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How the Bundesbank *really* conducted monetary policy

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Abstract

Papers estimating the reaction function of the Bundesbank generally find that its monetary policy from the 1970s to 1998 can be captured by a standard Taylor rule according to which the central bank responds to the output gap and to deviations of inflation from target, but not to monetary growth. This result is at odds with the Bundesbank's claim that it followed a strategy of monetary targeting. This paper analyzes whether this apparent contradiction is due to (a) the use of ex-post data which do not necessarily match policy makers' real-time information sets or (b) the omission of important explanatory variables. Accordingly, we compile a real-time data set for Germany including the Bundesbank's own estimates of potential output and use it to re-estimate the Bundesbank's reaction function. We find that the use of real-time data changes the results considerably. Moreover, when adding the change in the output gap as well as deviations of money growth from target to the set of explanatory variables, we find that both variables are highly significant. This suggests that the Bundesbank took its monetary targets seriously, but also responded to deviations of expected inflation and output growth from target.

Keywords: Monetary policy; Taylor rule; Real-time data; Bundesbank

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1. Introduction

The question of how the Bundesbank conducted monetary policy is of interest not only from a historical perspective. Given that the Bundesbank is usually seen as a comparatively successful central bank, it may be helpful to better understand its monetary policy in order to draw conclusions for current monetary policy. For example, there is an ongoing discussion about the interpretation of the U.S. Fed's monetary policy in the 1970s. While some commentators argue that the Fed was responsible for the "Great Inflation" of the 1970s, because its monetary policy was too expansionary compared with a Taylor rule, others stress that such an interpretation relies on the advantage of hindsight. Today, we know that the Fed's real-time assessment of the U.S. business cycle was too pessimistic. Taking this real-time problem into account, the Fed's monetary policy could be justified even from a Taylor-rule perspective. Or, to put it differently, the Fed's policy would not have been significantly different had it in fact followed a Taylor rule.

The inflation record of the Bundesbank in the 1970s and early 1980s was better than that of the Fed and many other central banks and one could ask why this was the case. One obvious distinctive feature of the Bundesbank's monetary policy since 1975 was that it announced annual targets for monetary growth and – according to its own descriptions – based monetary policy decisions on deviations of actual money growth from these targets. However, recent empirical studies of the Bundesbank's monetary policy generally find that monetary aggregates did not play a significant role in the Bundesbank's interest rate decisions, but that its policy can well be described by a standard Taylor rule.[1]

There are several ways to explain this apparent contradiction. One is that the Bundesbank did not practice the strategy of monetary targeting that it preached. Alternatively, one can question whether the econometric estimations that led to these results are correctly specified. In order to test the second hypothesis, we concentrate on two potential sources of mis-specification: (a) the above-mentioned "real-time" problem and (b) the choice of explanatory variables and the way they actually enter the Bundesbank's reaction function.

The first source of mis-specification relates to the fact that most empirical studies of the Bundesbank's monetary policy use the latest vintage of data available to the authors, i.e., they are based on ex-post revised data. This may not be adequate for the analysis of past monetary policy decisions, since some of the relevant data and estimates undergo major revisions in the course of time. By re-estimating policy reaction functions for the Fed, Orphanides has shown that the use of real-time information can considerably change the outcome of an analysis of past monetary policy decisions.[2] To test whether this is the case for the Bundesbank's reaction function as well, we have compiled a real-time data set which includes real and nominal output, the Bundesbank's own estimates of potential output, the rate of change in the consumer price index and the growth rate of the official monetary-target variable.

Apart from revised data, another source of mis-specification may be the choice of explanatory variables and the way they enter the reaction function. As a rule, the Bundesbank explained its monetary-policy measures with respect to its final goal, price stability,

[1] See, e.g., Clarida, Galí, and Gertler (1998), Faust, Rogers, and Wright (2001), Smant (2002).

[2] See, Orphanides (2001), Orphanides (2003b).

and its intermediate target, money growth. In this context, the "overall economic situation" was also taken into account. Interestingly, the Bundesbank's regular reports (as well as the internal briefing material available for the period in question) suggest that when assessing the overall economic situation, policy makers often focused on the *growth rate* of output relative to the growth rate of production potential rather than on the *level* of output relative to the level of potential.[3] In fact, for much of the period in question, it was more difficult to recover the Bundesbank's real-time estimates of the level of the overall production potential than estimates of the corresponding growth rates.[4] We, therefore, add the (real-time) change in the output gap (which is equivalent to growth in output relative to growth in potential) as well as the (real-time) growth rate of money relative to target to the set of explanatory variables in the Bundesbank's reaction function.

The paper is organized as follows. In Section 2, we present the structure of our real-time data set and discuss the extent of the revisions. Section 3 contains the econometric approach. In the fourth part, we use our real-time data to re-examine the estimates of the Bundesbank's reaction function used in the empirical literature. We find that using real-time data instead of ex-post data considerably changes the results. Specifically, the coefficient of expected inflation (relative to target) becomes insignificant, which, in our view, strongly suggests that the underlying model is mis-specified. We, therefore, enlarge the set of explanatory variables to include the (real-time) growth rate of money relative to target as well as the (real-time) *change* in the output gap. We find that both additional variables are highly significant, whereas the *level* of the real-time output gap drops out. The final section interprets the results and concludes.

2. Reconstruction of the Bundesbank's real-time data set

Unfortunately, real-time data for key macroeconomic variables were not saved systematically in Germany in the past. Clausen and Meier (2003), as well as Sauer and Sturm (2003), were the first to compile real-time data sets in order to estimate the Bundesbank's monetary policy reaction function in real time. Sauer and Sturm (2003) conclude that – contrary to the U.S. – the use of real-time data does not seem to play an important role. Clausen and Meier (2003) calculate various measures of real-time output gaps and use them to estimate Taylor-type reaction functions for the Bundesbank. They find that, at least for some of these measures, the real-time reaction coefficients resemble quite closely those originally proposed by Taylor (1993). Moreover, they find that broad monetary aggregates played only a minor role for Bundesbank policy.

The real-time data sets used in these studies are restricted to real output (GNP/GDP) and industrial production, respectively. To go one step further, we have compiled additional real-time data sets for potential output, consumer prices and money growth. With the exception of potential output, all data are taken from the Bundesbank's monthly reports and from the statistical supplements called "Seasonally Adjusted Business Statistics," which

[3] See, for instance, Deutsche Bundesbank (1981a, p. 30) and Deutsche Bundesbank (1984, p. 35). Walsh (2002, p. 2) presents similar evidence for the U.S.

[4] See Gerberding, Seitz, and Worms (2004, p. 9).

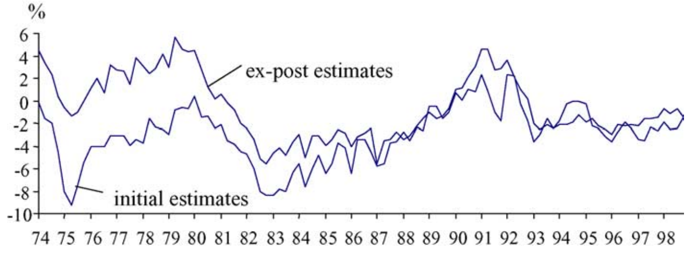

Fig. 1. Initial and ex-post estimates of the output gap.

the Bundesbank publishes regularly together with the monthly reports. For potential output, we have used Bundesbank sources (official publications and internal briefing documents) to reconstruct the Bundesbank's own real-time estimates of potential output.[5] The exact source of each vintage is given in the data files on potential output, which are part of the real-time data set available from the web site of the Economic Research Centre of the Bundesbank.[6]

In principle, the reconstruction of the Bundesbank's real-time data sets for actual as well as potential output should enable us to calculate the implied perceived output gap. However, to this end, we need first to convert the annual estimates of potential output into the quarterly frequency required for our analysis. This was done by applying a standard method of interpolation to each vintage of the original data.[7] The interpolated data were then used to calculate the corresponding real-time vintages of the output gap.

In Fig. 1, the initial (real-time) estimates of the output gap for each quarter are contrasted with the revised estimates from March 1999 which we choose as our benchmark ex-post series.[8] Due to the lag in the release of GDP data, the real-time estimates became available to policy makers with a lag of one quarter (that is, in quarter $t+1$). The changeover from West German to all-German data occurs in the third quarter of 1995 when the Federal Statistical Office started publishing quarterly GDP data for East Germany.[9]

Until the first quarter of 1988, the real-time series is always below the ex-post series, with the initial estimates consistently overestimating the amount of slack in the economy.

[5] The Bundesbank started to produce its own estimates of potential output in the early seventies. The methods used and the results are described in Deutsche Bundesbank (1973).

[6] http://www.bundesbank.de/volkswirtschaft/vo_forschungszentrum_daten.en.php.

[7] We choose the option "Quadratic match sum" offered by EViews 4.1. For more details, see EViews 4 User's Guide, p. 74f.

[8] One reason for this is that our real-time data set for potential output ends in January 1999 with the last vintage of estimates based on the Bundesbank's traditional production-function approach. Furthermore, the March 1999 vintage of GDP data is the last vintage before the changeover to ESA 1995, which led to major changes in the time series concerned. Revised GDP data for West Germany based on ESA 1995 and reaching back beyond 1991 were published only very recently (in August 2003). Most studies on the Bundesbank's reaction function are, therefore, based on pre-ESA 1995 vintages of GDP data.

[9] The assumption that policy makers at the Bundesbank still focused on output data for West Germany in the early years after reunification can be justified on at least two accounts. First, because the relevant data for East Germany were either non-existent or not sufficiently reliable and, second, because eastern Germany's structural problems could not be solved by monetary policy. See Deutsche Bundesbank (1999). Further details on the underlying data sets can be found in Gerberding et al. (2004) and Gerberding, Kaatz, Seitz, and Worms (2005).

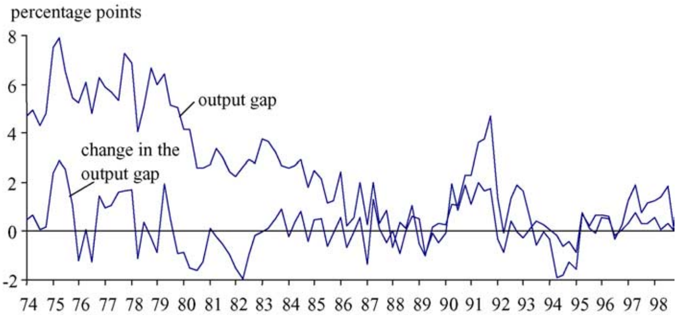

Fig. 2. Measurement errors of the output gap and the change in the output gap.

Splitting the revisions between actual and potential output shows that the positive sign of the forecast error was predominantly due to downward revisions in the estimated level of potential output. Revisions of actual GDP data dominate the overall forecast error only in the first half of the 1990s.

Interestingly, the measurement error regarding the *level* of the output gap is much larger and much more persistent than the measurement error regarding the *change* of the output gap. Fig. 2 illustrates this point. One reason for this is that the high degree of persistence in the measurement error for the level of the gap reduces the variance of the error in the measured change of the output gap.[10]

For completeness' sake, we also compiled real-time data sets for the rate of change in the consumer price index and the output deflator, as well as for money growth as measured by the Bundesbank's monetary target variable. As expected, the measurement errors regarding these variables pale in comparison with the revisions in the estimates of the output gap, and there is no indication of a bias in either direction (see Gerberding et al., 2004).

3. The econometric approach

The starting point of our analysis is the forward-looking version of the Taylor rule presented by Clarida et al. (1998), which has become standard in the empirical analysis of monetary policy decisions. They assume that within each operating period, the central bank sets its target for the short-term nominal interest rate, i_t^*, relative to its long-run equilibrium level in response to departures of either expected inflation or output from their respective targets. Furthermore, they assume that the actual rate adjusts only partially to the target rate. Specifically:

$$i_t^* = \bar{r} + \pi^* + \beta E_t((\pi_{t+n} - \pi^*) \,|\, \Omega_t) + \gamma E_t(y_t \,|\, \Omega_t) \tag{1$'$}$$

$$i_t = (1-\rho) i_t^* + \rho i_{t-1} + \upsilon_t, \tag{1$''$}$$

[10] For a formal derivation see Walsh (2003).

where $\bar{r}$ is the long-run equilibrium real rate of interest and π^* is the inflation target of the central bank (both of which are assumed to be constant). $E_t(.)$ is the expectation operator and Ω_t is the information set available to the central bank at time t, that is, when it sets the short-term interest rate. The horizon of the inflation forecast, $t+n$, is typically assumed to be one year, so that, with quarterly data, $n=4$. y is the gap between actual and potential output (in percent). Eq. ($1''$) explicitly allows for partial adjustment of the actual level of the interest rate to the target value, with ρ capturing the degree of interest-rate smoothing. Additionally, it includes an exogenous shock to the interest rate, υ_t, which may be interpreted as a pure random component to monetary policy (of the type stressed in the *VAR* literature on monetary policy) or, alternatively, as a shock to reserve demand not instantly met by the central bank.

When estimating this kind of reaction function for the Bundesbank, Clarida et al. (1998) find that it captures the Bundesbank's monetary policy remarkably well. However, their analysis is based on ex-post revised data. We try to replicate their results under more realistic informational assumptions. Ideally, to capture the intent of policy as closely as possible, the estimation of (1) should be based on consistent forecasts of inflation and the output gap, as formed by policy makers themselves at the time the decisions were made. In practice, several aspects need to be addressed, however. Monetary policy in Germany was decided by the Central Bank Council ("*Zentralbankrat*"). Unfortunately, it is not possible to reconstruct the Council's collective quantitative assessment of the economic outlook. Staff forecasts of inflation and output do exist, but their semi-annual frequency and varying time horizons render them unsuitable for our purposes. Therefore, the best we can do is to reconstruct the real-time information available to policy makers at the time the decisions were made.

Since real-time data on actual and potential output are only available at a quarterly frequency, we use quarterly data. To make sure that the real-time data included in the information set Ω_t were indeed available to policy makers when they set interest rates, we use end-of-quarter rather than average values of the three-month money market rate to capture the Bundesbank's interest rate policy.[11] In line with previous studies, we assume that policy makers at the Bundesbank targeted the (expected) rate of change in the consumer price index rather than domestic inflation.[12] In contrast to Clarida et al. (1998) and most other studies, we do not treat the (implicit) inflation target of the Bundesbank as constant over the sample period, but use the Bundesbank's "price assumption" or "price norm" which decreased from 5% in 1975 to 1.75% in 1998. The price assumption was one of the benchmark figures in the derivation of the annual monetary targets. Until 1984, it reflected the Bundesbank's view of the "unavoidable" rate of price increase for the year in question. From 1985, it was defined as the maximum rise in prices to be tolerated over the medium term.[13]

[11] Due to end-of-month volatility we do not use the overnight rate as the operational variable. Moreover, given that the stance of monetary policy does not only depend on the current level of the overnight rate, but also on its expected future development, the three-month interest rate may be more relevant. However, generally, the three-month rate and the overnight rate tend to move together.

[12] For a discussion, see Gerberding et al. (2004, p. 17).

[13] See Table 6 in Gerberding et al. (2004). This point has already been taken up by Smant (2002).

A key question is how to proxy the unobserved forecasts of inflation, $E_t(\pi_{t+n}|\Omega_t)$, and the output gap, $E_t(y_t|\Omega_t)$. In principle, we follow Clarida et al. (1998) in rewriting the policy rule in terms of realized values (that is, π_{t+n} and y_t) and subsuming the forecasting errors into the error term. However, in order to keep the forecast errors as small as possible, we do not use the most recent vintages of data (that is, $\pi_{t+n|T}$ and $y_{t|T}$), but the initial (unrevised) figures which became available in $t+n$ and in $t+1$, respectively.[14] Defining $\alpha = \bar{r}$and combining the target model with the partial adjustment mechanism yields:

$$i_t = (1-\rho)(\alpha + \pi^*_{t+n} + \beta(\pi_{t+n|t+n} - \pi^*_{t+n}) + \gamma y_{t|t+1}) + \rho i_{t-1} + \varepsilon_t, \qquad (2)$$

where the error term ε_t is a linear combination of the forecast errors of inflation and the output gap and the exogenous disturbance υ_t:[15]

$$\varepsilon_t = -(1-\rho)\{\beta(\pi_{t+n|t+n} - E_t(\pi_{t+n}|\Omega_t)) + \gamma(y_{t|t+1} - E_t(y_t|\Omega_t))\} + \upsilon_t. \qquad (2a)$$

Hence, our approach relies on the assumption that the forecast errors are unbiased and serially uncorrelated (i.e., white noise). As the time span between the (unobserved) real-time forecast and the release of the first official figures is rather short – n quarters and one quarter, respectively – we do not think that this presents a serious problem. In fact, as regards the output gap, we know that data on industrial production and other monthly indicators allow the Bundesbank staff to roughly estimate GDP some weeks before the first official number is published. In contrast, the assumption of white-noise forecast errors with respect to the ex-post revised data used by Clarida et al. (1998) is much more likely to be violated, especially as regards the output gap (see Fig. 1).

To avoid the endogeneity bias, which would result from the correlation between the inflation variable (dating from $t+n$) and the error term as well as from the correlation between the output-gap variable (dating from $t+1$) and the error term, we must find suitable instruments for both variables. Since the forecast errors are by definition uncorrelated with information already known in t or prior to t, consistent estimates of the parameters β and γ can be obtained by using values of the variables, which were already available at the end of quarter t (that is, $\pi_{t|t}$, $\pi_{t\text{-}1|t}$, etc., as well as $y_{t\text{-}1|t}$, $y_{t\text{-}2|t}$, etc.). We, therefore, include four lags of the interest rate, the output gap, the rate of inflation and the price norm in the instrument set. In line with Clarida et al. (1998), we estimate the parameter vector $[\alpha,\beta,\gamma,\rho]$ using GMM.[16] We select the weighting matrix in the objective function such that the GMM estimates are robust to heteroskedasticity and autocorrelation (which may result from the overlapping structure of the inflation forecast errors). The Bartlett kernel is used

[14] During the period in question, initial information on the change in the CPI in quarter t was usually already available at the end of quarter t. See Gerberding et al. (2004, p. 11f).

[15] Our econometric approach relies on the assumption that the variables entering Eq. (2) are stationary within the sample period. For the inflation gap and the output gap, this is the case and should be so for theoretical reasons. In contrast, it is not clear theoretically whether nominal interest rates should be $I(0)$. The usual unit-root and stationarity tests yield ambiguous results. However, the coefficient restrictions imply that Eq. (2) can be rewritten as a reaction function for the real interest rate, which again should be stationary for theoretical reasons; see Smant (2002, p. 332f). For this reason and to maintain comparability with other studies, we prefer to estimate Eq. (2) in levels.

[16] Instrumental variable estimation of a linear version of Eq. (2) confirmed the results of the nonlinear GMM estimations.

to weigh the autocovariances in computing the weighting matrix with a fixed bandwidth selection suggested by Newey and West. We test the validity of the instruments used and the overidentifying restrictions via Hansen's *J*-statistic.

4. Estimation results

In what follows, we present the results of estimating the Bundesbank's reaction function on a quarterly basis for the sample period 1979Q1–1998Q4, i.e., the EMS period. In line with Clarida et al. (1998), we neglect the first turbulent and volatile years of monetary targeting, which were later labeled the "experimental" phase even by Bundesbank officials.[17] As a starting point and in order to enhance comparability with existing studies, we re-estimate reaction function (2) with the ex-post revised data as of 1999Q1.

The left panel of Table 1 presents the results based on ex-post revised data with the horizon of the inflation gap varying from four to six quarters.[18] As we use the *end-of-quarter* values of the interest rate, but quarterly *averages* of the explanatory variables, a forecast horizon of four (five, six) quarters for the inflation gap in effect means that policy makers look three (four, five) and a half quarters ahead. In this setup, purely forward-looking policy makers will target inflation at a horizon of at least five quarters, rather than the (average) rate of inflation between t and $t+4$ which reaches back into the already bygone quarter t.

Several observations are in order. First, in all cases, the *J*-statistic confirms the validity of the overidentifying restrictions. Second, by setting the horizon of the inflation gap at five or six quarters, we can replicate the standard result that the Bundesbank followed a forward-looking Taylor rule with a substantial degree of interest-rate smoothing. In both cases, the point estimates of the response to expected inflation, β, exceed one and, at values of 1.4 and 1.6, respectively, come very close to the value of 1.5 originally proposed by Taylor. At the same time, the point estimates of the response to the output gap, at values of 0.53 and 0.51, respectively, are almost identical to the "Taylor value" of 0.5. Furthermore, we find that with values of around 0.8 for the "speed-of-adjustment" parameter ρ, the estimated degree of interest-rate smoothing also comes close to the value estimated by Clarida et al. (1998).

As a next step, we re-estimate Eq. (2) with real-time data (see the right panel of Table 1). Again, the overidentifying restrictions seem valid. In contrast to the estimates based on ex-post data, the results based on real-time data do not support the hypothesis that the Bundesbank followed a standard Taylor rule. Most importantly, the coefficient of the inflation gap is not significant for any of the horizons considered here (nor for smaller or larger values of n). By contrast, the coefficient of the real-time output gap is significant (at the 5% level) for $n = 5$, 6, with high point estimates of above one.

The estimated insignificance of the Bundesbank's response to the inflation gap certainly stands in stark contrast to its pronounced focus on fighting inflation, as well as to its relative success in pinning down trend inflation during the sample period. One reason for this apparent contradiction could be that the variables included in the instrument set, though

[17] See, e.g., Schlesinger (1985, p. 88).

[18] We are not able to estimate the Bundesbank's interest-rate setting satisfactorily in a backward-looking way.

Table 1
Parameter estimates of baseline reaction function

Coefficients	Based on ex-post revised data			Based on real-time data		
	$n=4$	$n=5$	$n=6$	$n=4$	$n=5$	$n=6$
α	3.79*** (0.28)	3.47*** (0.26)	3.38*** (0.24)	12.48 (10.95)	7.63*** (2.15)	5.89*** (1.60)
β	0.82** (0.34)	1.43*** (0.32)	1.61*** (0.28)	−5.26 (9.03)	−0.60 (1.20)	0.60 (0.83)
γ	0.76*** (0.19)	0.53*** (0.15)	0.51*** (0.13)	4.16 (5.26)	1.59** (0.77)	1.03** (0.51)
ρ	0.81*** (0.02)	0.79*** (0.02)	0.81*** (0.02)	0.97*** (0.04)	0.92*** (0.03)	0.92*** (0.03)
R^2	0.95	0.95	0.95	0.93	0.94	0.95
SEE	0.55	0.59	0.55	0.66	0.60	0.57
J-stat	0.78	0.86	0.87	0.75	0.69	0.73
Jarque Bera	0.81	0.26	0.52	0.23	0.28	0.41

***(**/*) denotes significance at the 1% (5%/10%) level. Estimation period: 1979Q1–1998Q4, $T=99$Q1, estimation method: GMM; HAC-robust standard errors in parentheses. To correct for extreme outliers in the residuals, it proved necessary to include a dummy variable in the estimations, which is one in the first quarter of 1981 and zero otherwise. The dummy captures the jump in money-market rates which occurred in February 1981 when the Bundesbank replaced its "normal" lombard loans with a new special lombard facility which cost 3 percentage points more (see Deutsche Bundesbank (1982, p. 5)). The instrument set includes the contemporary values of inflation and the price assumption (which were known to policy makers at the end of each quarter) as well as four lags of each explanatory variable. R^2: adjusted coefficient of determination; SEE: standard error of the regression; J-stat: p-value of the J-statistic on the validity of overidentifying restrictions; Jarque Bera: p-value of the Jarque Bera test of the normality of residuals.

valid instruments, are only weakly correlated with the rate of inflation prevailing in $t+n$. However, auxiliary regressions of the respective inflation variables on the instrument set do not support this argument. Another reason could be that the parameter estimates are biased (and inconsistent), because the standard specification of the Bundesbank's reaction function omits important explanatory variables. In order to shed more light on this issue, we now consider additional variables which are suggested by the Bundesbank's own descriptions of its monetary-policy strategy, as well as by the most recent literature on robust monetary-policy rules.

Certainly, the most prominent feature of the Bundesbank's monetary-policy strategy was the practice of formulating monetary targets. These referred to the rate of money growth from the fourth quarter of one year to the fourth quarter of the next year.[19] To gain some flexibility, the targets were formulated as a corridor of 2 or 3 percentage points (with the exception of the point target of 5% for the year 1989). The targets were announced in December and reviewed in the middle of the following year. This mid-term review resulted in a change of the target range only once (in 1991), but there were several instances when the corridor was narrowed.[20]

The Bundesbank did not try to achieve its monetary targets at all cost, but at times tolerated deviations from the target which were deemed to be caused by short-run shocks, such as deviations of output or velocity from their long-run trend values. In fact, during the 20 years of our sample period (1979–1998), the targets were missed 7 out of 20 times. In six of these seven instances, actual money growth in the fourth quarter was above target. However, the Bundesbank managed to keep *average* money growth just below 6% during this period, which, taken together with a trend rate of output growth of 2.1% and a trend decline of velocity of 1.1%, resulted in an *average* rate of inflation of 2.8% (both for CPI inflation and the change of the output deflator).

Clarida and Gertler (1997) and others have challenged the relevance of the monetary targets for the Bundesbank's day-to-day policy decisions. Clarida et al. (1998) apply a formal test by adding a measure of the gap between the actual money stock and the announced target path to the set of explanatory variables in the Bundesbank's reaction function, Eq. (1). They find that "the money aggregate just does not matter,"[21] while the other parameter estimates in the equation remain largely unchanged.

The reconstruction of real-time data sets for all relevant variables enables us to repeat this exercise under more realistic informational assumptions. Besides including a measure of money growth relative to target in the reaction function, we allow for the possibility that the Bundesbank responded to changes in the output gap – that is, to deviations of actual real growth from potential growth – as well as to the level of the output gap. This extension seems sensible for two reasons. First, discussions on economic activity and on the economic outlook were usually (and still are) conducted much more in terms of the growth rate of output (relative to trend growth) than in terms of the level of the output gap. The Bundesbank's own regular reports on the economic situa-

[19] Except for three of the early years of monetary targeting (1976–1978), when the targets were formulated for the annual average of money growth, but which were excluded from our sample.

[20] See Gerberding et al. (2004), Table 10.

[21] See Clarida et al. (1998), esp. p. 1046.

tion in Germany certainly back this observation. In fact, while the annual reports in the 1970s still contain a graph on the rate of capacity utilization, the concept is hardly ever referred to in the 1980s and 1990s (with the exception of Deutsche Bundesbank (1981b, 1995)).

Second, there is a growing theoretical and empirical literature, which suggests that it might be preferable for central banks to target the change rather than the level of the output gap.[22] As shown above, one advantage of such a strategy is that the measurement error regarding the change in the output gap is likely to be much smaller than the measurement error in the level of the gap. Accordingly, we include the change in the output gap as well as the money-growth gap among the explanatory variables:

$$i_t = (1-\rho)(\alpha + \pi^*_{t+n} + \beta(\pi^a_{t+n|t+n} - \pi^*_{t+n}) + \gamma_1 y_{t|t+1} + \gamma_2 \widehat{y}^a_{t|t+1} + \lambda(\widehat{m}^a_{t|t+1} - \widehat{m}^*_t)) + \rho i_{t-1} + \varepsilon_t. \tag{3}$$

The superscript a denotes rates of change over the previous four quarters. In contrast to Clarida et al. (1998), we define the money (growth) gap as the deviation of the (annual) money-growth rate from the midpoint of the official target corridor. In our view, this specification is more in line with the Bundesbank's emphasis on pinning down the medium-run or trend rate of money growth. However, our results are robust to changes in the exact definition of the money gap (see Table 2, right panel).

Again, we need to instrument the explanatory variables. As instruments, we use the contemporary values of those variables which were known at the end of each quarter, that is, the (annual) rate of change in the CPI, the price assumption, the average of the (annual) money-growth rates in the first two months of the current quarter and the money-growth target. Furthermore, we include four lags of all explanatory variables except the money-growth target in the instrument set.[23]

The left panel of Table 2 presents the parameter estimates. The time horizon of the inflation gap n is again set at four, five and six quarters, respectively. The J-statistic confirms the validity of the overidentifying restrictions for each case. As before, we find that the coefficient of the (real-time) inflation gap is highly significant with estimated values well above one. By contrast, the coefficient of the (real-time) *level* of the output gap is not significant. Obviously, policy makers at the Bundesbank did not strongly react to this variable, possibly because they were aware of the high degree of uncertainty surrounding its initial estimates.

However, the coefficient of the *change* in the gap is highly significant for all values of n considered. Interestingly, the point estimates of the coefficients β and λ are very similar, especially when the horizon of the inflation outlook is set at four or five quarters. Taken by itself, this result suggests a certain kinship of the Bundesbank's policy to a strategy of nominal income-growth targeting (although with different time horizons of the two components of nominal income).[24]

Furthermore, and in contrast to previous studies like Clarida et al. (1998), we find that the coefficient of the money-growth gap is highly significant, suggesting that the Bundesbank

[22] See, e.g., Walsh (2002, 2003). Empirical evidence for the Federal Reserve can be found in Orphanides (2003b).

[23] We do not include lags of the money-growth target in the instrument set, because we think that they do not contain useful information with regard to the variables which have to be forecasted.

[24] Dropping the insignificant output gap leaves the results for the other coefficients unchanged.

Table 2
Parameter estimates of extended reaction function with real-time data

Coefficients	Money gap measured by				
	Annual rate of money growth relative to target			Log money stock relative to target path	(Annualized) six-month money growth relative to target
	$n=4$	$n=5$	$n=6$	$n=5$	$n=5$
α	3.64*** (0.53)	3.65*** (0.60)	3.17*** (0.41)	3.17*** (0.53)	2.80*** (0.76)
β	2.07*** (0.26)	1.88*** (0.29)	1.70*** (0.20)	2.50*** (0.32)	2.50*** (0.47)
γ_1	0.05 (0.15)	0.13 (0.16)	−0.01 (0.11)	−0.05 (0.14)	0.08 (0.20)
γ_2	2.02*** (0.41)	1.90*** (0.39)	1.08*** (0.20)	1.76*** (0.35)	2.89*** (0.67)
λ	0.44*** (0.09)	0.54*** (0.08)	0.49*** (0.07)	0.58*** (0.09)	0.51*** (0.16)
ρ	0.88*** (0.02)	0.88*** (0.01)	0.84*** (0.01)	0.86*** (0.02)	0.91*** (0.02)
R^2	0.95	0.95	0.96	0.95	0.95
SEE	0.55	0.56	0.53	0.58	0.56
J-stat	0.93	0.91	0.90	0.94	0.88
Jarque Bera	0.86	0.52	0.16	0.45	0.42

***(**/*) denotes significance at the 1% (5%/10%) level. Estimation period: 1979Q1–1998Q4, T = 99Q1, estimation method: GMM; HAC-robust standard errors in parentheses. To correct for extreme outliers in the residuals, we include a dummy variable which is one in the first quarter of 1981 and zero otherwise. The instrument set includes the contemporary values of those explanatory variables which were known to policy makers at the end of quarter t (that is, inflation, the price assumption, average money growth in the first two months of the current quarter and the money-growth target), as well as four lags of each explanatory variable except the money-growth target. R^2: adjusted coefficient of determination; SEE: standard error of the regression; *J*-stat: *p*-value of the *J*-statistic on the validity of overidentifying restrictions; Jarque Bera: *p*-value of the Jarque Bera test of the normality of residuals.

reacted to deviations of money growth from the announced target independently of its concern about stabilizing future inflation (over the horizon assumed here) and real growth around their respective target values (which is captured by the use of money growth as an instrumental variable). The right panel of Table 2 shows that this result holds also for alternative definitions of the money-gap variable (even for *log money stock relative to target path* which was used by Clarida et al. (1998)).

The lagged interest rate is again highly significant, suggesting a substantial degree of interest-rate smoothing. The point estimate of ρ is even higher than the corresponding estimate based on ex-post data. This result is in accordance with the Bundesbank's often professed preference for conducting a "steady-as-she-goes" interest-rate policy ("Politik der ruhigen Hand").[25] It is also in line with the theoretical argument that in the case of uncertainty the degree of interest-rate smoothing should become larger.[26]

[25] See, for instance, Tietmeyer (1998, p. 2).

[26] This finding is also robust to estimation with a moving-average structure of the error term, as suggested by English, Nelson, and Sack (2003).

5. Interpretation of the results and conclusions

Taken together, our results throw serious doubts on the widespread view that the monetary policy of the Bundesbank can well be described by a generalized Taylor rule. Instead, they suggest that policy makers at the Bundesbank followed a strategy of *"flexible" monetary targeting* with a significant response to the money-growth gap as well as to the (expected) inflation gap and the output-growth gap. For several reasons, we believe that this result is very much in line with the Bundesbank's own descriptions of its strategy:

- In our view, the significance of the money-growth gap reflects the Bundesbank's commitment to its monetary targets. As mentioned above, the derivation of the targets was based on the Bundesbank's conviction, that in the long run inflation is pinned down by the economy's steady-state growth rate of money. The monetary targets were thus intended to anchor long-term inflation expectations as well as the trend rate of inflation. Another important aspect was to give guidance to other policy makers, especially to fiscal and wage policy. In terms of the more recent literature on the time inconsistency of optimal monetary policy, policy makers at the Bundesbank used the monetary targets as a commitment device to avoid the "classic" inflation bias of discretionary policy.[27]
- But why should the Bundesbank react to deviations of money growth from target independently of its concern about (expected) inflation? Several (non-exclusive) explanations are possible. First, in order to make the commitment to the target credible, the Bundesbank had to show some response to deviations of money growth from target even at times when inflation and output growth were in line with the respective targets.[28] Second, in view of the long transmission lags, the money-growth gap might contain information about future price developments over a longer horizon than the four to six quarters of the inflation-gap variable we have considered. To put it in the words of Karl Klasen, President of the Bundesbank from 1970 to 1977: "*in the absence of the monetary target, we would not have responded so early or so often*".[29] Third, monetary aggregates may contain useful information for specific (often unobserved) economic developments, e.g., the build-up of financial-market turbulences and asset-price bubbles. Finally, and closely related to the topic of our paper, as data on money growth were subject to very few revisions in Germany during the period in question,[30] they may have played a significant role in providing timely and steady information about the state of the economy.[31]

On the other hand, the formulation of the target as a corridor and the willingness to tolerate temporary deviations from this corridor, left some room for other considerations or "side targets", as they were called. It was this flexibility which led Otmar Issing (chief economist from 1990 to 1998) to describe the Bundesbank's variant of monetary targeting as "pragmatic monetarism" or "disciplined discretion".[32] Helmut Schlesinger, one of the "fathers" of

[27] See Issing (1995, pp. 588 and 607).
[28] See Schlesinger (2002, p. 147).
[29] See Schlesinger (1985, p. 91).
[30] See Gerberding et al. (2004, p. 13f).
[31] On the last two points, see, e.g., Masuch, Nicoletti-Altimari, Pill, and Rostagno (2003).
[32] See Issing (1997, p. 72).

the Bundesbank's monetary-targeting strategy, once stated that the monetary policy of the Bundesbank could be characterized as a mixture of two "pure" strategies: a medium-term monetarist and an anticyclical orientation.[33] He stressed the importance of the anticyclical component, because typically an economy is not in a general equilibrium situation, and therefore one of the preconditions of the pure medium-term monetarist strategy – which aims at maintaining an equilibrium situation – is not met. Therefore, *"the Bundesbank was moderately anticyclical, but at heart took a long-term view,"*[34] giving justification to the inclusion of short-term objectives like the stabilization of inflation and output – or output growth – around their steady state values in the Bundesbank's reaction function.

In order to assess an economy's current position in the business cycle and its likely development over the horizon relevant to monetary policy, both the level of the output gap as well as the change in the gap are certainly important. However, the real-time measurement problem seems to be much more severe in case of the level compared to the change of the output gap. Given this high degree of uncertainty, one would not expect the Bundesbank to put a strong weight on the real-time level of the output gap which is confirmed by our estimation results. In this respect, our results are in line with those of Orphanides (2003a), who concludes that successful central banks – like the Bundesbank and the Fed after the appointment of Volcker – have placed much less emphasis on (real-time estimates of) the output gap than suggested by simple activist policy rules such as the Taylor rule.

The simultaneous presence of the inflation gap and the output-growth gap in the Bundesbank's reaction function (and the closeness of the point estimates of their coefficients), suggests a certain kinship of the Bundesbank's policy with the concept of nominal-income-growth targeting, which has been advocated, among others, by Tobin (1980), McCallum (1985) and McCallum and Nelson (1999). Recently, academic interest in policy rules, which focus on growth rates (differences) as opposed to levels, has revived. Orphanides (2003a), Walsh (2003) and others have presented evidence that "difference rules" or "speed limit policies" may perform well in the presence of imperfect information about the level of potential output.[35] Whether these results are robust to other sources of uncertainty has yet to be proved. However, our finding that the Bundesbank during its most successful period (1979–1998) responded to deviations of money growth, inflation and output growth from their respective targets lends support to the view that difference rules deserve serious consideration.

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[33] See Schlesinger (1980, p. 35).
[34] Richter (1999, p. 550).
[35] See also Orphanides and Williams (2005).

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