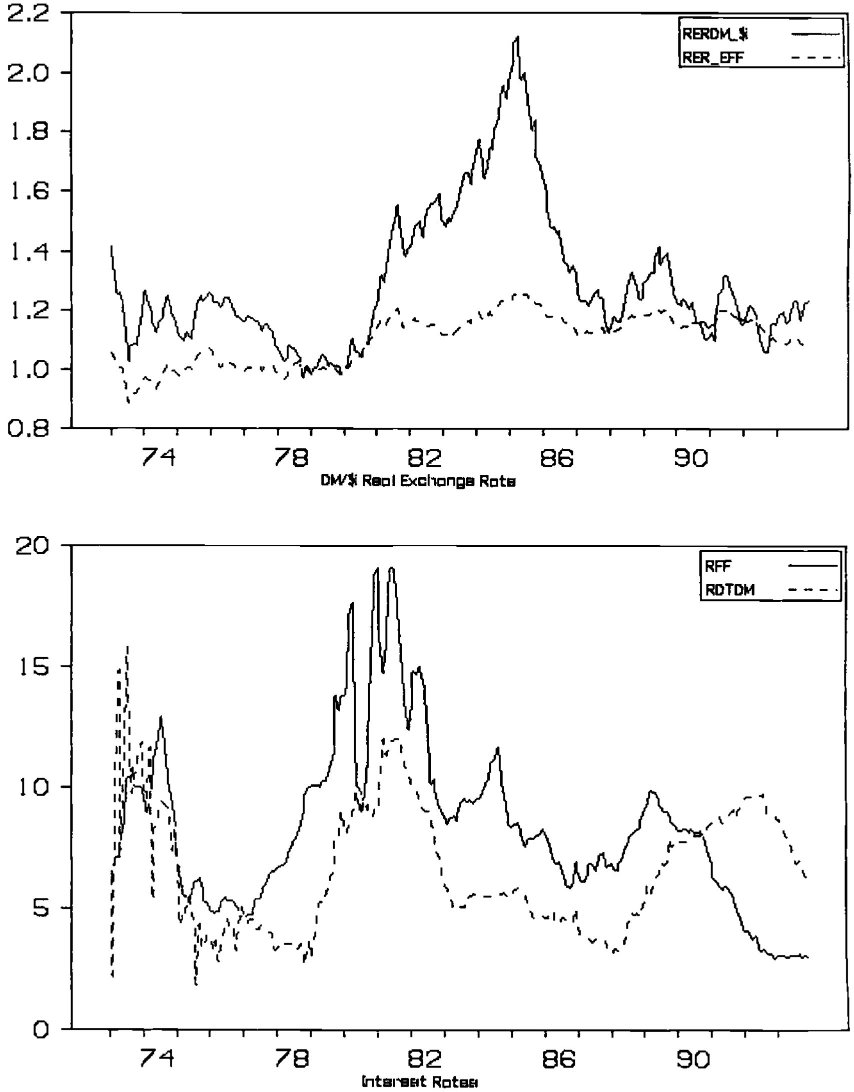

Fig. 10.3 Exchange rates and interest rates: *RERDM$*, D-Mark/dollar exchange rate; *RER EFF*, trade-weighted exchange rate; *RFF*, federal funds rate; *RDTDM*, day-to-day interest rate

It permitted both inflation and money growth to overshoot their targets by 1.1 and 2 percentage points, respectively. In particular it reduced short-term rates and kept them low through most of the rest of the decade. While ex post real short-term rates were above the negative rates being recorded in the United States, they were nonetheless clearly below the trend for the era.

After a brief expansion period, growth began to slacken in 1978. At this time the Bundesbank cited an appreciating mark to justify continued easing. In effect the Bundesbank was easing rates to stimulate a softening real economy. While it is not always so forthcoming, it has acknowledged that concern for the real economy influenced its behavior during this period.[13]

10.3.2 1979–1983

Just prior to 1979, macroeconomic conditions in West Germany were more favorable than in the United States. Output growth was roughly similar. While the inflation rate was still stubbornly high by West German standards, it was well below the U.S. inflation rate. Fortunes were reversed, however, in the eight years after.

The first oil shock and the subsequent shift in U.S. monetary policy ushered in a return to tight money. The Bundesbank was committed to avoiding (what it viewed as) its earlier mistake of largely accommodating the increases in oil prices during 1973 and 1974 (Tsatsaronis 1993). In addition the sharp rise in U.S. interest rates precipitated a sharp and steady depreciation of the mark relative to the dollar that lasted until 1985.

The Bundesbank responded to these events by raising the day-to-day rate from about 3% in 1979 to about 12% in the first quarter of 1981. In terms of basis points, this increase was similar in magnitude to the rise in the U.S. funds over same period. Ex post real rates rose sharply, as they did in the United States.

Again, its pragmatic side showed through: the Bundesbank raised the target rate of inflation from 3% in 1979 to 4% in 1980. And it still permitted inflation to overshoot its target by 1.3%. The weakening of the real economy at the time was again apparently a factor in the Bundesbank's decision making. For the next two years it continued the gradualist policy, tolerating above-target inflation in order to avoid further weakening a recessionary economy.

From the period of peak inflation to the beginning of 1983, the contraction in real activity in West Germany was of similar magnitude to that in the United States. On the other hand, the drop in inflation over the same time interval was far more dramatic in the United States. At the start of the period the U.S. inflation rate was nearly double that in West Germany. By the end it was roughly equal. These facts correspond closely to Ball's observation (1994) that the sacrifice ratio in Germany actually exceeds its counterpart for the United States.

Many have found this outcome surprising. Underlying this view is the belief that the Bundesbank's reputation for fighting inflation should have made the transition to lower inflation less painful in this country relative to other countries at the time. This in turn raises the possibility that the practical gains from establishing credibility in fighting inflation may not be substantial. Fully re-

13. The Bundesbank states that when the D-mark appreciated "excessively" in 1978 (and also in 1986–87), it felt "forced to pursue a more expansionary monetary policy and allow interest rate reductions . . . which led to an overshooting of the monetary target. Otherwise the appreciation shock would have too much for the economy, while inflationary pressures were being moderated by the appreciation" (Deutsche Bundesbank 1989, 103).

solving this issue is well beyond the scope of this paper, though we return to the matter later.

For now we simply note two considerations. First, the sacrifice ratio could be highly nonlinear in practice, something for which the Ball calculation does not allow. One could imagine why trying to move an economy from 6% to 2% inflation might result in greater short-run output loss than, say, trying to move it from 10% to 6%. This nonlinear relationship could resolve at least some of the differences in the U.S. and West German experience.

Second, and somewhat related, at the beginning of 1979 the public perception of the Bundesbank's commitment to reduce inflation below 5–6% may have been more ambiguous than it is today. As we have discussed, the Bundesbank pursued a relatively lax monetary policy in the roughly four years prior to the shift to tightening. Again, we turn to this issue later.

10.3.3 1983–1989

While the U.S. economy staged a strong recovery following the 1981–82 recession, the same was not true of the West German economy. Growth was slightly below trend in 1983 and only slightly above trend in 1984 and 1985. The unemployment rate continued to rise steadily, reaching 9.3% in 1985. On the other hand, a product of the weak economy was receding inflation. Inflation was below target from 1983 to 1985. During this period the Bundesbank returned short-term nominal rates to slightly above pre-1979 levels. Lower inflation, however, implied significantly higher real interest rates than during the late 1970s. As we show in section 10.5, real rates during this period hovered slightly around and above long-run equilibrium.

Why the West German economy (along with the rest of the European economy) performed poorly over this period is a complex issue, another that is well beyond the paper's scope. It is plausible that high real interest rates were a factor. Real rates were similarly high in the United States at this time. The United States, however, had shifted to an expansionary fiscal policy. The same kind of fiscal stimulus was not present in West Germany.

Another often-cited possibility is that the German economy was experiencing structural labor market problems at this time (e.g., Kahn and Jacobson 1989). This would imply that the stagnant economy was due mainly to supply-side problems, that is, declines in capacity output. It is true that real wages grew rapidly from 1973 through 1989. The period 1982–85, though, does not appear to have been a period of rapid wage growth. While we do not claim to resolve the issue, later we examine more carefully the behavior of output relative to capacity and real interest rates over this period.

In mid-1984 the United States began a systematic reduction of the funds rate in an effort, among other things, to reduce the value of the dollar. In early 1985 the mark began a steady appreciation against the dollar that lasted through early 1988. In response to the appreciating mark, the real economy weakened. Output growth declined over 1986 and 1987. Inflation fell below the 2% target.

The weak economy prompted the Bundesbank to once again demonstrate its flexibility in both actions and language. Citing an appreciating mark, the Bundesbank eased short-term interest rates. Real short-term rates fell, though not to the levels of the mid- to late 1970s. Following the easing, output growth picked up in 1989. A strong recovery finally materialized.

10.3.4 1990–1993

The robust output growth in West Germany that began in 1989 continued through reunification in 1990, and into 1991. The unemployment rate fell over this period, for the first time in a decade.

Reunification of course introduced new complexities for monetary management. At the time, though, the Bundesbank had two particular concerns. First, the robust expansion led inflation to accelerate above target in 1991. Second, the one-for-one currency exchange with East Germany led to a whopping 13% increase in the M3 aggregate within a single month. The jump complicated the problem of monetary targeting. Of greater concern to the Bundesbank was the possible consequence for inflation, especially given the large implicit subsidy in the currency swap.

Fear of renewed inflation induced the Bundesbank to aggressively tighten. It raised short-term nominal rates above 9%. Real rates rose to the high levels of the early 1980s. For the first time since Bretton Woods, both nominal and real rates in Germany were higher than in the United States. One casualty of the tightening was the EMS. The EMS collapsed in September 1992 due in large part to the unwillingness of other members, especially the United Kingdom, to keep their interest rates in line with the soaring German rates. The tightening also had predictable effects on the Germany economy. Due at least in part to monetary policy, output plummeted. West German industrial production dropped 15% from January 1992 through September 1993. And the unemployment rate rose nearly 3 percentage points over this same period.

The recessionary economy prompted the Bundesbank to ease rates. The easing, however, was modest. While both nominal and real rates declined, the level of the real rate remained high relative to earlier periods of downturns. We return to this issue in section 10.5.

10.3.5 Bundesbank Policy in Practice: Summary of the Narrative Evidence

The Bundesbank aggressively raises short-term interest rates in response to perceived inflationary pressures. An exception was the period 1975–78, when it maintained subnormal short-term real interest rates while inflation was above the desired trend, much as the United States was doing at the same time. There is some suggestion, even in official Bundesbank publications, that the experience with stagflation during this period explains why the Bundesbank has been more vigilant about controlling inflation in the years since then. The German experience suggests that, once inflation starts to persist above trend, it is difficult to bring down costlessly, even for a central bank with the reputation of the Bundesbank. Again, there is a clear parallel with the U.S. experience.

In its actions, if not its public pronouncements, the Bundesbank also clearly takes into account the performance of the real economy. While it desires to control inflation, it will not do so at any cost. Conversely, a soft economy with an appreciating D-mark normally induces the Bundesbank to ease. A case can be made, though, that in recent years the easings have been more modest relative to the overall condition of the economy.

What role does targeting play in the day-to-day formulation of policy? The targets do not define a rigid rule for money growth. In the period 1975–93 the Bundesbank failed to meet its money-growth target in 9 of 19 possible instances. Rather, as the Bundesbank has made clear on numerous occasions, the targets are to be viewed as guidelines. They provide the policy decision with a clear reference point. The Bundesbank is free to deviate from this reference point. But it is expected to explain the circumstances that lead it to do so. In this way the targets place discipline on the policymaking process.

The pattern of deviations from the inflation and money-growth targets are in our view symptomatic of the implicit stabilization component in the Bundesbank policy rule. The top panel of figure 10.4 plots the target price level (in logarithms) implied by the sequence of target inflation rates, relative to the actual price level. The middle panel does the same for the money supply. Note that during the high inflation of the late 1970s and early 1980s the Bundesbank persistently accommodated overshooting of the price target by simply rebenchmarking the path for the target price each year. That is, it made no attempt to target a long-term path for the price level, presumably because it feared the consequences for the real economy.

The bottom panel plots the percentage deviation of each variable from its target. Note that between 1979 and 1989 the two series are almost mirror images of one another. This strong negative relationship between the price-level and money-stock deviations also reveals an element of stabilization within the policy rule. Generally speaking, when the price level significantly overshoots its target, the Bundesbank pursues a contractionary policy that tends to push the money supply below target. As we have been emphasizing, the Bundesbank's toleration of this overshooting is evidence of a stabilization concern. In a way, the simultaneous undershooting of the money-growth target provides it with a formal justification not to tighten further.

Conversely, in periods where the price level is significantly under target, the Bundesbank often pushes money growth above target. The undershooting of the price target presumably gives it leeway to ease monetary policy. In these situations, as we have discussed, it usually cites an overvalued D-mark to rationalize its aims.

10.4 Identifying the Bundesbank's Policy Reaction Function: A Structural VAR Approach

In section 10.3 we developed a set of informal conclusions about the nature of Bundesbank policy. In this section and the next we probe the issues further

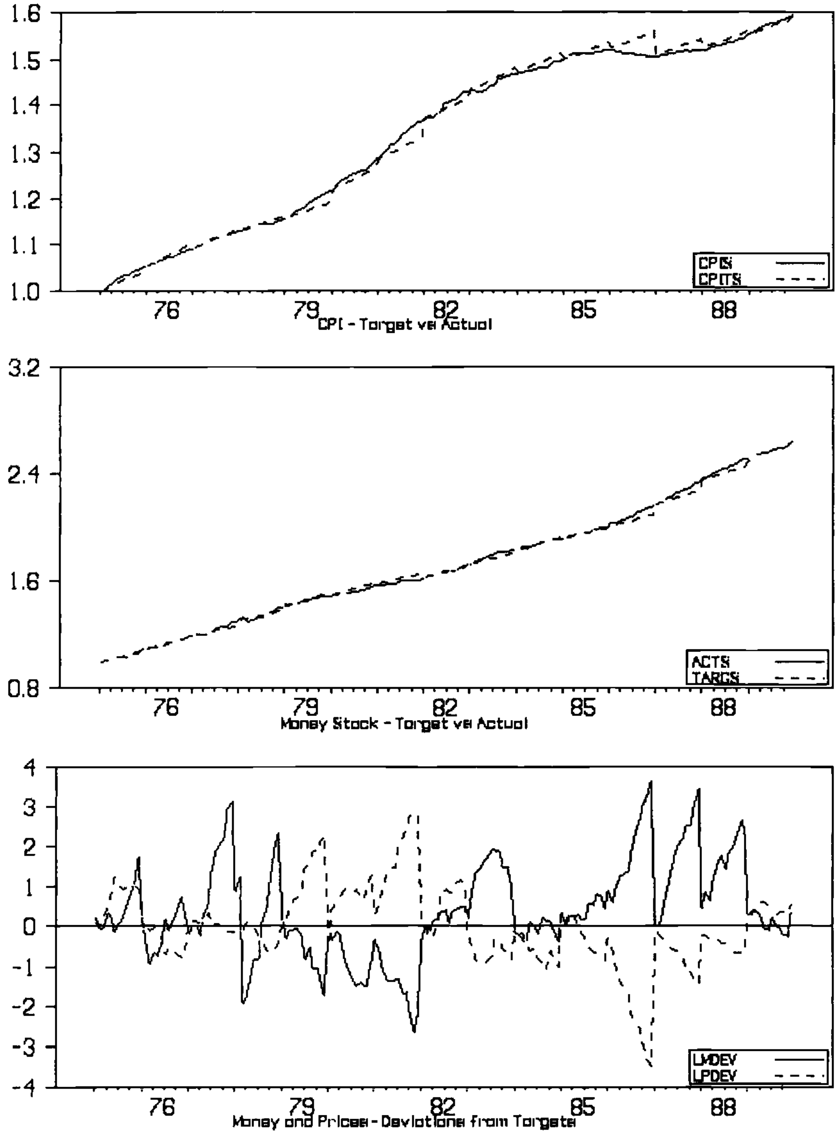

Fig. 10.4 Bundesbank money and price targets: ***CPI%,*** **consumer price index (January 1975 = 1) percentage (log);** ***CPIT%,*** **CPI target (January 1975 = 1) percentage (log);** ***ACTS,*** **actual money supply (log; January 1975 = 1);** ***TARGS,*** **target money supply (log; January 1975 = 1);** ***LMDEV,*** **percentage of money-stock deviation;** ***LPDEV,*** **percentage of price-level deviation**

by estimating policy reaction functions. Based on the previous discussion, we take as the Bundesbank's policy instrument the day-to-day interest rate. Our goal then is to identify an empirical relationship that is useful for characterizing how the Bundesbank adjusts the short-term rate over time.

In general, identifying a reaction function for central bank policy involves confronting two basic complex issues. First, one has to take a stand on the set of information to which the central bank responds. The central bank may have a primary goal of stabilizing inflation and output, for example. But it may (and in general does) take account of a far broader set of information than simply inflation and output. Additional information may be useful for forecasting future inflation and future output. Good examples are exchange rates and commodity prices. Also, the central bank may make use of intermediate targets such as the exchange rate or the money supply, either because it cannot directly observe current inflation and current output or because it desires some kind of commitment device. Indeed, the discussion in section 10.3 suggests that both the money supply and exchange rates are factored into Bundesbank policy decisions in an important way.

Second, there is a problem of simultaneity between the policy instrument and the information set. The Bundesbank may adjust short-term interest rates in light of news about exchanges rates, for example. But, certainly, the change in the short-term rate will feed back into the behavior of the exchange rate.

We take a two-pronged approach to the identification problem. The first prong, which we pursue in this section, is to estimate a policy reaction function for the day-to-day rate that is derived from a structural VAR model of the German macroeconomy.[14] With this reaction function we can characterize in a fairly general way how the Bundesbank adjusts policy in response to disturbances, such as supply shocks, changes in U.S. monetary policy, exogenous exchange rate shifts, and so on. The benefit of this approach is that we can address the identification issues by employing relatively few a priori restrictions (at least relative to other approaches). The cost is that because the estimated reaction function includes all the variables in the VAR it is difficult to interpret. Therefore, in section 10.5 we move on to the second prong, which involves imposing additional structure on the basic empirical model developed in this section.

10.4.1 Using a Structural VAR to Identify Policy Rules

The General Identification Strategy

Let y_t be a vector of macroeconomic variables and e_t be an associated vector of structural disturbances. The elements of e_t are mutually orthogonal iid disturbances. They are structural shocks in the sense that they are the primitive

14. For some useful descriptions of the structural VAR methodology, see Blanchard 1989; Gali 1992; Sims and Zha 1994; Kim and Roubini 1995; Bernanke and Mihov 1995.

exogenous disturbances to the economy. A very general representation of a macroeconomic framework that determines y_t is

$$(1) \qquad y_t = Cy_t + \sum_{i=1}^{\infty} A_i y_{t-1} + e_t,$$

where C and A_i are conformable square coefficient matrices, and where the diagonal elements of C are equal to zero. Equation 1 simply states that within this macroeconomy each variable may depend on its own lagged values plus the current and lagged values of all the other variables in the system. The feedback policy rule we are interested in identifying is the equation for the element of y_t that is the central bank policy instrument.

The logic of the structural VAR approach is to place a priori restrictions on the contemporaneous interactions among the macroeconomic variables in order to identify the coefficient matrix C. Once estimates of C are available, then it is possible to identify the dynamic impact of the structural shocks on the elements of y_t without placing any further restrictions on the data.[15] For the element of y_t that is the policy instrument, the exercise leads to a policy reaction function.

Subtract from each side of equation 1 $E_{t-1}\{y_t\}$, the expected value of y_t implied by the model, conditional on information at $t - 1$. Then define $y_t \equiv y_t - E_{t-1}\{y_t\}$ as the forecast error to obtain (dropping time subscripts for convenience):

$$(2) \qquad u = Cu + e.$$

In practice u is calculated as the forecast error of the reduced-form (i.e., VAR) representation of equation 1 (see note 15). Comparison of equations 1 and 2 indicates the restrictions on the contemporaneous interactions among the variables boil down to restrictions on the contemporaneous interactions between the reduced-form innovations. The identifying assumptions, therefore, take the form of restrictions on C (e.g., exclusion restrictions) based on assumptions about causality among the elements of u.[16]

Nonpolicy versus Policy Variables

To organize the identifying assumptions, it is useful to divide elements of y into nonpolicy and policy variables. For the purpose of studying monetary policy, we take as a policy variable any variable that the central bank may influ-

15. To see this, note that the reduced form of equation 1 is $y_t = \sum_{i=1}^{\infty} B_i y_{t-i} + u_t$, where $B_i = (I - C)^{-1}A_i$ and $u_t = (I - C)^{-1}e_t$. Since the lagged values of y_t are orthogonal to the vector of reduced-form disturbances u_t, estimates of the B_i may be readily obtained using least squares. Knowing both C and the B_i then makes it possible to trace the impact of a shock to any element of e_t on the path of any element in y_t.

16. Roughly speaking, a necessary condition for identification is that the number of restrictions on C (beyond the zero restrictions on all the diagonal elements of C) be at least as large as the number of parameters in C to be estimated.

ence within the current period (e.g., within the current month). This definition thus includes not only the central bank's direct policy instrument (e.g., the day-to-day interest rate), but also observable "jump" variables such as the exchange rate, over which it exerts indirect influence within the period. Due to the within-period simultaneity, the central bank is effectively choosing values of all the variables that move contemporaneously. Presumably, when the central bank adjusts the short-term interest rate, for example, it takes into account the implied contemporaneous reaction of the exchange rate.

The dual implication of our classification scheme is that nonpolicy variables respond only with a lag to movements in the policy variables. Output may react over time to a shift in interest rates, for example, but due to adjustment costs and so on, it does not respond instantaneously. From the standpoint of identification, innovations in the nonpolicy variables are exogenous to the innovations in the policy variables.[17] To identify the equation for the policy instrument, therefore, we need to worry only about addressing the possible contemporaneous simultaneity among the policy variables (e.g., how the day-to-day rate responds to the exchange rate and vice versa).

10.4.2 The Empirical Model

Variables

We use eight variables to describe the German macroeconomy. Five are nonpolicy variables. Of these, three are meant to characterize the state of the German economy: industrial production (*ip*), retail sales (*ret*), and the consumer price level (*p*). The two others reflect important external factors that influence the German economy: real commodity prices (*cp*) (meant to capture supply shocks) and the U.S. federal funds rate (*ff*).

The three Bundesbank policy variables are the day-to-day (i.e., short-term) interest rate (*rs*); the real money supply (*m*) (specifically the broad money aggregate M3 divided by the price level), and the real D-mark/dollar exchange rate (*er*). We treat the short-term interest rate as the Bundesbank's policy instrument, for reasons discussed in section 10.2.3.

17. In particular the contemporaneous exogeneity of the nonpolicy variables implies a set of useful exclusion restrictions on the coefficient matrix C in equation 2. Let u^x be the vector of reduced-form disturbances to the elements of y that are nonpolicy variables and let u^{pol} be the vector of reduced-form disturbances to the policy variables. Then equation 2 may be disaggregated as follows:

$$\begin{bmatrix} u^x \\ u^{pol} \end{bmatrix} = \begin{bmatrix} C^{xx} & 0 \\ C^{px} & C^{pp} \end{bmatrix} \begin{bmatrix} u^x \\ u^{pol} \end{bmatrix} + \begin{bmatrix} e^x \\ e^{pol} \end{bmatrix},$$

where the diagonal elements of the submatrices C^{xx} and C^{pp} are all equal to zero. The recursive structure implies we can separate the problem of identifying the equations for nonpolicy variables from that of doing the same for the policy innovations. It also implies that we can use the nonpolicy innovations as instruments in the policy-innovation equations. We will make use of both of these implications.

The real money supply and real exchange rate fit our policy-variable classification, since the Bundesbank can quickly influence these variables (via its choice of the short-term interest rate), and because its choice of interest rates presumably is influenced by these variables.[18] We use the D-mark/dollar rate since our reading of the narrative evidence suggests that it is this exchange rate that has had the the most influence over Bundesbank policy.

Identifying Assumptions

Our identifying assumptions about the contemporaneous interactions among the reduced-form innovations are as follows:

- Among the five nonpolicy variables, there is a recursive causal relationship, ordered as follows: commodity prices, industrial production, retail sales, the price level, and the funds rate.
- The reduced-form money and interest rate innovations (i.e., the money-demand and money-supply innovations) are given by

  $$u^{m} = \alpha_1 u^{ip} + \alpha_2 u^{rs} + e^{m} \tag{3}$$

  (money demand), and

  $$u^{rs} = \beta_1 u^{cp} + \beta_2 u^{m} + \beta_3 u^{er} + e^{rs} \tag{4}$$

  (money supply).
- The exchange rate innovation (u^{er}) may be influenced by any of the other seven innovations in the system (i.e., we place no restrictions on the exchange rate equation).

In general our main results are robust to different orderings among the nonpolicy variables. Nonetheless, some specific considerations motivated the particular sequence we picked. Over our sample, oil price shocks primarily drove movements in real-world commodity prices. Since oil shocks contain a large idiosyncratic component (due to the Organization of Petroleum Exporting Countries [OPEC], etc.), it seems reasonable to order commodity prices first in the system. Also, since movements in the U.S. funds rate are unlikely to affect German output and prices within the period, it seems reasonable to order this variable last among the nonpolicy variables. We place retail sales after production, based on the view that production adjusts to movements in demand with a lag.

Equation 4 reveals our assumptions about the contemporaneous information that the Bundesbank uses to adjust the short-term rate. This equation is key. We make two assumptions. First, any contemporaneous information the Bundesbank employs in its decision making must actually be available within the

18. Kim and Roubini (1995) also develop a structural VAR model with a nonrecursive relationship between the interest rate and the exchange rate.

period of its decision. Since news about industrial production, retail sales, and consumer prices become available only with a lag, we exclude innovations in these variables from the Bundesbank's information set. On the other hand, we let the Bundesbank adjust the interest rate to contemporaneous innovations in commodity prices, the money supply, and the exchange rate, since these variables are directly observed within the period. The second assumption, following Kim and Roubini (1995), is that within the period the Bundesbank only cares about the implications of news in the U.S. funds rate for the D-mark/dollar rate. Thus, the innovation in the funds rate does not enter the reaction function independently of the exchange rate.

The only other relation we restrict is money demand. Equation 3 relates the demand for real money balances to real output and the nominal interest rate, in keeping with standard convention.

Intuitively, the identification scheme works as follows: Excluding certain nonpolicy variable innovations from the money-supply equation 4 permits using these innovations as instruments for the two endogenous right-hand-side variables, specifically the exchange rate and money-supply innovations. Our decision criterion (which was based on assumptions about the timing of data release) led us to exclude more nonpolicy variables than was necessary to achieve identification. The results, however, do not rely on overidentification. We also consider a just identified version of the model and show that the results are essentially unchanged.

Sample Period and Estimation

Since our key identifying restrictions are based on assumptions about timing (e.g., variable X affects variable Y only with a lag), we use monthly data, the shortest frequency available. The sample period is August 1974 to September 1993. We begin shortly after the dismantling of Bretton Woods and continue through the early stages of reunification. To ensure that our results are not influenced by structural changes stemming from reunification, we also consider the sample period August 1974 to December 1989. In general we find that the results do not change over the two different samples.

We estimate the eight variable VARs, entering all variables in log-difference form except the two interest rates, which are in levels. In addition we impose two cointegrating relationships: between retails sales and industrial production, and between real money balances and industrial production.[19] In each case, cointegration tests justified imposing these long-run restrictions. Finally, in the VAR we include six lags of each variable, but we stagger the lags as follows: 1, 2, 3, 6, 9, 12. Convention dictates using twelve lags with monthly

19. We include a time trend in the cointegrating vector for real money balances and industrial production. We use the error-correction form rather than the standard log level representation because in the next section we need to make use of the model's forecasts of long-run equilibrium. Because the error correction imposes long-run restrictions among variables, it is better suited for making long-run forecasts.

data to avoid problems of seasonality. However, because the sample period is short relative to the number of variables and because we also want to use the model to make long-horizon forecasts in the next section, we opted for a more parsimonious parameterization.

10.4.3 Results

We are interested in assessing how the Bundesbank adjusts the short-term interest rate to disturbances to the economy, particularly in light of the narrative evidence developed in section 10.3. We first report evidence on how the Bundesbank adjusts the day-to-day rates to within-period news. We then analyze the response of the interest rate over time to various shocks to the economy. In this way we are able to characterize policy reaction function for the Bundesbank.

Policy Response to Contemporaneous News

Table 10.2 reports estimates of money-supply equation 4, which relates the innovation in the interest rate to the innovations in commodity prices, the money supply, and the exchange rate. The point estimates are as one would expect. The Bundesbank lets the short-term rate rise in response to news of increases in inflationary pressures, manifested in either a rise in commodity prices, a rise in the money supply, or a depreciation of the exchange rate. None of the news variables is statistically significant, however. This suggests that the Bundesbank does not try to tightly meet monetary or exchange rate targets within the month. It also suggests that it is mainly lagged rather than current information that is fed into the Bundesbank's policy rule. Within a given month the Bundesbank tends to maintain a desired short-term rate, given the information available at the start of the period.

As a check that our identification scheme is reasonable, we also report the estimates of the two other equations that enter the policy block, the money-demand and exchange rate relations. In both cases the outcomes are quite sensible. Money demand has a significant negative interest elasticity. An innovation in the funds rate causes the exchange rate to depreciate significantly, while an innovation in the German short-term rate does the reverse. Finally, a just-identified version of the model yields very similar coefficient estimates for all three equations.

Dynamic Policy Response to Various Shocks

We next assess how the Bundesbank adjusts the short-term rate over time to disturbances to the economy. To do so, we report the response to each of the eight structural shocks of a subset of four core variables that characterize the overall state of the economy and policy: industrial production, inflation, the short-term interest rate, and the real exchange rate. In addition we report the response of the variable that is shocked. Figures 10.5 and 10.6 show the results, the mean responses of the variables and their 95% confidence intervals.

Table 10.2 Structural VAR Estimates

Overidentified Model										
u^{m}	=	$0.024u^{ip}$	−	$0.003u^{rs}$	+	e^{m}				
		(0.021)		(0.001)						
u^{rs}	=	$0.459u^{cp}$	+	$12.39u^{m}$	+	$4.25u^{er}$	+	e^{rs}		
		(0.727)		(13.51)		(5.75)				
u^{er}	=	$0.09u^{ip}$	−	$0.03u^{ip}$	−	$0.03u^{ret}$	−	$0.50u^{p}$	−	$0.01u^{rs}$
		(0.12)		(0.04)		(0.09)		(1.01)		(0.003)
	+	$0.008u^{ff}$	−	$0.423u^{m}$	+	e^{er}				
		(0.002)		(0.39)						
Exactly Identified Model										
u^{m}	=	$0.032u^{ip}$	−	$0.003u^{rs}$	+	...	+	e^{m}		
		(0.019)		(0.001)						
u^{rs}	=	$0.427u^{cp}$	+	$11.45u^{m}$	+	$4.04u^{er}$	+	...	+	e^{rs}
		(0.756)		(13.95)		(5.75)				
u^{er}	=	$0.09u^{ip}$	−	$0.03u^{cp}$	−	$0.03u^{ret}$	−	$0.45u^{p}$	−	$0.01u^{rs}$
		(0.12)		(0.04)		(0.09)		(1.01)		(0.004)
	+	$0.008u^{ff}$	−	$0.392u^{m}$	+	e^{er}				
		(0.003)		(0.39)						

Notes: The sample is August 1974–September 1993. Estimation is by instrumental variables. For the u^{m} equation, the instruments are u^{cp}, u^{ip}, u^{ret}, u^{p}, u^{ff}, and e^{rs}. For the u^{rs} equation the instruments are u^{cp}, u^{ip}, u^{ret}, u^{p}, and u^{ff}. For the u^{er} equation, the instruments are u^{cp}, u^{ip}, u^{ret}, u^{p}, u^{ff}, e^{rs}, and e^{m}.

The results are very consistent with the narrative evidence, in two main ways. First, the Bundesbank aggressively adjusts short-term rates to control inflationary pressures. Second, it responds to exchange rate movements in a clearly countercyclical fashion.

Consider the effects of a commodity price shock, as portrayed in figure 10.5. The outcome looks very much like the consequence of a supply shock, as one would hope. Output declines while inflation rises. The Bundesbank sharply increases the short-term rate, to a point where it produces a sustained significant rise in the real rate. As the figure shows, the Bundesbank similarly adjusts the short-term rate to curtail inflationary pressures in response to output, retail sales, and inflation shocks.

The countercyclical response to the exchange rate may be seen two different ways. First, figure 10.6 shows that a depreciation of the exchange rate produces a sharp sustained rise in both nominal and real short-term rates. The rise in rates in turn generates a decline in output. After rising initially in response to the exchange rate depreciation, inflation rate drops quickly back to trend as the economy weakens. It follows, of course, that an exchange rate appreciation does just the opposite: there is an easing of rates and an eventual expansion, consistent with the narrative evidence. Second, the short-term rate also rises as

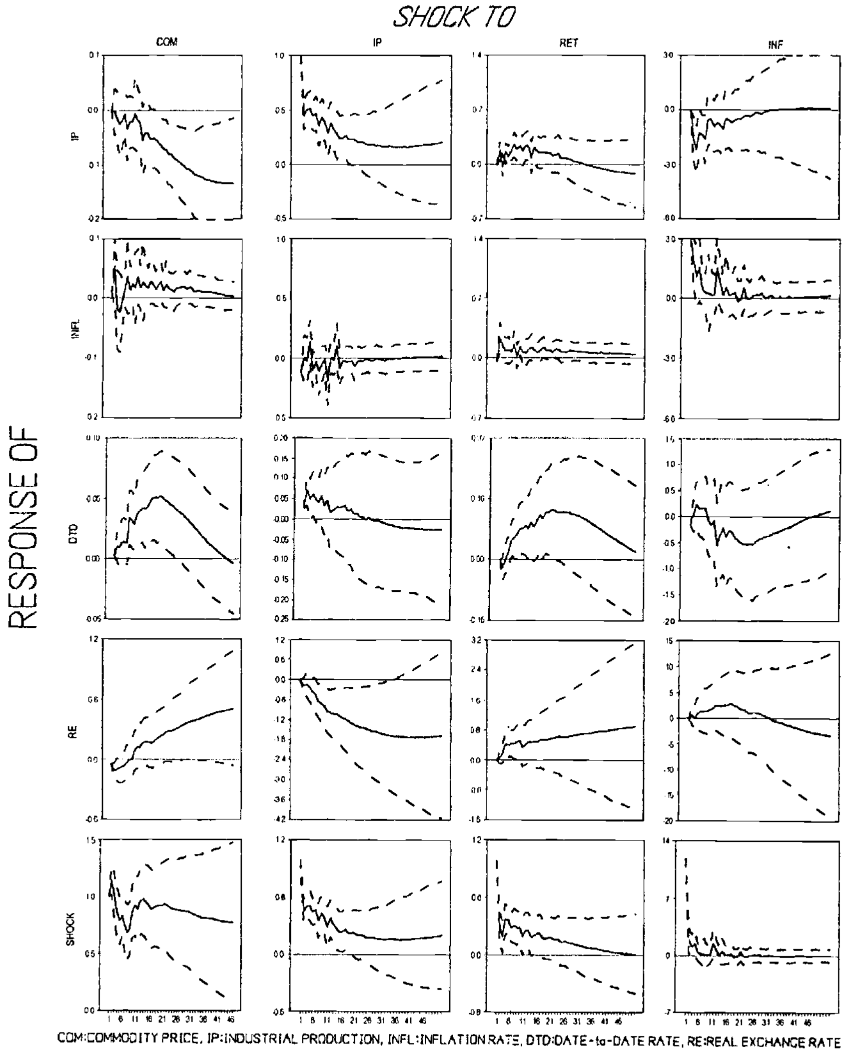

Fig. 10.5 Impulse responses to shocks: *COM*, commodity price; *IP*, industrial production; *RET*, retail sales; *INFL*, inflation rate; *RE*, real exchange rate; *DTD*, day-to-day rate

the currency depreciates in response to an increase in the funds rate, as figure 10.6 indicates.[20]

The response of the economy to a money-demand shock provides support

20. The response of the D-mark dollar rate to the funds rate shock is consistent with Eichenbaum and Evans (1995).

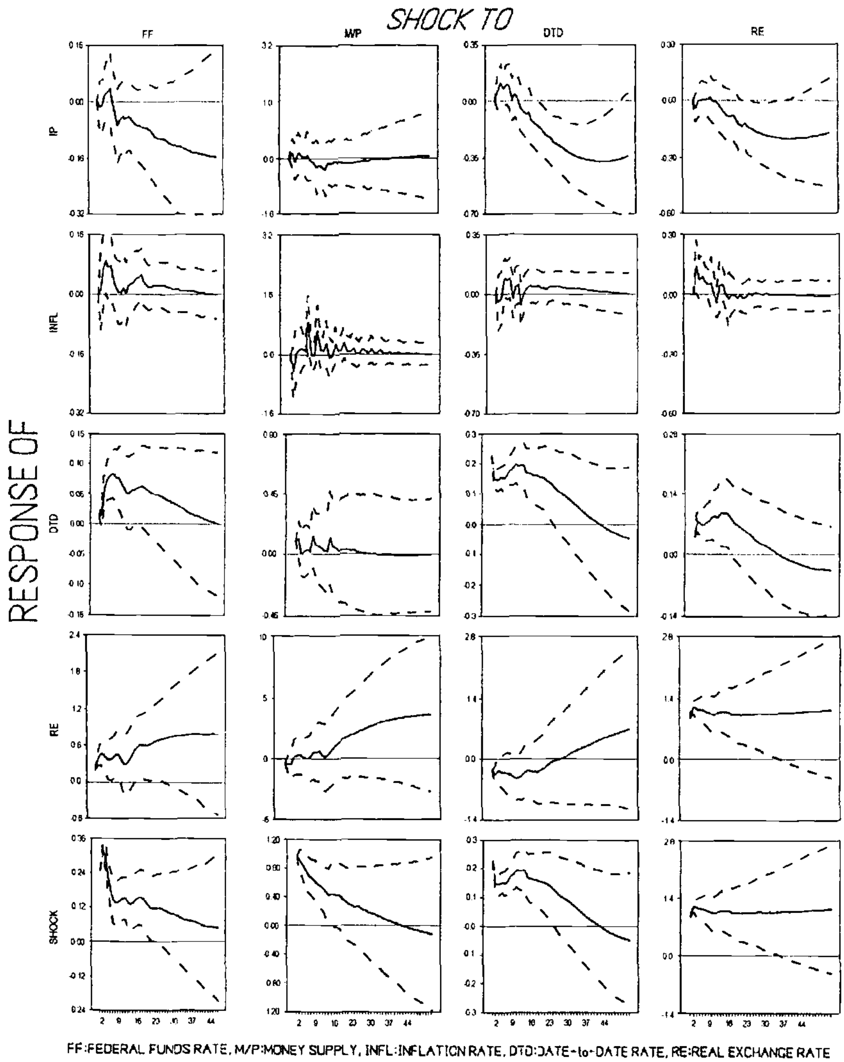

Fig. 10.6 Impulse responses to shocks: *FF,* federal funds rate; *M/P,* money supply; *DTD,* day-to-day rate; *RE,* real exchange rate; *INFL,* inflation rate; *IP,* industrial production

for the view that the Bundesbank treats the short-term interest rate as its policy instrument. Under strict money targeting, money-demand shocks should induce interest rate fluctuations that in turn affect the real economy. Figure 10.6, on the other hand, suggests that the Bundesbank accommodates money-demand shocks. Shocks to money demand have no significant affect on interest rates or on any other variables, except for real money balances.

Impact of a Day-to-Day Rate Shock

Finally, we examine the impact of an orthogonalized innovation in the short-term rate. This is the issue on which the structural VAR literature has tended to focus attention.[21] We interpret this kind of exercise not as an attempt to determine whether unsystematic policy shocks are important driving forces in the economy (we doubt that they are), but rather as a (less than ideal) way to show that policy movements matter to the economy.[22] The reduced-form policy-response exercises that we have just conducted do not permit us to sort out how much of the impact on output and inflation was due to the policy reaction, for example, and how much was due to the initial shock (e.g., the rise in commodity prices). By examining the effect of orthogonalized policy shocks, we gain a limited feel for the role of policy.

Figure 10.6 shows that, as one would expect, the unanticipated rise in the short-term rate reduces output and, at least in the very short run, causes the exchange rate to appreciate. There is, however, no significant impact on inflation. The point estimates go in the wrong direction, but they are small and insignificant. Two interpretations are possible. First, since the policy shock produces only a modest temporary rise in short rates, it does not induce a sufficient tightening to bring down inflation. Second, the policy shock may not be perfectly identified; there may be some news about inflation that the Bundesbank uses but is not summarized in the information set of the model. It is likely that some combination of these two factors is at work.

10.4.4 Sources of Variation in the Policy Instrument

In section 10.4.3 we analyzed how the Bundesbank adjusts short-term nominal and real rates in response to different kinds of primitive disturbances to the economy. Now we ask what kinds of disturbances are important to the variation in rates. That is, to what kinds of disturbances has the Bundesbank responded primarily, particularly during critical junctures for the economy?

Variance Decomposition

Table 10.3 presents a simple variance decomposition of the nominal rate, as implied by the structural VAR. Since there are eight structural disturbances in the model, there are eight potential sources of variation. As the table indicates, aside from the "own disturbance" to the German short-term rate, four kinds of shocks are important: the exchange rate, the funds rate, commodity prices, and retail sales. Consistent with the narrative evidence, the exchange rate and the funds rate shocks appear to have particularly strong influence on the Bundes-

21. For some recent examples, see Sims and Zha 1994; Christiano, Eichenbaum, and Evans 1995; and Bernanke and Mihov 1995.

22. We find, as does Kim (1994), that monetary shocks are not an important source of output variation in Germany. This does not mean, however, that monetary policy is unimportant. Variance decomposition exercises are silent on the importance of the policy feedback rule.

Table 10.3 **Variance Decomposition for the Nominal Interest Rate**

Horizon (months)	Fraction of Forecast Error Variance due to							
	e^{cp}	e^{ip}	e^{ret}	e^{p}	e^{ff}	e^{m}	e^{rs}	e^{er}
6	0.01	0.04	0.03	0.01	0.16	0.01	0.57	0.16
12	0.06	0.03	0.08	0.01	0.15	0.01	0.50	0.17
24	0.11	0.02	0.18	0.01	0.13	0.01	0.42	0.13
48	0.12	0.02	0.22	0.01	0.13	0.01	0.38	0.12

bank behavior in the short run, together accounting for about a third of the overall variation in the short-term rate over a six-month horizon. At twelve- and twenty-four-month horizons, the commodity and retail sales shocks rise in relative importance. Overall, the four shocks account for about half the variation in the short-term rate over twelve months and about 60% over twenty-four months.

Historical Decomposition

How do the four shocks account for the observed temporal pattern of German short-term rates? Figure 10.7 presents a historical decomposition of the variation in the nominal rate. The top panel shows the cumulative error in the forecast of the nominal rate as the sample period unwinds. This measure indicates how the short-term rate adjusted over time to shocks taking place during the sample. The two periods of unforecastable declines in the short-term rate are the late 1970s and the late 1980s. These correspond to the periods of policy easing cited in the narrative evidence. Similarly, the two periods are unforecastable increases are the early 1980s and the early 1990s, periods where the informal evidence suggests policy tightness.

In the panels below we plot the contribution to the cumulative forecast error by each of the four main sources (other than the own disturbance) of variation in the short-term rate. Again, there is a reasonable correspondence between the narrative and statistical evidence. Unexpected appreciations of the mark help account for the unexpected rates declines in 1978–79 and 1986–87. The rise in rates in the early 1980s is associated with a rise in real commodity prices, a depreciation of the currency, and a rise in the funds rate, much as the narrative evidence suggests. In particular these three factors appear to account for about two-thirds of the rate increase that occurred at this time.

Finally, there are some direct signs that the real economy influences Bundesbank behavior. Unexpected declines in retail sales, along with an unexpected appreciation of the mark, contributed to the decline in rates during the mid- to late 1980s. Conversely, following this period, interest rates surged in large part as a consequence of an unexpected sharp rise in retail sales, in conjunction with an unexpected currency depreciation.

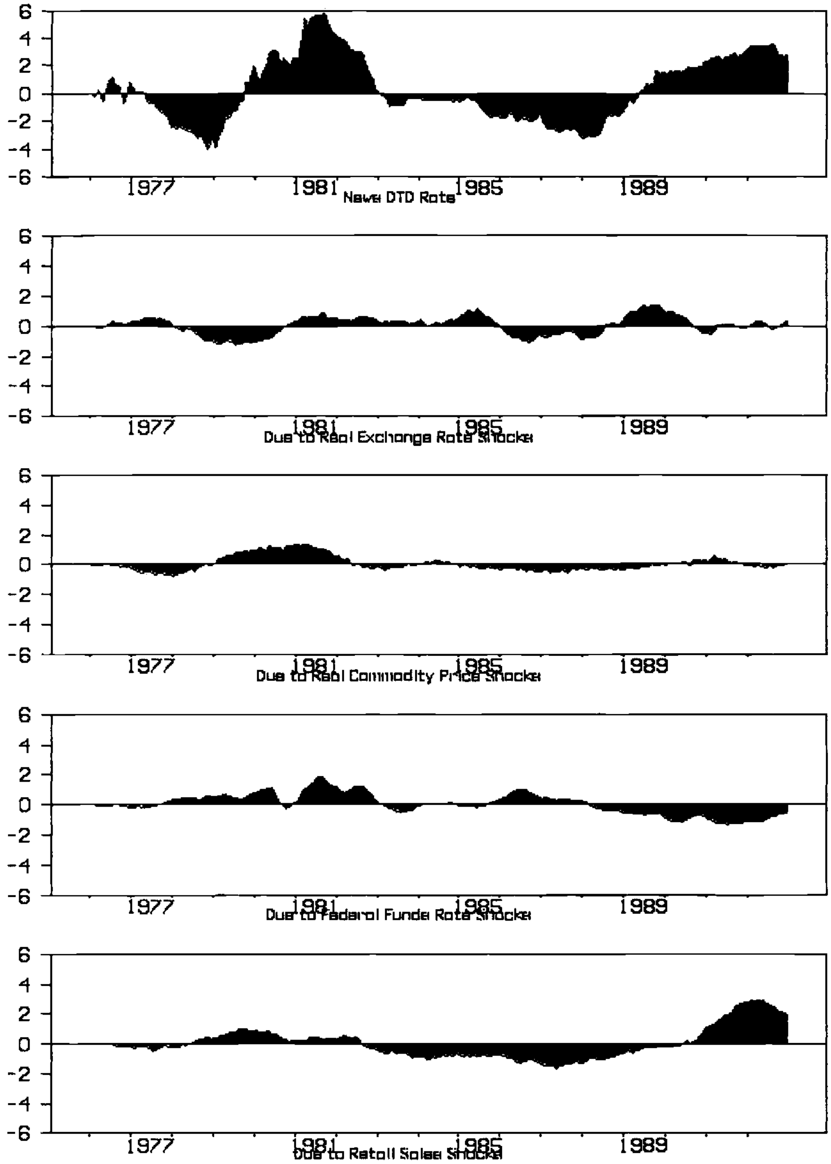

Fig. 10.7 Historical decomposition of day-to-day rate

10.5 Adding Structure: A Policy Reaction Function Based on Inflation and Output Objectives

From the structural VAR we are able to ascertain how different primitive disturbances to the economy influence the Bundesbank's choice for the time path of short-term interest rates. However, the policy reaction function we obtain from this exercise—the identified VAR equation for the day-to-day interest rate—is difficult to compactly summarize. We learn, for example, how the Bundesbank has responded to movements in the D-mark. But we do not directly learn why. Was inflation the primary consideration? Or was concern about output also a factor?

In this section we estimate a compact and intuitive reaction function for the day-to-day rate. We do so by imposing additional structure on the reaction function obtained from the identified VAR. We assume that the Bundesbank cares about stabilizing both inflation and output. In addition we allow for the possibility that the Bundesbank is forward-looking in the sense that it adjusts policy in response to anticipation of future inflation as opposed to simply past inflation. Further, we take into account that in setting interest rates the Bundesbank may not know the current values of inflation and output (which is consistent with what we assumed in section 10.4).

To form beliefs about expected inflation and output relative to their respective targets, the Bundesbank (we assume) filters the current and lagged information about the economy, as captured by our eight variable VARs. Thus, for example, we allow for movements in exchange rates to influence the day-to-day rate, as the reduced-form evidence suggests. But we restrict these movements to enter the policy reaction function based on the information they contain about expected inflation and output (relative to capacity). In the end we obtain a simple policy reaction function that relates the movement in short-term rates to two "gap" variables that reflect the position of inflation and output. As we show, this reaction function provides a very useful yardstick to interpret the course of Bundesbank monetary policy.

10.5.1 A Day-to-Day Rate Reaction Function

Let rs_t be the nominal day-to-day rate and rs_t^0 be the Bundesbank's target for this rate. Let rrs_t denote the real day-to-day rate. Let π_{t-j}^k be the rate of inflation from period $t - j$ to $t - j + k$: equivalently, $\pi_{t-j}^k = p_{t-j+k} - p_{t-j}$, where, as before, p_t is the logarithm of the price level. Also, as before, ip_t is the logarithm of output. Finally, let an asterisk denote the steady-state trend value of a variable. We assume that the following two equations characterize the day-to-day rate reaction function:

$$(5)\quad rs_t^0 = E_t\{\pi_{t-j}^k\} + rrs^* + \gamma^p[E_t\{\pi_{t-j}^k\} - \pi^{*k}] + \gamma^{ip}[E_t\{ip_t - ip_t^*\}]$$

and

(6) $$rs_t = \lambda rs_t^0 + (1 - \lambda)[\sum_{i=1}^{k} w_i rs_{t-1}] + \varepsilon_t,$$

with $\sum_{i=1}^{k} w_i = 1$ and where the expectation operator $E_t\{\quad\}$ is conditioned on the central bank's information set at t.[23] As we noted in section 10.4, the Bundesbank observes certain variables, such as industrial production and consumer prices, with a one-month lag.

Equation 5 is a slight variation of the type of reaction function that Taylor (1993) used to characterize the behavior of the Federal Reserve Board under Alan Greenspan.[24] Underlying the rule is the notion that monetary policy is neutral in the long run: the central bank cannot influence the long-run equilibrium values either of the real interest rate, rrs^*, or of output, ip_t^*. Due to nominal rigidities, however, the central bank does have leverage over the short-term real interest rate, and can thus influence the course of real activity in the short run.

The feedback rule has a general kind of lean-against-the-wind form. Roughly speaking, it has the central bank raise the short-term real interest rate as either inflation or output rise relative to long-run trend. Trend inflation is the steady-state inflation rate that the central bank is willing to accept, as is implicit in its policy rule. That is, it is the rate of inflation that the central bank is willing to accommodate when output is at its trend capacity value. It is thus a choice variable for the central bank. Trend output is the value of output that would arise if the economy were currently in long-run equilibrium, and is thus beyond the control of the central bank.

We assume further, according to equation 6, that each month the Bundesbank sets the actual day-to-day rate equal to a convex combination of the target rate and a weighted average of lagged rates. We allow for partial adjustment because institutional factors in policymaking likely preclude the Bundesbank from always reaching its target at the same frequency of our data. For example, the effective decision-making interval may be longer than the monthly interval we use. In practice we find that the adjustment period is usually very fast (as we show later).

An important difference between our specification and Taylor's is that we allow for the possibility that the central bank is forward-looking in its concern for inflation, whereas Taylor instead assumes that the central bank responds to inflation over the past year. In particular we consider three formulations of the inflation gap variable: two that are forward-looking and one that corresponds to Taylor.

Case 1 (forward-looking, one-year horizon):

23. We assume further that the Bundesbank responds only to movements in anticipated inflation that are exogenous with respect to movements in the current short-term rate. In the estimation we take account of this assumption explicitly by using instrumental variables. For this reason our rule is not subject to the instrument instability problem discussed in Woodford (1994). In addition we allow for partial adjustment of the interest rate, which is also a stabilizing factor.

24. Taylor does not formally estimate his model. He does demonstrate, however, that his informal method of choosing parameters seems to work quite well for the Greenspan period.

$$E_t\{\pi^k_{t-j}\} - \pi^{*k} = E_t\{\pi^{12}_t\} - \pi^{*12}$$

Case 2 (forward-looking, infinite horizon):

$$E_t\{\pi^k_{t-j}\} - \pi^{*k} = \lim_{k\to\infty} E_t\{\pi^k_t\} - \pi^{*k} = E_t\{p^*_t - p_t\}$$

Case 3 (backward-looking, Taylor):

$$E_t\{\pi^k_{t-j}\} - \pi^{*k} = E_t\{\pi^{12}_{t-12}\} - \pi^{*12}$$

Case 1 is the mirror image of the Taylor specification: the central bank looks one year forward at inflation, as opposed to one year back. Because the one-year horizon is somewhat arbitrary, in case 2 we have the central bank respond to expected total cumulative excess inflation. We define the latter as the expected percentage of change in the price level relative to trend indefinitely into the future. This measure corresponds exactly to the percentage of difference between the current trend and spot price levels. Intuitively, if the price level is 5% below trend (i.e., $p^*_t - p_t = 5\%$), then the spot price level is expected to grow 5% faster than trend before reverting to long-run equilibrium.[25]

Finally, for comparison purposes, in case 3 we consider the backward-looking measure that Taylor used. The expectation operator appears in this case only because we allow for the possibility that the central bank may not observe the current price level. (In equation 5 we similarly allow for the possibility that it does not observe current output.)

We proceed by first computing the long-run equilibrium variables and the gap variables that enter the policy reaction function. We use our estimated structural VAR to obtain values of these variables for each calendar month. In addition to obtaining inputs for the reaction function, we also extract information that is helpful for judging the position of the economy and monetary policy, as we discuss below.

10.5.2 Long-Run Equilibria and Short-Run Deviations: A Historical Decomposition of the Data

To identify the long-run equilibrium and the inflation and output gap variables, we return to the eight variable VARs of the German economy. We obtain the steady-state value for any (stationary) variable in the VAR simply by finding the k-step-ahead forecast of the respective variable, for k large.

Long-Run Equilibrium Interest Rates and Inflation

Figure 10.8 reports estimates of the long-run equilibrium values of the nominal interest rate, inflation, and the real interest rate. In each panel is the time

25. We emphasize that stabilizing the gap $p^*_t - p_t$ does not correspond to stabilizing the price level around a deterministic trend. The empirical model of section 10.4 on which we base the analysis presumes a stochastic trend rather than a deterministic trend for the price level, owing to the presence of a unit root in the price level. The unit-root assumption (which is consistent with the data) reflects the fact that the Bundesbank accommodates changes in the price level, as the narrative evidence suggests (see section 10.3).

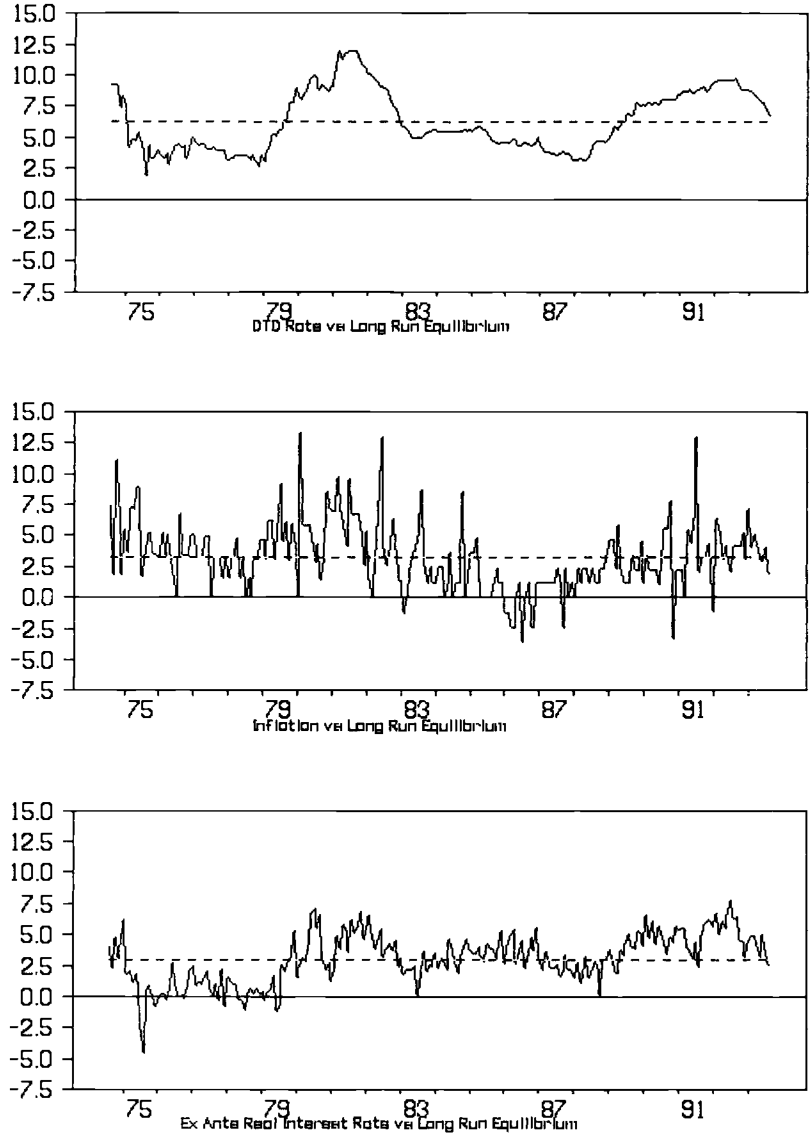

Fig. 10.8 Interest rates and inflation

series of the current value of the respective variable. To construct a time series for the real interest rate, we used the observed nominal rate minus the inflation forecast generated by the VAR. We computed steady-state values of 6.28 for the nominal rate, 3.2 for inflation, and 3.1 for the real rate (simply the difference between the two). In each instance the estimates are close to the sample mean (and are quite sensible).

As we emphasized earlier, the steady-state inflation rate provides a measure of the long-run dimension of monetary policy. Since this number is a product of the steady-state money-growth rate that the policy rule generates, it is ultimately a choice variable of the Bundesbank. In this respect we confirm the obvious: the Bundesbank policy rule is geared toward maintaining a long-run equilibrium inflation rate.

The behavior of the real interest rate can potentially tell us something about monetary policy in the short run. Given that the monetary policy may influence the short-run but not the long-run real rate, we may interpret a rise in the real rate above its long-run equilibrium as one piece of evidence of a tightening of Bundesbank policy. This spread alone does not provide sufficient information to judge whether policy is tight or loose; the answer, of course, also depends on the overall condition of the economy. Nonetheless, knowledge of where real rates stand relative to the long run is an important reference point.

The bottom panel of figure 10.8 provides us with a sharper perspective on the path of policy than that in our previous analysis. Real interest rates were very low relative to the long-run equilibrium during the mid- to late 1970s, which is consistent with the narrative evidence that the Bundesbank eased during this period.[26] Conversely, real rates were well above the steady state during the two main periods of tightening, the early 1980s and the early 1990s. Despite economic stagnation during most of the 1980s, real rates were either above or not far below long-run equilibrium.[27]

Inflation and Output Gaps

We next compute the inflation and output gap variables. The top panel of figure 10.9 presents the two forward-looking measures of the inflation gap: (1) the anticipated percentage of change in the price level relative to trend over a one-year horizon and (2) the same over the infinite horizon. In each case we use the VAR model of section 10.4 to compute anticipated excess inflation.[28] Interestingly, the two measures are highly correlated, with the latter typically being about twice the size of the former. That is, if the percentage of change

26. One possibility is that the shift in the real interest rate from the 1970s to the 1980s could also reflect a permanent change in the long-run equilibrium. However, our empirical analysis indicates that the real rate is stationary over that period, which appears to rule out this possibility. Also, the notion that the real rate contains a unit root is unappealing as a matter of theory.

27. We account for the influence of high real interest rates during this time by allowing the U.S. interest rate (which enters our VAR) to influence the forecast of the gap variables for inflation and output that enter the equation for the target interest rate (equation 5).

28. As we argue in the text, the expected percentage of change in the price level over the infinite horizon is simply the difference between the trend log price level p_t^* and the current log price level p_t. To obtain p_t^*, we first find the long-horizon forecast of the price level. We then use the estimate of the steady-state inflation rate to determine the portion of the long-horizon forecast that is due to the long-run drift in the price level. To obtain p_t^*, we simply remove the estimated drift from the long-horizon forecast. Thus p_t^* is the estimate of where the German price level would be at time t had been no shocks pushing it away from the long-run equilibrium. Formally, p_t^* is the Beveridge-Nelson permanent component of the price level, as derived from the forecast of our eight variable VARs.

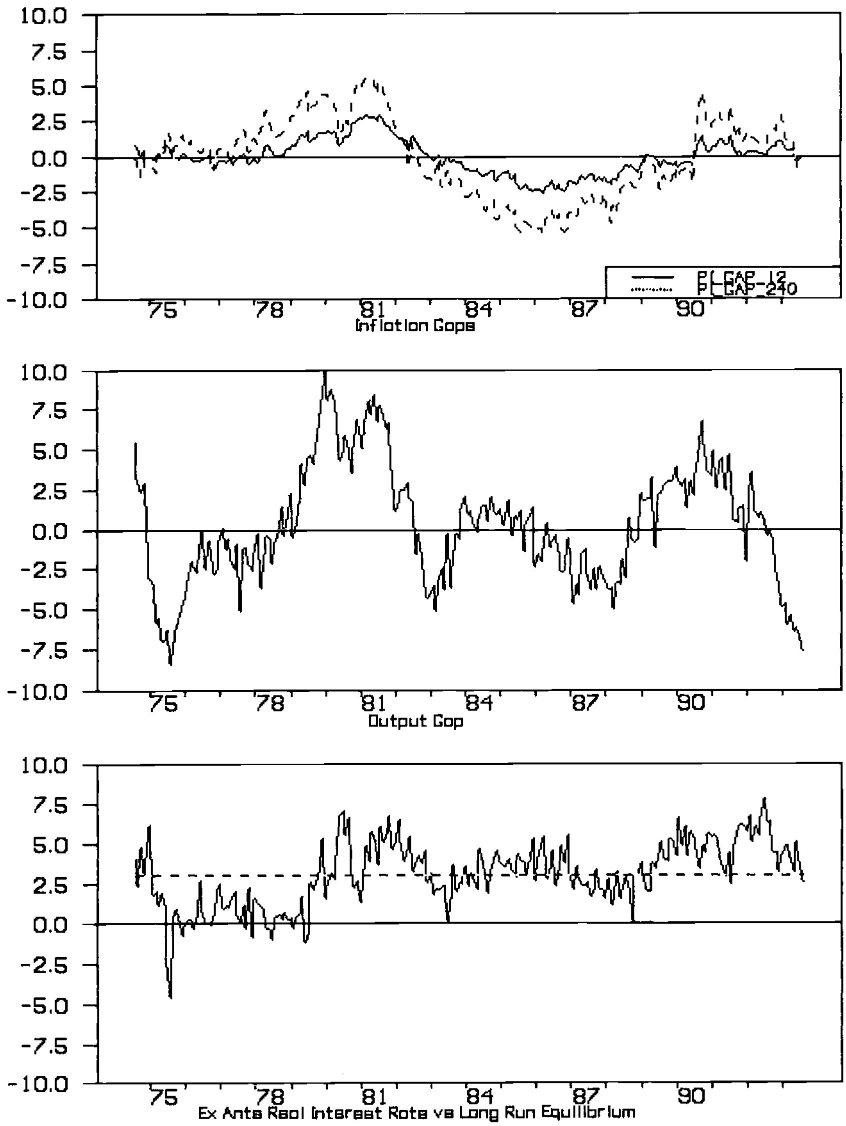

Fig. 10.9 Inflation gaps, output gap, and real interest rates: *PI GAP 12*, price-level gap for one year; *PI GAP 240*, infinite horizon price-level gap

in the price level is expected to be 1% above trend for the next year, then it is likely to be a total of 2% above trend over the indefinite future.

The middle panel of figure 10.9 presents our measure of the gap between output and its long-run equilibrium, $ip_t - ip_t^*$. To compute long-run equilibrium output, we allow for the possibility that the trend drift in output is stochastic due to the presence of a unit root. The unit root will arise, for example, if (as we might expect) shocks to the level of technology have a permanent component.[29]

Finally, the bottom panel of figure 10.9 plots the real interest rate (taken from figure 10.8). The two main periods of monetary tightening in the sample, the late 1970/early 1980s and the late 1980/early 1990s, are also periods where expected excess inflation was highest. It is also true that during these periods output was above trend.[30] On the other hand, during the period of stagnation during the 1980s, there were forecastable declines in inflation relative to trend along with below-capacity output.[31] The 1992–93 recession also pushed output below trend.

10.5.3 The Empirical Day-to-Day Rate Reaction Function

If we add and subtract long-run equilibrium inflation, π^*, from the right side of equation 5, we can express the relation for the target rate simply as

$$(7) \qquad rs_t^0 = rs^* + (1 + \gamma^p)[E_t\{\pi_{t-j}^k\} - \pi^{*k}] + \gamma^{ip}[E_t\{ip_t - ip_t^*\}],$$

where rs^* $(= rrs^* + \pi^*)$ is the steady-state nominal interest rate, equal to the sum of the steady-state real rate and the steady-state inflation rate. Equation 7 together with equation 5 then determines the day-to-day rate. We first consider the two cases with forward-looking inflation and then turn to the Taylor specification.

Forward-Looking Inflation Gap

We estimate, using instrumental variables, the following equation for the day-to-day rate (obtained from substituting equation 7 into 5:

$$(8) \qquad rs_t = a + b_1[E_t[\{\pi_{t-j}^k\} - \pi^{*k}] + b_2[E_t\{ip_t - ip_t^*\}] + \sum_{i=1}^{k} d_i rs_{t-i} + \varepsilon_t.$$

We use as instruments for $E_t\{\pi_{t-j}^k\} - \pi^{*k}$ and $E_t\{ip_t - ip_t^*\}$, lagged values of these gap variables and also the orthogonalized time t innovations in the variables that the Bundesbank can observe contemporaneously (real commodity prices, the money supply, and the real exchange rate).[32] We found that $k = 3$

29. Formally, ip_t^* is the Beveridge-Nelson permanent component of output and is computed analogously to p_t^* (see note 28). See Rotemberg (1994) for Beveridge-Nelson decompositions of output and prices for U.S. data. See Clarida and Gali (1994) for an application of this technique to variety of aggregate series for OECD countries.

30. Output was above trend during the 1980 and 1981 in part because there were declines in trend capacity output, possibly due to the oil shocks.

31. The 1986 decline in oil prices likely also contributed to the forecastable decline in inflation.

32. Since cumulative expected inflation and cumulative expected output growth will in general depend on the current interest rate, we use instrumental variables. If there is no serial correlation in the error term, then the lagged independent variables are legitimate instruments. It is also legitimate to use orthogonalized values of the observable shocks as instruments since, by construction, the orthogonalized shocks are exogenous with respect to the current interest rate.

lags of the day-to-day rate is sufficient to eliminate serial correlation from the estimated reaction function.

Table 10.4 reports the results along with the implied estimates of the relation for the target rate rs_t^0, given by equation 5. The top panel reports the estimates using the year-ahead forecast of excess inflation as the relevant gap variable, and the bottom panel does the same using the infinite-horizon forecast. Overall, the results indicate that the Bundesbank responds significantly to expected inflation and output growth, and does so in the direction that one would expect. They also indicate that the day-to-day rate adjusts quickly to the target rate: only the first lagged interest rate enters significantly, and it does so with a coefficient that suggests reasonably fast adjustment.

The implied equation for the target rate is informative about the implications of our estimates for nature of Bundesbank policy. For the "year-ahead" inflation gap, this relation is given by

$$(9) \qquad rs_t^0 = 6.06 + 0.78[E_t\{\pi_{t-j}^k\} - \pi^{*k}] + 0.64[E_t\{ip_t - ip_t^*\}].$$

The estimated equation for the infinite-horizon case is quite similar. The coefficient on the inflation gap falls in half, which simply reflects the fact that this gap variable is normally about twice the size of its counterpart in the year-ahead case (see figure 10.9).

We note first that the constant term in equation 9 gives an implied estimate of the steady-state nominal interest rate rs^* (compare equations 8 and 9), which is very close to the estimate of 6.28 obtained in section 10.5.2. Second, the estimates imply that a 1-percentage-point rise in expected excess inflation in-

Table 10.4 The Bundesbank Reaction Function

Twelve-Month Inflation Forecast
Dynamic Partial Adjustment Equation

$$\underset{}{rs_t} = \underset{(0.12)}{0.57} + \underset{(0.03)}{0.07(\pi_t^{12} - \pi_t^*)} + \underset{(0.02)}{0.06(ip_t - ip_t^*)} + \underset{(0.07)}{0.71rs_{t-1}} + \underset{(0.08)}{0.10rs_{t-2}} + \underset{(0.07)}{0.10rs_{t-3}}$$

The sample is September 1974 to September 1993. Estimation is by instrumental variables. The instruments are a constant, rs_{t-1}, rs_{t-2}, rs_{t-3}, $(\pi_{t-2} - \pi_{t-2}^*)$, $(ip_{t-2} - ip_{t-2}^*)$, and e_t^{cp}, e_t^{ff}, e_t^m, e_t^{er}. Box-Pierce $Q(36) = 47.88$, which is significant at the 0.09 level. $R^2 = 0.96$. Standard error of the estimate is 0.47.

Implied Equation for the Target Day-to-Day Rate

$$rs_t^0 = 6.06 + 0.78(p_t^* - p_t) + 0.64(ip_t - ip_t^*)$$

Infinite-Horizon Forecast
Dynamic Partial Adjustment Equation

$$\underset{}{rs_t} = \underset{(0.11)}{0.53} + \underset{(0.01)}{0.03(p_t^* - p_t)} + \underset{(0.01)}{0.06(ip_t - ip_t^*)} + \underset{(0.07)}{0.71rs_{t-1}} + \underset{(0.08)}{0.11rs_{t-2}} + \underset{(0.07)}{0.10rs_{t-3}}$$

The instruments are a constant rs_{t-1}, rs_{t-2}, rs_{t-3}, $(p_{t-2}^* - p_{t-2})$, $(ip_{t-2} - ip_{t-2}^*)$, and e_t^{cp}, e_t^{ff}, e_t^m, e_t^{er}. Box-Pierce $Q(36) = 44.99$, which is significant at the 0.14 level. $R^2 = 0.96$. Standard error of the estimate is 0.47.

Implied Equation for the Target Day-to-Day Rate

$$rs_t^0 = 6.00 + 0.36(p_t^* - p_t) + 0.69(ip_t - ip_t^*)$$

Table 10.5 **The Bundesbank Reaction Function, Asymmetric Response to Expected Inflation and Disinflation**

Twelve-Month Inflation Forecast
Dynamic Partial Adjustment Equations

When $(\pi_t^{12} - \pi_t^{*12}) > 0$

$$rs_t = \underset{(0.13)}{0.53} + \underset{(0.08)}{0.15}(\pi_t^{12} - \pi_t^{*12}) + \underset{(0.02)}{0.05}(ip_t - ip_t^*) + \underset{(0.07)}{0.71}rs_{t-1} + \underset{(0.08)}{0.10}rs_{t-2} + \underset{(0.07)}{0.09}rs_{t-3}$$

When $(\pi_t^{12} - \pi_t^{*12}) < 0$

$$rs_t = \underset{(0.13)}{0.53} + \underset{(0.06)}{0.03}(\pi_t^{12} - \pi_t^{*12}) + \underset{(0.02)}{0.06}(ip_t - ip_t^*) + \underset{(0.07)}{0.71}rs_{t-1} + \underset{(0.08)}{0.10}rs_{t-2} + \underset{(0.07)}{0.09}rs_{t-3}$$

The sample is September 1974 to September 1993. Estimation is by instrument variables. The instruments are a constant, rs_{t-1}, rs_{t-2}, rs_{t-3}, $(\pi_{t-2} - \pi_{t-2}^*)$. $(ip_{t-2} - ip_{t-2}^*)$, and e_t^{rp}, e_t^{ff}, e_t^{m}, e_t^{er}. Box-Pierce $Q(36) = 54.64$, which is significant at the 0.03 level. $R^2 = 0.96$. Standard error of the estimate is 0.47.

Implied Equations for the Target Day-to-Day Rate

When $(\pi_t^{12} - \pi_t^{*12}) > 0$

$$rs_t^0 = 5.6 + 1.60(\pi_t^{12} - \pi_t^{*12}) + 0.56(ip_t - ip_t^*)$$

When $(\pi_t^{12} - \pi_t^{*12}) < 0$

$$rs_t^0 = 5.6 + 0.28(\pi_t^{12} - \pi_t^{*12}) + 0.56(ip_t - ip_t^*)$$

duces the Bundesbank to raise the target day-to-day rate by 78 basis points, while a 1-percentage-point increase in the output gap induces it to raise the day-to-day rate 64 basis points.[33] Thus, the Bundesbank does appear to condition policy on the state of the real economy, as our earlier analysis suggests.

One surprising feature of equation 9 is the implication that the Bundesbank raises the target rate by less than the increase in expected inflation. One possibility is that the policy rule is asymmetric with respect to inflation. That is, it may be the case that if output is at capacity, the Bundesbank does not ease much when expected inflation is below trend, but it tightens aggressively when expected inflation is above trend. In this case the low coefficient on the inflation gap could be due to the asymmetric policy response. We reestimated the feedback rule to allow the response to differ across positive and negative inflation gaps. The results support the asymmetry hypothesis.

Table 10.5 presents estimates of the asymmetric policy rule using the year-ahead measure of excess inflation. Results for the infinite-horizon case are very similar. Note that the response of the day-to-day rate to expected excess inflation is positive and significant when the gap is positive, while it is not significant when the gap is negative. The implied relation for the day-to-day rate is

$$(10) \quad rs_t^0 = \begin{cases} 5.60 + 1.60[E_t\{\pi_{t-j}^k\} - \pi^{*k}] \\ + 0.56[E_t\{ip_t - ip_t^*\}], & \text{if } E_t\{\pi_{t-j}^k\} - \pi^{*k} \geq 0. \\ \\ 5.60 + 0.28[E_t\{\pi_{t-j}^k\} - \pi^{*k}] \\ + 0.56[E_t\{ip_t - ip_t^*\}], & \text{if } E_t\{\pi_{t-j}^k\} - \pi^{*k} < 0. \end{cases}$$

33. Each of the gap variables is multiplied by one hundred, implying that the respective coefficients are in basis points.

When the inflation gap is positive, the Bundesbank raises the day-to-day rate 160 basis points in response to a 1% rise in expected excess inflation, implying a real rate increase of 60 basis. On the other hand, it barely responds when the inflation gap is negative. Allowing for an asymmetric policy response thus appears to resolve the puzzle. Another interesting feature of equation 10 is that, for the case of positive excess inflation, the estimated coefficients on the gap variables are very close to the ones Taylor used.[34] Thus, after allowing for our modifications, it is not an exaggeration to suggest that the Bundesbank policy rule during the post–Bretton Woods era bears a reasonable proximity to the rule that Taylor employs to characterize U.S. monetary policy under Greenspan.

As an informal way to judge both the fit and the implications of our estimated reaction function, figure 10.10 plots the estimated target day-to-day rate rs_t^0 against the actual rate rs_t for the linear policy rule described by equation 9. Figure 10.11 does the same for the asymmetric rule described by equation 10. In each case the target rate tracks the actual rate reasonably well, suggesting that the model provides a decent accounting of Bundesbank policy.

It is interesting to note that, during the mid- to late 1970s, policy was somewhat easier than the norm for the era predicted by the model, which is consistent with the narrative evidence. Specifically, the target rate was systematically above the actual rate over this period. Conversely, policy was somewhat tighter than the norm for the latter half of the sample. Particular episodes of relative tightness were late 1982 to early 1983, when the real economy was still experiencing the effects of a severe recession, and 1992–93, the approximate time of the breakup of the EMS. The relatively large gap between the actual and target rates during this latter period provides support for the view that the Bundesbank was being unusually tough prior to the EMS collapse.

Interestingly, the linear model portrayed in figure 10.10 suggests that policy was somewhat tougher than the norm during the mid-1980s, when the real economy was stagnating and inflation was low. As figure 10.11 suggests, however, this discrepancy may be due to the failure to allow for an asymmetric policy response during this period of below-trend inflation. The nonlinear model, in contrast, tracks this period reasonably well.

The Taylor Specification

We now reestimate the model using the difference between inflation over the past year and trend inflation as the relevant gap variable. We try two variations. The first follows Taylor strictly.[35] The second allows for partial adjustment.

34. The corresponding coefficients for Taylor's rule are 1.5 on the inflation gap and 0.5 on the output gap.

35. Because Taylor used quarterly data, we measure the output gap using the quarterly average of our monthly data. We also followed Taylor by assuming a deterministic trend for output. The results are not particularly sensitive to the method of detrending output, though allowing for a stochastic trend does seem to improve the fit.

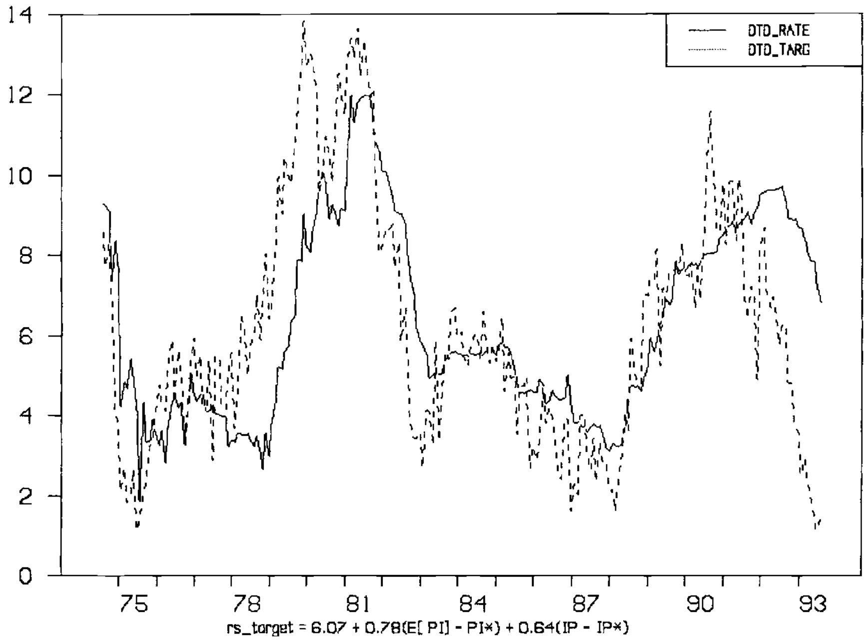

Fig. 10.10 Bundesbank day-to-day interest rate, target versus actual
Note: See equation 9.

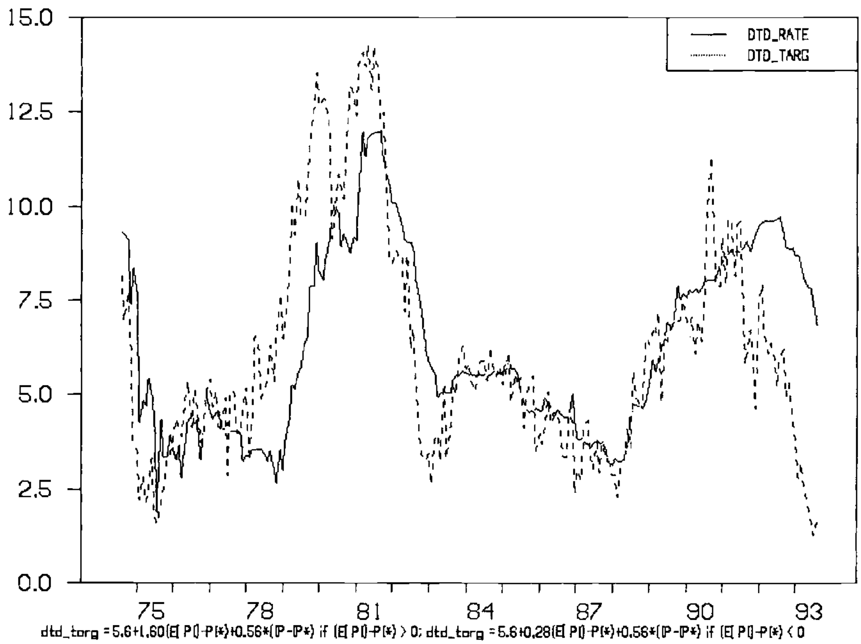

Fig. 10.11 Asymmetric response of day-to-day interest rates to inflation, target versus actual
Note: See equation 10.

Table 10.6 Bundesbank Reaction Function: Taylor Rule Specification

Taylor Rule

$$rs_t^0 = \underset{(0.12)}{6.35} + \underset{(0.07)}{0.71}(\pi_t - \pi_t^*) + \underset{(0.03)}{0.20}(ip_t - ip\tau_t)$$

The sample is September 1974 to September 1993. Estimation is by OLS. Box-Pierce $Q(36) = 2{,}551.88$, which is significant at the 0.00001 level. $R^2 = 0.43$. Standard error of the estimate is 1.82. $IP\tau_t$ is the estimated trend in industrial production.

Taylor Rule with Partial Adjustment

$$rs_t = \underset{(0.12)}{0.33} + \underset{(0.02)}{0.01}(\pi_t - \pi^*) + \underset{(0.01)}{0.04}(ip_t - ip\tau_t) + \underset{(0.07)}{0.80}rs_{t-1} + \underset{(0.09)}{0.11}rs_{t-2} + \underset{(0.07)}{0.03}rs_{t-3}$$

The sample is September 1974 to September 1993. Estimation is by OLS. Box-Pierce $Q(36) = 50.03$, which is significant at the 0.06 level. $R^2 = 0.96$. Standard error of the estimate is 0.50. π_t is average inflation over previous twelve months. π^* is sample average inflation. $ip\pi_t - ip_t$ is deviation of deterministic trend ip from actual ip averaged over the previous three months.

Implied Equation for the Target Day-to-Day Rate

$$rs_t^0 = 6.6 + 0.15(\pi_t - \pi^*) + 0.84(ip_t - ip\tau_t)$$

Table 10.6 reports the results. The top panel presents estimates of the standard Taylor specification. The coefficients are of the right sign, though the coefficient on the inflation gap is too low to have the real rate move in the wrong direction. More significantly, there is strong evidence of residual serial correlation, suggesting the possibility of omitted variable bias. The bottom panel presents the estimates for the case of partial adjustment. Including the lagged day-to-day rate significantly reduces the residual correlation. On the other hand, the coefficient on the inflation gap is no longer significant.

Finally, figure 10.12 plots the implied target rates for the two Taylor specifications against the actual day-to-day rate. The top panel portrays the case with partial adjustment, while the bottom line portrays the standard specification. Overall, the results suggest that the basic Taylor specification does not work as well as our modified version.[36]

10.6 Concluding Remarks

Despite the public focus on monetary targeting, in practice German monetary policy involves the management of short-term interest rates, as it does in the United States. The targets, however, do provide a reference point for decision making. The key feature is that they provide a benchmark policy rule that is designed to meet a clearly articulated long-term inflation goal. While the Bundesbank can and often does deviate from this rule, it must always provide justification for doing so. By forcing this kind of focused discussion of Bundesbank decisions, the targeting provides some discipline on the policy process.

36. We also try a variation that uses the coefficients that Taylor specified for the United States. This specification does not improve the model's performance.

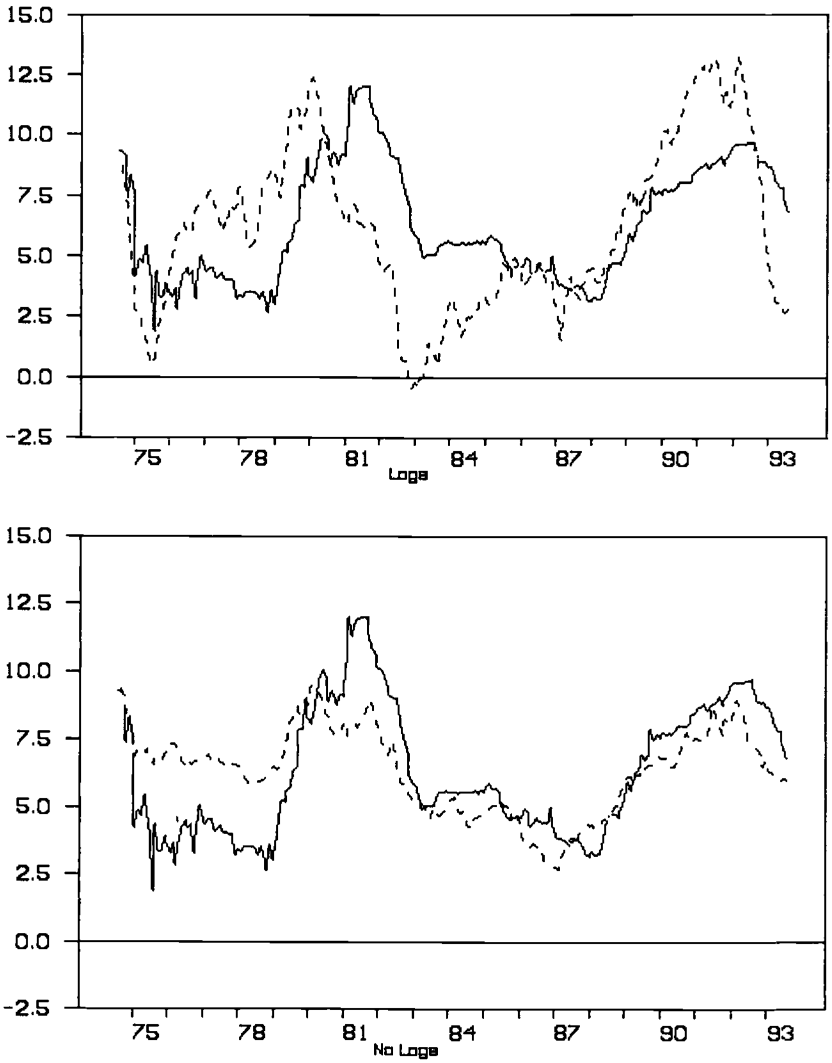

Fig. 10.12 Target interest rates implied by Taylor rules versus actual

Except during the mid- to late 1970s, the Bundesbank has aggressively adjusted interest rates to achieve and maintain low inflation. The goal of a low long-term inflation rate is paramount. However, from a variety of evidence, both informal and formal, we find that the performance of the real economy also influences Bundesbank decision making. It adopts a gradualist approach to disinflating, and it does ease when the real economy weakens. During these situations it often cites other factors in public announcements—concern about maintaining the stability of exchange rate regimes, for example. Our results suggest, however, that it is implicitly pursuing a countercyclical policy. In particular our formal analysis suggests that, for the most part, the Bundesbank has adjusted short-term interest rates according to a kind of modified Taylor rule: one that has the short-term rate adjust to anticipated inflation as opposed to past inflation, and that allows for an asymmetric response of the short-term rate to the inflation gap. In this respect there is a noteworthy parallel between the conduct of Bundesbank policy in the post–Bretton Woods era and the operation of the Federal Reserve Board since 1987.

Despite obvious success in maintaining a low long-term inflation rate, the Bundesbank has not been able to make disinflation a relatively painless process, as the recessions of the early 1980s and the early 1990s suggest. Why it has not reaped measurable gains from reputation building is a major puzzle, one that a number of economists have noted. As we discussed earlier, the Bundesbank's accommodation of inflation during the 1970s may have influenced public perceptions during the early 1980s, though it is doubtful that this could be the entire story. Further, since the Bundesbank aggressively pursued a low-inflation policy over the 1980s, this kind of explanation is less persuasive for the most recent recession. On the other hand, it is possible that reunification posed a special set of circumstances. Clearly, this general issue is an important topic for future research.

We conclude with a perhaps mundane but nonetheless potentially important lesson from the analysis. A current widely discussed issue is whether the monetary policy should be aimed at achieving zero inflation. We learn from the analysis that the Bundesbank has never tried to achieve exact price stability, and has instead focused on a goal of 2% long-run inflation. Concern about measurement error in the price index—specifically, possible overstatement of inflation due to imperfect adjustment for quality improvements—is the rationale provided for this objective. This measurement issue ought to be a key concern of monetary policymakers, as it appears it is becoming in the United States.

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Comment Rudiger Dornbusch

The paper by Clarida and Gertler (ClaGer for short) offers a revisionist view of the Bundesbank. The myth has been that of an institution fighting inflation, with little other concern, predominantly with an M3-oriented strategy. ClaGer make a good case that the Buba is no different from most other central banks, notably the Fed. They establish a reaction function with inflation and output gaps as the chief determinants of an interest rate–oriented policy. Amazingly, M3 plays *absolutely* no role in the story.

That rendition is nothing short of dramatic. After all, the Buba keeps talking about M3 and keeps getting entangled in the huge discrepancies between targeted M3 and the large departures of actual M3. I argue that ClaGer have done a great job in bringing Buba policy down to earth, but that they have not gone far enough. Whenever M3 goes wild, the Buba is mired in its own rhetoric. That is precisely when the Buba does *not* do the obvious, that is, cut rates in the midst of a no-inflation, serious-downturn situation. The first half of 1996 is a case in point.

I review briefly the Buba folklore, consider the ClaGer rendition, and move on to an attempt to reestablish some role for M3 in interpreting Buba policy mistakes. The point is, when common sense and adherence to M3 targets point in opposite directions, the Buba sometimes goes the wrong way.

The Folklore

The setting is shown in figure 10C.1, which reports German CPI inflation (for twelve-month periods). Three major inflation episodes are apparent. Coming out of the destructive experience of a hyperinflation, a monetary write-off in 1948, dollar dependence under Bretton Woods, and an unsuccessful encounter with supply-shock inflation, the Buba places great weight on a firm anchor. A premium is placed on a simple message that allows the Buba to tie its hands against any temptation to pursue a long-run inflationary strategy.

M3 is thought to offer precisely that assurance.

The relationship in question derives from a stable long-run M3 real money demand. The velocity of M3, other than for a 1% per year downward trend, is near-constant over the medium term. Accordingly, there is a relationship between the medium-term price level P^*, the level of potential output Y^*, trend velocity V^*, and the trend price level P^*:

$$P^* = V^*M3/Y^*. \quad (1)$$

Such a relationship existed in the United States until Goodhart's law caught up with it; in Germany it is believed still to exist. Empirical evidence for various

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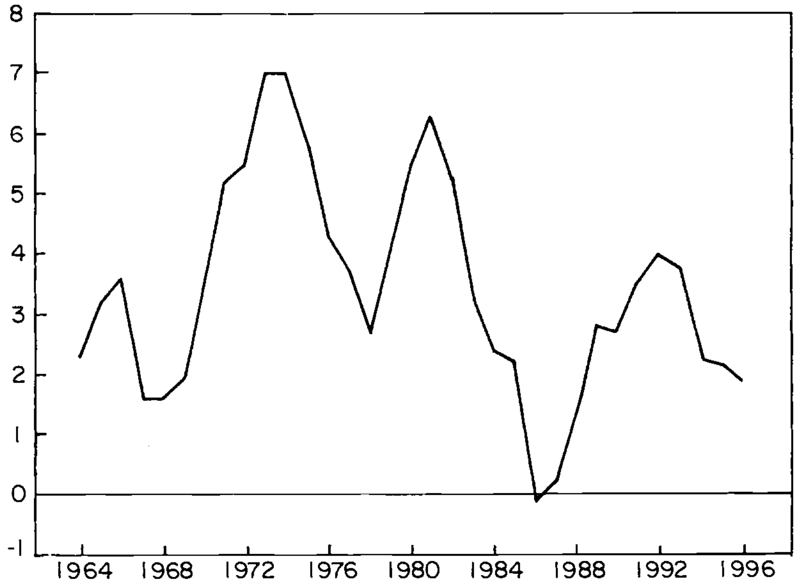

Fig. 10C.1 Germany: CPI inflation (percentage during the past twelve months)

OECD countries is reviewed in Hoeller and Poret (1991). In the case of Germany, as recently as 1995 the evidence of a stable M3 equation has been reviewed by the Buba (*Monthly Report,* July 1995) and the conclusion remains: yes, there is a stable demand for M3, and as a consequence, M3 targeting is the basis of a sound monetary strategy. "Most of the empirical studies now available show positive results. Hence German monetary policy makers can continue to count on lastingly stable money demand" (Deutsche Bundesbank 1995).

With a stable money-demand equation in hand, the Buba operates its policy by setting annual M3 growth corridors. The extraordinary claim of ClaGer is that this is just camouflage. A plain vanilla reaction function à la Taylor explains what goes on, M3 is just not there!

The Clarida-Gertler Rendition

The ClaGer paper reviews in careful detail the broad trends in Buba policy and then comes down to the hard work of identifying just what goes on. The central conclusion is that policy can be modeled as a reaction function. The short-term interest rate is expressed as a function of the discrepancy between actual and long-run target inflation and the output gap. There is also a dynamics to the rate setting, which I skip here. The real interest rate target level, R, that emerges is

$$R = r^* + \alpha (\pi - \pi^*) + \beta gap, \quad (2)$$

where r^* is the long-run real interest rate (3%), while π and π^* are the forward-looking inflation forecast and the long-run equilibrium rate. There are important technical features in the modeling of the inflation deviation and the output gap—they are forward-looking using estimates of a variable autoregression (VAR) model, but that is not a central issue here. The focus rather is on the finding that inflation gaps and the output gap explain what the Buba does with interest rates; M3 is just not part of the story. (Not part of the story over and above the role in the VAR forecast.) Figures 10.10 and 10.11 show the target interest rate emerging from the reaction function as well as the actuals, and it is clear that the model works surprisingly well.

The details of the coefficient deserve attention. ClaGer experiment with asymmetries and their conclusion is this.

- The Buba responds to a 100-basis-point inflation shock with a 60-basis-point increase in real interest rates.
- A 100-basis-point favorable inflation surprise induces only a 28-basis-point cut in nominal interest rates or, equivalently, a 72-basis-point increase in real rates. Thus interest rate policy does not fully accommodate disinflation.
- A 100-basis-point increase in the output gap (measured by industrial production) includes a 64-basis-point increase in nominal and real interest rates.

A central question in this reaction-function setting is what the long-run or target level of inflation is. ClaGer find that the level of π^* is 3.2%. This is surprising because, at least since the 1980s, the rhetoric is 0–2%. Even so, they refer to their finding as "sensible" and note: "the steady-state inflation rate provides a measure of the long-run dimension of monetary policy. Since this number is a product of the steady-state money-growth rate that the policy rule generates, it is ultimately a choice variable of the Bundesbank."

Bundesbankers would be surprised to find that their long-run strategy implies a 3.2% inflation! The authors may have come to their unusual finding because their sample period includes the supply-shock period of the 1970s, where the Buba was taken by surprise and spent a long time with inflation rates that were out of sight. That argues for using the post–oil shock sample period, where the recognition is made explicitly that moderate inflation in long-run averages requires that any overshooting be followed by periods of undershooting. This point is particularly obvious in the 1995–96 discussion rendered in the *Monthly Reports*. There we read that, yes, inflation is safely below 2% but that is not an invitation for expansion. It has to be kept low and pushed down so that the long-run averages come out right. Some of this may be brinkmanship, but the fact is that Germany is in a slump and the Buba is not rushing out to give relief. In sum, modeling strategy around a target of 3.2% inflation is plainly a misreading of what the Buba is about, at least in the last decade.

M3 Matters

A second question about the reaction functions is just how successful they are. I note that, indeed, the major episodes of large rate changes are captured well. But as figure 10.11, for example, shows, there are major and persistent discrepancies between target and actual rates. Thus, in 1978–81 targets exceed actuals persistently, while in 1982–83 the converse is the case. Once again, in 1991–93 actuals exceed targets significantly. The figure shows that by 1993 the target nominal rate would have been below 2.5%! It is tempting to believe that M3 has to do with precisely these persistent discrepancies between the reaction-function prediction and the outcome. Consider, for example, the experience of the 1990s. ClaGer show large discrepancies of target and actual rates in 1993–93. Table 10C.1 shows large overshooting of M3 relative to target. Is it not tempting to consider that the Buba gave some weight to the M3 overshooting, and for that reason the reaction function, which does not contain M3, misfires?

It is tempting therefore to suggest a formulation well within the spirit of ClaGer but with a Buba special. The real interest rate equation might be stated as

$$R' = \gamma R + (1 - \gamma) M3\ Overshoot. \quad (3)$$

In this fashion we capture the factors ClaGer identify in the Taylor-style rendition of the reaction function but at the same time leave room for the situation where M3 overshooting puts the Buba in a bind.

An episode along these lines is surely the early part of 1996. As figure 10C.2 shows, after a slow year of M3 growth, far below target, in 1996 M3 growth took off like a bat out of hell. The Buba is bewildered: the economy with low inflation and no growth needs stimulus, but M3 is running wild. What to do? The Buba is all tied in knots, hoping that M3 will slow down, the economy will recover, and M3 targeting can be kept alive.

European Monetary Union

Another direction to look, if we want to understand just how committed the Buba is to monetary targeting, is the setup for Europe's new monetary institutions. As Europe moves toward a common money, the operating instructions for the European Central Bank are being drafted. The Buba has weighed in heavily: predictably, with monetary targeting. The Buba has denounced inflation-targeting U.K.-style and has insisted on monetary-aggregates targeting. Specifically, Buba president Tietmeyer (1996) argued that stability of real money demand in Europe, outside Germany, was a fact: "As a result, a monetary aggregate strategy, in my judgment, is the most convincing concept for monetary policy in the monetary union. With its use, the European Central Bank could inherit the reputation of the Bundesbank. For a young institution such as ECB will be, this seems certainly attractive" (Tietmeyer 1996).

Table 10C.1 Bundesbank M3 Targets and Outcomes

	Target	Actual
1992	3.5–5.5	9
1993	4.5–6.5	7
1994	4.0–6.0	6
1995	4.0–6.0	2
1996	4.0–7.0	

Source: Deutsche Bundesbank 1995.
Note: Growth rate fourth quarter to fourth quarter.

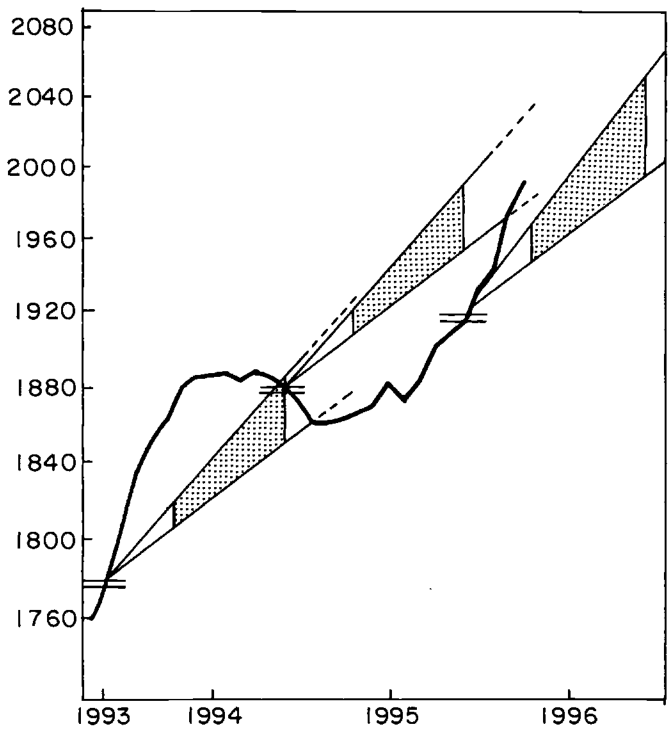

Fig. 10C.2 M3 growth targets

Of course, the short-run instability of M3 in Germany and the controversy over a stable real money demand in most countries on earth make it a bit hard to force all new partners into the same straitjacket. Whereas Tietmeyer was still all-out M3, the most recent struggle with M3 in early 1996 has cooled the enthusiasm somewhat. Thus Issing came out with a milder version, a mix of both inflation targeting and room for aggregates. In a significant weakening of the dogma, leaning far in the direction of the U.K. plea for monetary targeting as the new central bank culture, he notes: "In the end, the discussion about an optimal concept cannot be an Either-Or but must rather a combination of monetary aggregates strategy and inflation targeting" (1996, 8; see also König 1996).

The point remains: M3 has been there, is there, and is not about to disappear. The German saving public (*die Sparer*) have been brought up to trust in the simple quantity theory, and they are not ready to believe in a new institution *and* new operating instructions all at once.

It is appropriate to end on a quote from the *Zauberlehrling* of Goethe: "Herr, die Not is gross, die ich rief die Geister, werd ich nun nicht los."

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