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How the Bundesbank really conducted monetary policy: An analysis based on real-time data

Christina Gerberding
(Deutsche Bundesbank)

Andreas Worms
(Deutsche Bundesbank)

Franz Seitz
(Fachhochschule Amberg-Weiden)

Abstract:

Papers estimating the reaction function of the Bundesbank generally find that its monetary policy from the 1970s to 1998 can well 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 analyses 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 and (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 considerably changes the results. 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.

Non-Technical Summary

The inflation record of the Bundesbank in the 1970s and early 1980s was better than that of many other central banks. A distinctive feature of the Bundesbank´s monetary policy since 1975 was that it announced targets for monetary growth and - according to its own descriptions - based monetary policy decisions on deviations of actual money growth from these targets. However, contrary to that description, recent empirical studies generally find that monetary aggregates did not play a significant role for the Bundesbank´s interest rate decisions. We find that this "contradiction" can be explained by two deficiencies of the respective empirical analyses. First, the use of ex-post revised data ignores that the data and estimates relevant for monetary policy decisions underwent major revisions in the course of time and, second, these studies restrict the set of explanatory variables only to those contained in the Taylor rule plus a variable that serves to capture monetary targeting.

To test the implications of the data revisions, we have compiled a real-time data set which includes real and nominal output, the Bundesbank's own estimates of potential output, the inflation rate (measured by consumer prices and the GDP deflator) and the growth rate of the official monetary target variable. While we are able to reproduce the result of the previous literature on the basis of ex-post data - i.e. we find that the Bundesbank´s policy can be described fairly well by a standard Taylor rule - this result does not hold if we use real-time data. More specifically, we find that the Bundesbank based its monetary policy decisions on the (real-time) expected inflation gap, but not on its (real-time) estimate of the output gap.

Instead, the Bundesbank's own regular reports on the economic situation in Germany during the period in question (1975-1998) point into the direction that concern about economic activity and the economic outlook focused on the *growth* in output (relative to the *growth* in potential) rather than on the *level* of output (relative to the *level* of potential). Therefore, we add 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, whereas the *level* of the real-time output gap still drops out. This suggests that the Bundesbank took its monetary targets seriously, but also

responded to deviations of expected inflation and output growth from the respective targets.

Nichttechnische Zusammenfassung

Das Ergebnis der Bundesbankpolitik hinsichtlich der Preisstabilität war in den 70er und frühen 80er Jahren besser als das vieler anderer Zentralbanken. Ein besonderes Merkmal der Bundesbankpolitik war dabei, dass sie seit 1975 ein jährliches Geldmengenziel verkündete und - ihren eigenen Aussagen nach - ihre geldpolitischen Entscheidungen auf Abweichungen des tatsächlichen Geldmengenwachstums von diesem Ziel basierte. Im Gegensatz hierzu haben neuere empirische Studien jedoch gefunden, dass die Geldmenge keine signifikante Rolle bei den Zinsentscheidungen der Bundesbank spielte. Wir finden, dass dieser "Widerspruch" durch zwei Schwachstellen dieser empirischen Arbeiten erklärt werden kann. Zum einen vernachlässigt die Verwendung ex-post revidierter Daten, dass Daten und Schätzungen, die den geldpolitischen Entscheidungen in Echtzeit zugrunde lagen, im Laufe der Zeit gravierend revidiert wurden. Zum anderen berücksichtigen diese empirischen Studien lediglich jene Variablen, die sich in der Taylor-Regel befinden, zuzüglich einer Geldmengengröße und keine weiteren Variablen.

Um die Implikationen der Datenrevisionen abschätzen zu können, haben wir einen Echtzeitdatensatz konstruiert. Er enthält die reale Produktion, das nominale Volkseinkommen, die Bundesbank-eigenen Schätzungen des Produktionspotenzials, die Inflationsrate (gemessen auf Basis des Konsumentenpreisindex und des BIP-Deflators) und die Wachstumsrate der offiziellen Geldmengen-Zielgröße. Während wir die Ergebnisse der früheren empirischen Arbeiten mit ex-post Daten reproduzieren können, d. h. wir finden auf Basis revidierter Daten, dass die Bundesbankpolitik gut durch eine gewöhnliche Taylor-Regel beschrieben werden kann, hat dieses Resultat auf Basis von Echtzeitdaten keinen Bestand mehr. Insbesondere ergibt sich, dass die Bundesbank ihre geldpolitischen Entscheidungen auf die erwarteten (Echtzeit-)Inflationslücken stützte, nicht aber auf ihre (Echtzeit-)Schätzung der Produktionslücke.

Statt dessen deuten die eigenen regelmäßigen Berichte der Bundesbank aus der fraglichen Zeit (1975-1998) an, dass ihre Konjunkturanalyse und -ausblick sich auf das Produktions*wachstum* (relativ zum Potenzial*wachstum*) und weniger auf das Produktions*niveau* (relativ zum Potenzial*niveau*) bezog. Daher fügen wir die *Änderung* der Produktionslücke gemeinsam mit der Abweichung der Geldmengenwachstumsrate vom Ziel als zusätzliche erklärende Variablen in die Schätzung ein. Wir finden, dass beide Variablen hochsignifikant sind, während das Niveau der Echtzeit-Produktionslücke weiterhin nicht signifikant ist. Dies bedeutet, dass die Bundesbank ihre Geldmengenziele durchaus ernst genommen hatte, dass sie aber auch auf die Abweichungen der erwarteten Inflationsrate und des Produktionswachstums von den jeweiligen Zielwerten reagierte.

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1   Introduction

The question of how the Bundesbank conducted monetary policy is of interest not just from a historical perspective. Given that the Bundesbank is usually seen as a comparatively successful central bank it may be useful 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 US-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 (according to which the short-term real interest rate should be raised if inflation increases above the target level and/or if real output rises above trend), others stress that such an interpretation relies on the advantage of hindsight: Today, we know that the Fed´s real-time assessment of the US 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 whether the Bundesbank was able to avoid some of the "mistakes" made by others and – if so – 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 that analyse the Bundesbank´s monetary policy generally find that monetary aggregates did not play a

significant role for 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 in fact not practise 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 for the second hypothesis, we concentrate on two specific sources for possible mis-specifications: (a) the already mentioned "real-time" problem and (b) the choice of the 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 of the previous empirical studies on 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. This is especially true for the output gap and its components, but also for other variables like consumer prices and – to a lesser extent – monetary aggregates. By re-estimating policy reaction functions for the US-Fed, Orphanides and others have 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 inflation rate (measured by consumer prices and the GDP deflator) and the growth rate of the official monetary target variable.

Besides the use of revised data, another possible source for mis-specification may be the choice of explanatory variables and the way they enter the reaction function. For

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[1] See e.g. Clarida et al. (1998); Faust et al. (2001); Herz and Greiber (2001), Weymark (2001); Bec et al., (2002); Kamps and Pierdzioch (2002); Neumann and von Hagen (2002); Smant (2002); Surico (2003a, b). An exception as regards the role of money is Brand (2001). Solveen (1998) estimates a backward-looking reaction function within a cointegration framework and interestingly finds no evidence in favour of a Taylor rule. Brüggemann (2003) does not impose such a Taylor-type relation a priori but finds it based on a Structural Vector Error Correction Model.

[2] E.g. Orphanides (2001a, b, 2002), Orphanides and Williams (2003), Tchaidze (2002), Lansing (2002). There are also other fields where results were distorted by using final data in comparison to real time data, see e.g. Kozicki (2001), Croushore and Stark (2002), Jacobs and Sturm (2003), Koenig (2003), and Orphanides and van Norden (2003).

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instance, the standard Taylor rule restricts the set of variables which reflect the central bank's concern about the real economy to the *level* of the output gap. But, as recently pointed out by Walsh (2003) and others, actual statements from central banks suggest that concern about economic activity and the economic outlook focuses on the *growth* in output (relative to the *growth* in potential) rather than on the *level* of output (relative to the *level* of potential). The Bundesbank's own regular reports on the economic situation in Germany during the period in question (1975-1998) back this observation. Second, there is a growing theoretical and empirical literature suggesting that in the presence of imperfect information about the level of the output gap it might be a good idea for central banks to target the change in the gap – which is equivalent to the growth rate of output relative to trend growth.[3] We therefore add the (real-time) estimate of the change in the output gap as well as the (real-time) growth rate of money relative to target to the set of explanatory variables of the Bundesbank's reaction function.

The paper is structured as follows. In section 2, we review the class of monetary policy reaction functions introduced by Taylor (1993) and generalised by Clarida et al. (1998) which have become a standard analytical tool for the analysis of monetary policy decisions. The structure of our real-time data set and the extent of the revisions are sketched in the third section. In the fourth part, we use our real-time data set to re-examine the estimates of the Bundesbank's reaction function presented by previous empirical papers, e.g. Clarida et al. (1998). 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. In part 5, 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 still drops out. The final section summarises and concludes.

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[3] See Orphanides et al (1999), Orphanides (2000), Walsh (2004).

2 Specification of the Central Bank's Reaction Function

Following the influential study by Taylor (1993), it has become widespread practice to model monetary policy decisions as simple linear feedback rules linking the central bank´s interest rate decision to the output gap and the rate of inflation:

$$i_t^T = \pi_t + \bar{r} + 0.5(\pi_t - \pi_t^*) + 0.5 y_t, \tag{1}$$

where

i is the short-term nominal interest rate set by the central bank (the superscript T indicates the value implied by the Taylor rule)

         is the annual rate of inflation

$\bar{r}$ is the long-run equilibrium real rate of interest

π^* is the inflation target of the central bank

y is the percent deviation of real GDP from target; that is $y = 100(Y\text{-}Y^*)/Y^*$ where Y is real GDP, and Y^* is trend real GDP or potential GDP.

The Taylor rule as defined in (1) is written in "real" terms, with the current inflation rate π_t serving as a proxy for expected inflation. According to this rule, the central bank should raise the short-term real interest rate (i_t - π_t) above its long-run equilibrium level ($\bar{r}$) if inflation increases above the target and/or if real GDP rises above trend.

Clarida et al. (1998) have generalised the interest-rate rule (1) to a class of policy rules that explicitly include forward-looking elements. They assume that within each operating period the target real rate, that is $r_t^* = i_t^* - E(\pi_{t+n}/\Omega_t)$, adjusts relative to its long-run equilibrium level in response to departures of either expected inflation or output from their respective targets. Specifically:

$$i_t^* - E\left(\pi_{t+n}|\Omega_t\right) = \bar{r} + (\beta-1)E\left((\pi_{t+n} - \pi_{t+n}^*)|\Omega_t\right) + \gamma E\left(y_t|\Omega_t\right), \tag{2}$$

where $E(.)$ 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. This specification allows for the possibility that the central bank does not have exact information about the current values of either output or the rate of inflation. The horizon of the inflation forecast, $t+n$, is typically assumed to be one year, so that, with quarterly data, $n = 4$. [4]

Rearranging (2) yields the "nominal" interest-rate rule:

$$i_t^* = \bar{r} + E\left(\pi_{t+n}^*\middle|\Omega_t\right) + \beta E\left((\pi_{t+n} - \pi_{t+n}^*)\middle|\Omega_t\right) + \gamma E\left(y_t\middle|\Omega_t\right). \tag{3}$$

The coefficients β and γ reflect the extent to which the central bank responds to deviations of expected inflation and output from their respective targets. Based on the result that self-fulfilling bursts of inflation may be possible if $\beta \leq 1$, the so-called "Taylor principle" requires β to be larger than 1. In this case the central bank´s response to a deviation of inflation from target does not only entail an increase in the nominal but also in the real interest rate.[5]

To allow for the observed tendency of central banks to smooth changes in interest rates, Clarida et al (1998) assume that the actual rate partially adjusts to the target rate:

$$i_t = (1 - \rho)i_t^* + \rho i_{t-1} + \upsilon_t \tag{4}$$

where ρ captures the degree of interest rate smoothing.[6] This specification additionally 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.

Combining the target model (3) with the partial-adjustment mechanism (4) yields:

$$i_t = (1 - \rho)\left(\bar{r} + E(\pi_{t+n}^*|\Omega_t) + \beta E((\pi_{t+n} - \pi_{t+n}^*)|\Omega_t) + \gamma E(y_t|\Omega_t)\right) + \rho i_{t-1} + \upsilon_t. \tag{5}$$

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[4] Clarida et al. (1998) suggest to think of the real rate as an "approximate" real rate because the maturity of i_t may be less than the inflation forecast horizon.

[5] See Bernanke and Woodford (1997), Clarida et al (1998), Clarida et al (2000). It should be noted that Benhabib et al (2001) have shown that $\beta > 1$ is not sufficient to guarantee determinacy of equilibrium. Whether $\beta > 1$ is stabilising or destabilising depends crucially on the way money is assumed to enter preferences and technology.

This specification has become standard in the empirical analysis of monetary policy decisions. We therefore take it as our starting point. Ideally, to capture the intent of policy as closely as possible, the estimation of (5) 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 bi-annual frequency and varying time horizon renders them unsuitable for our purposes (i.e. there is no data source comparable to the Greenbook produced by the Federal Reserve Board's staff). Therefore, the best we can do is to reconstruct the data set which was available to policy makers at the time the decisions were made. These data can then be used to proxy the real-time forecasts in (5).

3 Reconstruction of the Bundesbank's real-time data set

Research on real-time issues in monetary policy owes much to the efforts of Croushore and Stark from the Federal Reserve Bank of Philadelphia who compiled a comprehensive real-time data set for the US economy which was then made available to the public.[7] Unfortunately, no such data set is publicly available for Germany up to now. However, Clausen and Meier (2003) as well as Sauer and Sturm (2003) have recently estimated monetary policy reaction functions for the Bundesbank using real-time data sets compiled by their own. Sauer and Sturm (2003) compare estimated reaction functions of the ECB and the Bundesbank for the 1990s. They conclude that – contrary to the US – the use of real-time data on industrial production does not seem to play an important role. Clausen and Meier (2003) construct a real-time data set for real GDP to calculate various measures of real-time output gaps which are then used to estimate Taylor-type reaction functions for the Bundesbank. They find that, at least for some of their measures of the output gap, the real-time reaction coefficients resemble

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[6] See Sack and Wieland (2000) as well as Srour (2001) for a discussion of theoretical justifications for such smoothing.
[7] See Croushore and Stark (2001).

quite closely those originally proposed by Taylor (1993). Moreover, they find that broad monetary aggregates played only a minor role for the Bundesbank policy.

The real-time data sets used in these studies are restricted to real output (GNP/GDP) and industrial production, respectively, and do not extend to other key variables like the Bundesbank's estimates of potential output, consumer prices, the output deflator and monetary aggregates. In order to overcome this shortcoming, we have compiled real-time data sets for all relevant variables. The data are taken from the Bundesbank's monthly reports and from the statistical supplements called "Seasonally Adjusted Business Statistics" which the Bundesbank publishes regularly together with the monthly reports. Furthermore, we have used Bundesbank sources (official publications and internal briefing documents) to reconstruct the Bundesbank's real-time estimates of potential output. The reconstruction of real-time data sets for actual and potential output enables us to calculate the Bundesbank's real-time estimates of the output gap.

The data sets can be thought of as matrices, with each column representing a new vintage (i.e. a new time series) of data. Table 1 illustrates the structure of the data set for real and nominal output. The Bundesbank started publishing seasonally-adjusted quarterly data for real and nominal GNP in December 1971.[8] These series constitute the first columns in the respective matrices of Table 1. In general, the published series reach back about ten years (so that the series from December 1971 starts with an observation for 1962Q1 etc.). The stepwise entry of new data reflects the fact that during our sample period, output data for the previous quarter became available in February, June, September and December. Therefore, we can safely assume that policymakers at the end of quarter t knew the level of GNP in quarter t-1. Our data set ends with the vintage of March 1999 which we use as the benchmark ex post series for purposes of comparison. We will label this series as "final", recognising, of course, that "final" is very much an ephemeral concept in the context of our analysis.[9]

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[8] The Federal Statistical Office started publishing quarterly data on GNP only in 1978. Before, the Bundesbank used its own method to break down the official semi-annual data.

[9] All these remarks are equally true for the GNP/GDP deflator. In April 1999, the German Statistical Office introduced the new ESA 1995 which led to major changes in the time series concerned. However, 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

The data set reflects the shift from GNP to GDP as the headline measure of "output" which occurred in June 1992. From December 1971 to March 1991, the published series were seasonally adjusted but not adjusted for the effects of working days and holidays; from April 1991 onwards, the series are seasonally and calendar adjusted (s.c.a.). However, we believe that we can safely assume the consequences of this shift for our analysis to be negligible.[10] Finally, quarterly GDP data for East Germany became available only from September 1995 onwards. Therefore, the data vintages up to August 1995 refer to West Germany only. Beginning with the vintage of September 1995, we use data for unified Germany.[11]

Figure 1 illustrates the differences between the real-time growth rates of real GNP/GDP – that is, the first estimates for quarter t from $t+1$ – and the ex post revised data (as of March 1999). Figure 2 repeats the exercise for the annual rate of change of the GNP/GDP deflator (which is calculated by dividing nominal through real output). In both cases, the two series are generally quite similar, indicating that the magnitude of revisions is not very large. By far the biggest difference between the series occurs in 1975Q3, when the first estimate of real GNP growth was later revised upwards from - 4.7% to -0.9% (that is, by +3.8 percentage points) and the first estimate of inflation was later revised downwards from 8.6 to 4.8% (that is, by -3.8 percentage points).

However, revisions in growth rates are conceptually distinct from revisions in the levels. Hence, it is possible that there was much more measurement error as regards the level of real output that is not picked up by the growth rates shown in Figure 1. We will come back to this issue when discussing the split of revisions in the output gap into revisions in actual and potential output.

In order to reconstruct real-time estimates of the output gap, we need real-time data on actual output as well as on potential output. In view of the prominent role of the production potential in the debate on economic policy, the Bundesbank started to

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function are therefore based on vintages of GDP data which do not reflect the changeover to ESA 1995.

[10] Comparing the ex post series of s.a. and s.c.a. output data for West Germany, we found the differences to be minimal. See also Clausen and Meier (2003), p. 4.

[11] 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. Firstly, because the relevant data for East Germany were either non-existent or not sufficiently reliable and, secondly,

produce its own estimates of potential output in the early seventies.[12] From 1974 to 1998, the growth rate of potential output was a key input for the derivation of the Bundesbank's monetary targets. Information on the Bundesbank's estimates of the expected growth of potential output can therefore be found in the official statements on the derivation of the target range for the coming year (usually published in December) and in the mid-year reviews of the target (usually published in July).

In order to recover the real-time estimates of the *level* of potential output from the "official" estimates of the rate of growth, we need additional information on the estimated level for at least one data point of each vintage. During the 1970s, the Annual Reports contained this information,[13] but the Bundesbank did not continue to publish estimates of potential output on a regular basis. However, we were able to reconstruct the missing data from the briefing material for the Council's discussions on the monetary target for the year to come and the briefing material for the mid-year review of the target. Where possible, we cross-checked the real-time estimates of potential output derived from these two sources with the estimates published in the Bundesbank's Annual and Monthly Reports as well as with more detailed information from internal notes. Table 2 depicts the structure of the data set for potential output.[14]

The reconstruction of real-time data sets for real and potential output enables us to calculate the Bundesbank's real-time estimates of the output gap. To convert the annual data on potential output into quarterly data, we apply a standard method of interpolation.[15] As shown in Table 3, the data set for the output gap starts in April 1974 and ends in March 1999. Reflecting the lag in the release of the underlying GDP data, estimates of the level of the output gap in quarter t do not become available before the second or third month of the following quarter.[16] Figure 3 illustrates the extent of revisions between the first estimates of the output gap (from quarter $t+1$) and our benchmark ex post series (the vintage of March 1999). Until the first quarter of 1988,

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because eastern Germany's structural problems could not be solved by monetary policy. See Deutsche Bundesbank (1999).

[12] The methods used and the results were explained in greater detail in Deutsche Bundesbank (1973).

[13] See, for instance, Deutsche Bundesbank (1972), p. 3.

[14] Estimates of the level of potential output were only published in two articles in Deutsche Bundesbank (1981, 1995).

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

[16] In contrast, estimates of potential output are usually available with a lead of one quarter, that is in *t-1*.

the real-time series is always below the ex post series, suggesting that the initial estimates consistently overestimated the amount of slack in the economy. The forecast error peaks in 1975Q2 (when it amounts to 7.88 percentage points) and then narrows gradually. After a short period of small revisions in the late 1980s, it rises again in the early 1990s, with a second peak in 1991Q4 (amounting to 4.72 p.p.). Except for a short time span in the mid-1990s (with a peak of –1.88 p.p. in 1994Q2), there is little evidence of sizable downward revisions of the first estimates.

Table 4 presents some statistics on the extent and the sources of revisions. For this purpose, the period 1974-1998 is divided into five subsamples. The average forecast error is most sizable in the second half of the 1970s and smallest in the second half of the 1990s (the latter of course being the subsample closest to the benchmark ex post series). In order to find out how much of the forecast error is due to later revisions in the GDP data and how much to changes in the perception of potential output, we calculated the split of revisions between actual and potential output for each subsample.[17] As shown in Table 4, there is only one subsample in which the revision of actual GDP data dominates the overall forecast error, that is the first half of the 1990s. In all other cases, the positive sign of the forecast error was predominantly due to downward revisions in the estimated level of potential output.

The fact that the mean forecast error is always positive strongly suggests a downward bias in the initial estimates. In fact, the null hypothesis that the first estimates are unbiased predictors of the ex post values has to be rejected for the whole period of 1974 - 1998.[18] The errors in measuring the level of the output gap are also quite persistent, with a correlation coefficient of 0.94 between the error and its lagged value. This pattern is strikingly similar to the one found by Orphanides (2001a) when reconstructing the US Fed's real-time estimates of the output gap.[19] Nelson and Nikolov (2001) find such a pattern for the UK, too. As Cukierman and Lippi (2003) point out, this is the pattern one would expect with a process of gradual learning about the nature

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[17] This exercise was complicated by the fact that the real-time series of actual and potential output exhibit several breaks reflecting changes in the base year. Calculating the extent of revisions in actual or potential GDP therefore requires rebasing all observations of the real-time series to the base year of the final data (which is 1991).

[18] The property of unbiasedness can be tested by regressing the forecast error on a constant. If the constant is significantly different from zero, the null of unbiasedness has to be rejected.

[19] See Orphanides (2001a), Figure 5.

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of adverse supply shocks and their effects on the level and growth rate of potential output growth.[20]

As mentioned in the introduction, we are also interested in the *change* of the output gap which is approximately equal to the growth rate of actual output relative to the growth rate of potential output. Real-time estimates of the change in the output gap can easily be calculated from our real-time data set for the output gap. Figure 4 illustrates the differences between the initial estimates (dating from quarter *t*+1) of the annual change in the output gap and their ex post counterparts. Although there are some instances of substantial revisions (again, in 1975:1 and 1975:2), there is no indication of an overall bias in the initial estimates.[21] In fact, the measurement error regarding the change in the output gap pales in comparison with the revision to the estimated level of the gap (see Figure 5). 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.[22]

Although we shared the general feeling that the problem of data revisions is much less acute for consumer prices and monetary aggregates than for variables like actual and potential output, we included the rate of change in the consumer price index and the Bundesbank's monetary target variables in our real-time data set as well. We chose to compile real-time data on the non-seasonally adjusted year-on-year rate of change of the consumer-price index, which was (and still is) generally used as headline measure of inflation. The data are taken from the statistical section of the Bundesbank's monthly reports. As the data are not seasonally adjusted, the only source of revisions are changes in the base year which occurred four times during the sample period. The structure of the data set is shown in Table 5. It starts with the vintage of January 1974 and ends with the vintage of January 1999. Each vintage reaches back about 12 months.[23] The publication lag of one month reflects the fact that official data on the rate of change in the CPI are released in the first or second week of the next month. However, the release

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[20] On the other hand, learning of private agents becomes more complicated if important variables undergo major revisions, see in connection with Taylor rules Honkapohja and Evans (2002).

[21] In fact, when regressing the forecast error regarding the change in the gap on a constant, we find that the constant is insignificant and that the residuals are not autocorrelated beyond the order which is justified by the overlapping nature of the data.

[22] For a formal derivation, see Walsh (2004).

of the official figure is usually just an affirmation of the first estimate which is presented by the Statistical Office around the 25th/26th of the reported month. Hence, for the purposes of our investigation, we think it is reasonable to assume that data on the rate of inflation in quarter *t* was usually available at the end of this quarter.

Figure 6 provides a comparison of the real-time rate of CPI inflation with the benchmark ex post series. The values shown are quarterly averages of the monthly source data. The largest upward revision amounts to 0.61 percentage points in 1981Q4, the largest downward correction to –0.67 pp in 1993Q2. Compared to the magnitude of the revisions in the rates of change of real output and the output deflator, these differences are indeed rather small, and there is no indication of a bias in either one direction.

As becomes evident from Figure 6, the rate of change in consumer prices during the sample period exhibits a downward trend. However, according to Equation (5), it is not the rate of inflation, but the difference between the (expected) rate of inflation and the central bank's inflation target that enters the central bank's reaction function. As shown in Table 6, the Bundesbank's target inflation rate – the so-called price assumption or price norm - also decreased from 5% to 1.75% during the period in question (1975-1998).[24] The price assumption was one of the benchmark figures for 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. With few exceptions, the Bundesbank did not state explicitly whether the price assumption referred to domestic prices (as measured by the output deflator) or to consumer prices (as measured by the CPI). Separate targets for the increase in domestic prices and the increase in consumer prices were only specified once (in 1977). We therefore think it reasonable to assume that the price assumption referred to both concepts in all other years.

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[23] By drawing on publications from the Statistical Office, it is possible to extend the series backwards to 1948.

[24] As a result of new information which we found in the briefing material for the Council's discussions on the monetary target, the figures for the early years of monetary targeting (1975-1979) differ slightly from the ones given in Reckwerth (1997), p. 30.

Figure 7 illustrates the differences between the real-time inflation gaps as measured by the rate of change in consumer prices or, alternatively, by the rate of change of the output deflator relative to the price assumption.[25] In contrast to the inflation series, the inflation gap series do not exhibit a visible trend during the sample period. Except for two episodes, the two series are not too far apart. The large divergence in 1975 is primarily due to the jump in the real-time rate of change of the GNP deflator caused by the perceived collapse of real GNP growth (see Figures 1 and 2). From 1985 to 1987, falling energy prices and an appreciating exchange rate caused the two indicators to move in opposite directions (with the difference rising to 4.31 pp. in 1986Q4).

The real-time data on money growth are again taken from the Bundesbank's "Seasonally Adjusted Business Statistics". For each month, we collected the data corresponding to the Bundesbank's monetary target of the time. The data thus reflect the shift in the definition of the target variable from the central bank money stock (defined as currency in circulation plus required minimum reserves on domestic deposits calculated at constant reserve ratios with base January 1974) to the broad aggregate M3 which occurred in January 1988. German M3 consisted of currency in circulation (excluding the credit institutions' cash balances) and sight deposits, time deposits for less than four years and savings deposits at three months' notice held by domestic non-banks – other than the Federal Government – at domestic credit institutions.[26]

The Bundesbank published seasonally adjusted data on the level of the money stock as well as (annualised) six-month rates of change. Only the latter were adjusted for statistical breaks. Accordingly, we use these data to calculate money growth rates over the past twelve months (that is, four quarters). The data on the central bank money stock are monthly averages of the daily source data. In contrast, for the years 1988 and 1989, the data on M3 are end-of-period figures. Beginning with the new figures for January 1990 (which were published in March 1990), the data on M3 are again monthly averages.[27] The changeover from West-German to all-German data occurs with the figures for January 1991 (published in March 1991). This is consistent with the fact that

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[25] The annual data on the price assumption were interpolated to obtain a quarterly series.
[26] Before July 1993, the savings deposits included were called savings deposits at statutory notice.

the monetary target for 1991 was for the first time formulated for the new extended currency area.[28]

The data set starts with the vintage of October 1974 and ends with the vintage of March 1999 (see Table 7). Official data on monetary developments in month t usually became available around the 20th of the following month. Depending on whether the "Seasonally Adjusted Business Statistics" were published before or after their release, the publication lag varies between one or two months. However, we can be sure that money data for the past month were always available to policy makers by the end of the following month.

Figure 8 provides a comparison of the real-time data on money growth over the past four quarters and their ex post counterparts. The real-time data shown are the first official figures for quarter t which became available with a lag of about three weeks. Compared to variables like the output gap or the growth rate of real output, the differences between the two series are minimal. This result backs the Bundesbank's claim that revisions in money data were negligible and the data are thus more reliable compared to other macroeconomic data.[29]

4 The econometric approach

4.1 Derivation of an estimable equation

We are now in a position to estimate Equation (5) in a real-time framework. Since real-time data on actual and potential output are only available at a quarterly frequency, we use quarterly data. To obtain an estimable equation, we define $\alpha = \bar{r}$ and rewrite (5) as:

$$i_t = (1-\rho)\big(\alpha + E(\pi_{t+n}^*|\Omega_t) + \beta E((\pi_{t+n} - \pi_{t+n}^*)|\Omega_t) + \gamma E(y_t|\Omega_t)\big) + \rho i_{t-1} + \upsilon_t. \tag{6}$$

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[27] The averages were calculated from five bank-week return days. The end-of-month levels were included with a weight of 50%.

[28] The reconstruction of the real-time vintages of M3 for 1990/1991 is complicated by the fact that the Bundesbank did not publish any data on the six-month rates of change of all-German M3 for the first half of 1991. However, we were able to reconstruct these data from internal sources.

[29] There were, however, revisions of the seasonal adjustment factors, but these obviously did not affect the annual growth rates depicted in Figure 8 as much as they did the published rates of change over the past six months.

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As the short-term nominal interest rate set by the Bundesbank we choose the three-month money market rate. To make sure that the real-time data included in the information set Ω_t was indeed available to policy makers when they set interest rates, we use end-of-quarter rather than average values of the three-month rate.[30] In contrast to CGG (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 price assumption of Table 6 as a proxy for the "true" target rate.[31] Furthermore, we proxy the unobserved forecasts of inflation and the output gap by the first official figures/estimates which were released in $t+n$ (in $t+n+1$ when inflation is measured by the output deflator) and in $t+1$, respectively:[32]

$$i_t = (1-\rho)\left(\alpha + E(\pi^*_{t+n}|\Omega_{t+n}) + \beta E((\pi_{t+n} - \pi^*_{t+n})|\Omega_{t+n}) + \gamma E(y_t|\Omega_{t+1})\right) + \rho i_{t-1} + \varepsilon_t. \qquad (7)$$

The forecast errors as defined by:

$$E\{\pi^*_{t+n}|\Omega_{t+n}\} - E\{\pi^*_{t+n}|\Omega_t\} = \sum_{i=1}^{n} \mu_{t+i} \qquad (7a)$$

$$E\{\pi_{t+n}|\Omega_{t+n}\} - E\{\pi_{t+n}|\Omega_t\} = \sum_{i=1}^{n} \nu_{t+i} \qquad (7b)$$

$$E\{y_t|\Omega_{t+1}\} - E\{y_t|\Omega_t\} = \xi_{t+1} \qquad (7c)$$

are subsumed into the error term ε. Hence, our approach yields valid estimates only if the forecast errors with respect to the first estimates are unbiased and serially uncorrelated (i.e. white noise). As the time span between the (unobserved) real-time

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[30] 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 3-month interest rate may be more relevant. However, the 3-month rate and the overnight rate behave very similar (see figure 9).

[31] This point has already been taken up by Smant (2002).

[32] Our econometric approach relies on the assumption that the variables entering Eq. (7) 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 theoretically not clear whether nominal interest rates should be I(0), see Seitz (1998). The usual unit root and stationarity tests yield ambiguous results. However, the coefficient restrictions imply that Eq. (7) 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. (7) in levels.

forecast and the release of the first estimate is relatively short – n quarters and one quarter, respectively – this assumption is much weaker than that of white noise forecast errors with respect to the ex post data:

$$E\{\pi_{t+n}|\Omega_T\} - E\{\pi_{t+n}|\Omega_t\} = \sum_{i=t+1}^{T} \mu_i \qquad \text{(7b')}$$

$$E\{y_t|\Omega_T\} - E\{y_t|\Omega_t\} = \sum_{i=t+1}^{T} \xi_i \qquad \text{(7c')}$$

which underlies the studies of CGG (1998, 1999, 2000), Smant (2002) and others. 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 the level of GDP some weeks before the first official figure is published. In contrast, the assumption of white noise forecast errors with respect to the ex post data is much more likely to be violated, especially as regards the output gap (see Figure 3).

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 (7a) - (7b) 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, $E\{\pi_t|\Omega_t\}, E\{\pi_{t-1}|\Omega_t, etc\}$ as well as $E\{y_{t-1}|\Omega_t\}, E\{y_{t-2}|\Omega_t, etc\}$). 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 CGG (1998) we estimate the parameter vector $[\alpha, \beta, \gamma, \rho]$ using GMM.[33] We select the weighting matrix in the objective function such that the GMM estimates will be robust to heteroskedasticity and autocorrelation. The Bartlett kernel is used 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.

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4.2 Basic specification with ex post data

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 CGG (1998) we neglect the first turbulent and volatile years of monetary targeting which have later been labelled the "experimental" phase even by Bundesbank officials.[34] As a starting point and in order to enhance comparability with existing studies, we re-estimate the reaction function (7) with the ex post revised data as of 1999Q1.

We use the rate of increase in consumer prices to measure the inflation gap in the Bundesbank's reaction function. Again, this choice is in line with the previous literature. The assumption that policy makers at the Bundesbank focused on consumer price inflation rather than domestic inflation can be justified from a positive as well as from a normative perspective. First of all, the consumer price index was the headline measure of inflation in Germany during the period in question, and the Bundesbank did not deviate from this practice. Secondly, there are several good reasons why this should be so in an open economy. From a welfare-theoretic point of view, stabilisation of CPI inflation reduces the uncertainty about future real consumption, which is welfare-improving for risk-averse consumers. Therefore, it can be argued that in an open economy, CPI inflation rather than domestic inflation is the adequate target variable for the central bank. Furthermore, an interest rate response to CPI inflation rather than domestic inflation implies an indirect response to the exchange rate which may be welfare-enhancing independent of whether society values domestic or CPI inflation stabilisation.[35] In fact, as pointed out by Taylor (2001, p. 267), there are several reasons why such an indirect reaction to the exchange rate may be preferable to a direct response. One of them is that temporary fluctuations in the exchange rate may not have much effect on expected inflation and thus may cause little indirect reaction of interest rates, while such movements could result in harmful swings in interest rates if there were a strong direct reaction.

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[33] For a discussion of this estimation method, see Davidson and MacKinnon (1993), Ch. 17. GMM estimation of a linear version of Eq. (7) confirmed the results of the nonlinear GMM estimations.

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

[35] See Adolfson (2002).

Table 8 presents the results based on ex post revised data with the horizon of the inflation gap varying from four to six quarters.[36] 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. Figure 10 illustrates this point.

Several observations are in order. Firstly, in all cases, the J-statistic confirms the validity of the overidentifying restrictions. Secondly, 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 1.43 and 1.61, 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 comes close to the value estimated by CGG (1998).

4.3 Basic specfication with real-time data

As a next step, we re-estimate Equation (7) with real-time data (see Table 9). 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) when n is set at five or six quarters, with point estimates above one.

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

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 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 argument, we next consider extensions to the baseline specification which we derive from the Bundesbank's own descriptions of its monetary policy strategy and from the most recent literature on robust monetary policy rules.

4.4 Extensions of the basic specification

Certainly, the most prominent feature of the Bundesbank's strategy was the practice of announcing monetary targets. Their derivation was based on the conviction that in the long run, inflation is pinned down by the economy's steady-state growth rate of money relative to the trend growth rate of output and the trend rate of change of the velocity of circulation. Accordingly, the targets depended on three benchmark figures: (1) the medium-term price norm or price assumption (the maximum rise in prices which can be tolerated in the medium run), (2) the estimated growth rate of the overall production potential and (3) the estimated trend rate of change (decline, as it were) in the velocity of circulation. The derivation of the targets from these benchmark figures shows that the Bundesbank's strategy of monetary targeting was, by its very nature, a medium-term concept. However, to make it operational, the Bundesbank formulated and announced *annual* targets which were applied to the rate of money growth from the fourth quarter of one year to the fourth quarter of the next year.[37] 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 (see Table 10).

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 deviations of output or velocity from their long-run trend values. In fact, during the 20 years of our sample period (1979-1998), which excludes the first four years of monetary targeting, the targets were missed 7 out of 20 times (see Table 10). 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.[38] CGG (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, Equation (5). They find that "*the money aggregate just does not matter*"[39], 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, to our knowledge, 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 situation in Germany certainly back this observation. In fact,

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[37] Except for three of the early years of monetary targeting (1976-78) when the targets were formulated for the annual average of money growth.

[38] See also Bernanke and Mihov (1997).

while the annual reports in the 1970s still contain a graph on the rate of capacity utilisation, the concept is hardly ever referred to in the 1980s and 1990s (with the exception of Deutsche Bundesbank (1981, 1995)). Second, there is a growing theoretical and empirical literature suggesting that it might be a good idea for central banks to target the *change* in the output gap (or simply the growth rate of output which dominates the change in the output gap) in the presence of imperfect information about the *level* of the output gap.[40] 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 extend the baseline specification of the Bundesbank's reaction function to include a money gap variable, $(\hat{m} - \hat{m}^*)$, as well as the change in the output gap, $(\hat{y})$, among the explanatory variables:

$$
\begin{aligned}
i_t = (1-\rho)\big(\alpha + E(\pi_{t+n}^*|\Omega_{t+n}) + \beta E(\pi_{t+n} - \pi_{t+n}^*|\Omega_{t+n}) + \gamma_1 E(y_t|\Omega_{t+1}) \\
+ \gamma_2 E(\hat{y}_t|\Omega_{t+1}) + \lambda_1 E((\hat{m}_t - \hat{m}_t^*)|\Omega_{t+1})\big) + \rho i_{t-1} + \varepsilon_t
\end{aligned}
\tag{11}
$$

In contrast to CGG (1998), we measure the money (growth) gap by the deviation of the *annual* money growth rate from the targeted money growth rate:

$$
\hat{m}_t - \hat{m}_t^* = \frac{M_t - M_{t-4}}{M_{t-4}} - \hat{m}_t^*
$$

We prefer this measure of the money gap because we believe that it is better able to capture the medium-term nature of the monetary targets. By contrast, the money gap used by CGG implies that the time horizon of the relevant money growth rate changed from quarter to quarter (i.e. that policy makers targeted the three-month rate of money growth in the first quarter, the six-month rate of money growth in the second quarter etc.). However, our results are robust to changes in the time horizon of the money growth variable (see Table 12).

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

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[39] See CGG (1998), p.1046.
[40] See e.g. Walsh (2004).

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.[41]

Table 11 presents the parameter estimates for the real-time reaction function specified by Equation (11). The time horizon of the inflation gap 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, maybe because they were aware of the high degree of uncertainty surrounding its initial estimates that has been demonstrated in the previous section.

However, the coefficient of the *change* in the gap is highly significant for all values of n considered here. Interestingly, the point estimates of the coefficients β and λ_2 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).[42]

Furthermore, in contrast to previous studies like CGG (1998), we find that the coefficient of the money-growth gap is highly significant, suggesting that the Bundesbank reacted to deviations of money growth from the announced target independently of its concern about stabilising 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). By contrast, Kamps and Pierdzioch (2002) find that money growth does not belong to the true set of explanatory variables in a standard Taylor-type model of the Bundesbank's reaction function – instead, in their study it is useful only as an instrument for future inflation. The difference between

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[41] 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.
[42] Nominal income growth targeting and related concepts have been advocated, among others, by McCallum (1985, 1999, 2001), Orphanides (2000) and Jensen (2002).

their results and ours could be due to several reasons, the most important of them being of course that they use ex post data instead of real-time data and that they do not include the change in the output gap which may cause an omitted variable bias in their estimates.

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 final 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").[43] It is also in line with the theoretical argument that in the case of uncertainty the degree of interest rate smoothing should become larger.[44] As a robustness check, Table 12 shows that all results are qualitatively unchanged when alternative monetary variables are used.

5   Interpretation

As pointed out in the introduction, this paper was motivated by the apparent contradiction between the Bundesbank's own description of its strategy and the empirical evidence presented by CGG (1998) and others that the Bundesbank's policy can well be described by a generalised Taylor rule. Our results contribute to this debate in several ways.

Firstly, they support the view that the Bundesbank did not follow a strategy of *strict monetary targeting* which would be represented by a reaction function with only one explanatory variable, namely money growth relative to target:

$$i_t = (1-\rho)\big(\bar{r} + E(\pi_{t+n}^* | \Omega_t) + \lambda_1 E((\hat{m}_t - \hat{m}_t^*) | \Omega_t)\big) + \rho i_{t-1}. \tag{12}$$

Actually, to our knowledge, the Bundesbank never claimed that it had followed such a policy. Instead, Bundesbank officials like Otmar Issing called its policy one of "pragmatic monetarism" or "disciplined discretion".[45] Secondly, our results are at odds with the by now widespread view that the Bundesbank preached monetary targeting, but

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[43] See, for instance, Tietmeyer, H. (1998), p. 2.
[44] See e.g. Sack and Wieland (2000) and Srour (2001).
[45] See Issing (1997), p. 72.

in fact practised inflation targeting.[46] In contrast to this view, we find that the Bundesbank followed a strategy of what could be called *"flexible" monetary targeting[47]* with a significant response to the money growth gap as well as to the (expected) inflation gap and the output growth gap:[48]

$$i_t = (1-\rho)\left[\bar{r} + E\left(\pi_{t+n}^*|\Omega_t\right) + \lambda_1 E\left((\widehat{m}_t - \widehat{m}_t^*)|\Omega_t\right) + \beta E\left((\pi_{t+n} - \pi_{t+n}^*)|\Omega_t\right) + \gamma_2 E\left((\hat{y}_t)|\Omega_t\right)\right] + \rho i_{t-1} \quad (13)$$

For several reasons, this representation of the Bundesbank's strategy is very much in line with the Bundesbank's own descriptions of its strategy. First, 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 inflation in the long run 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 policy 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.[49]

But why should the Bundesbank react to deviations of money growth from target independently of its concern about (expected) inflation? Two (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.[50] Secondly, 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*

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[46] See, for instance, Gerlach and Svensson (2003), p. 1649.

[47] This terminology follows Svensson's distinction between strict and flexible inflation targeting. See Svensson (1999).

[48] A "hybrid rule" in which money enters the central bank´s reaction function besides the usual Taylor-variables (but not the change in the output) is discussed in Masuch et al. (2003) as the optimal policy rule if two macroeconomic frameworks are taken into account, a standard New Keynesian model without an explict role for money and a modified New Keynesian model in which money directly enters the Phillips curve.

[49] See Issing (1995), p. 588 and p. 607.

[50] See Schlesinger (2002), p. 147.

monetary target, we would not have responded so early or so often".[51] Thirdly, 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 money is subject to very few revisions, it may play a significant role in providing timely and steady information about the state of the economy.[52]

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. Helmut Schlesinger, one of the "fathers" of the Bundesbank's monetary targeting strategy, once stated that the monetary policy of the Bundesbank could be characterised as a mixture of two "pure" strategies: a medium-term monetarist and an anticyclical orientation.[53] 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*"[54], giving justification to the inclusion of short-term objectives like the stabilisation 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, as already mentioned, the real-time measurement error problem is 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 output gap which is confirmed by our estimation results. In this respect, our results are in line with those of Orphanides' (2000) who concludes that successful central banks – like the Bundesbank and the Fed after the appointment of Volcker – have placed much

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[51] See Schlesinger (1985), p. 91.
[52] On the last two points, see e.g. Masuch et al. (2003).
[53] See Schlesinger (1980), p. 35.
[54] Richter (1999), p. 550.

less emphasis on (real-time estimates of) the output gap than suggested by simple activist policy rules such as the Taylor rule.

Still, the fact remains that when using ex post data, our estimates of the Bundesbank's reaction function look very much like a standard Taylor rule, confirming the general result of the recent empirical literature. This, together with the fact that policy makers at the Bundesbank managed to avoid the policy mistakes which could have resulted from the sizable downward bias in the real-time estimates of the output gap, raises a couple of interesting questions: Did policy makers in effect know more about the "true" value of the output gap than suggested by the real-time estimates we were able to recover? Or did they attribute so much uncertainty to their staff's estimates of the output gap that they all but ignored them and relied on other or additional indicators of economic activity? If so, did their reliance on these other indicators result in a policy which ex post turned out to be effective in stabilizing the level of real output around the unknown "true" level of potential output?

6   Outlook

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) suggest a certain kinship of the Bundesbank's policy to the concept of nominal income growth targeting which has been advocated, among others, by Tobin (1980), Gordon (1983) 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. Walsh (2004) 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. 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.

References

Adolfson, M. (2002): Incomplete Exchange Rate Pass-Through and Simple Monetary Policy Rules, Sveriges Riksbank Working Paper Series, No. 136, June 2002.

Bec, F., Salem, M.B. and F. Collard (2002): Asymmetries in Monetary Policy Reaction Function: Evidence for the U.S., French and German Central Banks, Working Paper.

Benhabib, J., Schmitt-Grohé, S. and M. Uribe (2001): Monetary Policy and Multiple Equilibria, American Economic Review, 91, pp. 167-1186.

Bernanke, B.S. and I. Mihov (1997): What Does the Bundesbank Target, European Economic Review, 41, pp. 1025-1053.

Bernanke, B.S. and M. Woodford (1997): Inflation Forecasts and Monetary Policy, Journal of Money, Credit and Banking, 29, pp. 653-684.

Brand, C. (2001): Money Stock Control and Inflation Targeting in Germany, Physica Publisher, Heidelberg.

Brüggemann, I. (2003): Measuring Monetary Policy in Germany: A Structural Vector Error Correction Approach, German Economic Review, 4, pp. 307-339.

Clarida, R. and M. Gertler (1997): How the Bundesbank Conducts Monetary Policy, in: Romer, C. and D. Romer (eds.), Reducing Inflation: Motivation and Strategy, University of Chicago Press, Chicago, pp. 363-406.

Clarida, R., Gali, J. and M. Gertler (1998): Monetary Policy Rules in Practice: Some International Evidence, European Economic Review, 42, pp. 1033-1067.

Clarida, R., Gali, J. and M. Gertler (2000): Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory, Quarterly Journal of Economics, 115, pp. 147-180.

Clausen, J.R. and C.-P. Meier (2003): Did the Bundesbank Follow a Taylor Rule? An Analysis Based on Real-Time Data, Working Paper.

Croushore, D. and T. Stark (2001): A Real-Time Data Set for Macroeconomists, Journal of Econometrics, 105, pp. 111-130.

Croushore, D. and T. Stark (2002): Is Macroeconomic Research Robust to Alternative Data Sets, Federal Reserve Bank of Philadelphia, Working Paper No. 02-3, March.

Cukierman, A. and F. Lippi (2003): Endogenous Monetary Policy with Unobserved Potential Output, working paper, December 2003.

Davidson, R. and J.G. MacKinnon (1993): Estimation and Inference in Econometrics, Oxford University Press, Oxford et al.

Deutsche Bundesbank (1972): Annual Report for 1971.

Deutsche Bundesbank (1973): Production Potential in the Federal Republic of Germany, Monthly Report October, pp. 27-32.

Deutsche Bundesbank (1981): Recalculation of the Production Potential of the Federal Republic of Germany, Monthly Report October, pp. 30-36.

Deutsche Bundesbank (1982): Annual Report for 1981.

Deutsche Bundesbank (1995): Production Potential in Germany and its Determinants, Monthly Report August, pp. 39-53.

Deutsche Bundesbank (1999): Taylor Interest Rate and Monetary Conditions Index, Monthly Report April, pp. 47-63.

Evans, G.W. and S. Honkapohja (2002): Adaptive Learning and Monetary Policy Design, paper presented at the 2002 JMCB conference on "Recent Developments in Monetary Macroeconomics".

Faust, J., Rogers, J.H. and J.H. Wright (2001): An Empirical Comparison of Bundesbank and ECB Monetary Policy Rules, International Finance Discussion Papers No. 690, August.

Gerlach, S. and L. Svensson (2002): Money and Inflation in the Euro Area: A Case for Monetary Indicators?, Journal of Monetary Economics 50 (2003) 1649-1672.

Gordon, R. J. (1983): The Conduct of Domestic Monetary Policy, NBER Working Paper No. 1221.

Herz, B. and C. Greiber (2001): Taylor-Regeln: Erfahrungen der Deutschen Bundesbank, Implikationen für die Europäische Zentralbank, in: Söllner, F. and A. Wilfert (eds.), Die Zukunft des Sozial- und Steuerstaates, Heidelberg, pp. 453-469.

Issing, O. (1995): Die Geldmengenstrategie der Deutschen Bundesbank, in: Siebke, J. and J. Thieme (eds.): Zwanzig Jahre Geldmengensteuerung in Deutschland, Baden-Baden, pp. 586-611.

Issing, O. (1997): Monetary Targeting in Germany: The stability of monetary policy and of the monetary system, Journal of Monetary Economics, 39, pp. 67-79.

Jacobs, J. and J.E. Sturm (2003): Do Ifo Indicators Help Explain Revisions in German Industrial Production?, paper prepared for the Victor Zarnowitz Seminar, RWI, Essen, Germany, on June 27/28, 2003.

Jensen, H. (2002): Targeting Nominal Income Growth or Inflation?, American Economic Review, 92(4), Sept. 2002, 928-956.

Kozicki, S. (2001): How Useful are Taylor Rules for Monetary Policy?, Federal Reserve Bank of Kansas City Economic Review, 84(2), pp. 5-33.

Kamps, C. and C. Pierdzioch (2002): Geldpolitik und vorausschauende Taylor-Regeln – Theorie und Empirie am Beispiel der Deutschen Bundesbank, Kiel Working Paper No. 1089, January.

Koenig, E.F. (2003): Is the Mark-Up a Useful Real-Time Predictor of Inflation, Economics Letters, 80, pp. 261-267.

Krause, S. (2003): Measuring Monetary Policy Efficiency in European Union Countries, Working Paper, Emory University, May.

Lansing, K.J. (2002): Real-Time Estimation of Trend Output and the Illusion of Interest Rate Smoothing, Federal Reserve Bank of San Francisco Economic Review 2002, pp. 17-34.

Masuch, K., Nicoletti-Altimari and Massimo Rostagno (2003): The Role of Money in Monetary Policymaking, in: Issing, O. (ed.), Background Studies for the ECB's Evaluation of its Monetary Policy Strategy, pp. 187-228.

McCallum, B. T. (1985): On Consequences and Criticisms of Monetary Targeting, Journal of Money, Credit and Banking, 17(4), Part 2, November, 570-597.

McCallum, B. T. (1999): Issues in the Design of Monetary Policy Rules, in Taylor, J. B. and M. Woodford (eds.): Handbook of Macroeconomics, Amsterdam.

McCallum, B. T. (2001): Should Monetary Policy Respond Strongly to Output Gaps?, American Economic Review, 91(2), 258-262.

McCallum, B. and E. Nelson (1999): Nominal Income Targeting in an Open-Economy Optimizing Model, Journal of Monetary Economics, June 1999, 43(3), 553-78.

Murchison, S. and P. Siklos (1998): Central Bank Reaction Functions in Inflation and Non-Inflation Targeting Countries: Are they Informative about the Conduct of Monetary Policy?, Wilfried Laurier University, Ontario, mimeo, August.

Nelson, E. and K. Nikolov (2001): A Real-Time Output Gap Series for the United Kingdom, 1965-2000: Construction, Analysis and Implications for Inflation, CEPR Discussion Paper No. 2999, October.

Nelson, E. and K. Nikolov (2003): UK Inflation in the 1970s and 1980s: the role of output gap mismeasurement, Journal of Economics and Business, 55, pp. 353-370.

Neumann, M.J.M. and von Hagen, J. (2002): Does Inflation Targeting Matter?, Federal Reserve Bank of St. Louis Review, 84(4), pp. 127-148.

Orphanides, A. (2000): The Quest for Prosperity without Inflation, ECB Working paper No. 15, March.

Orphanides, A. (2001a): Monetary Policy Rules, Macroeconomic Stability and Inflation: A View from the Trenches, ECB Working Paper No. 115, December.

Orphanides, A. (2001b): Monetary Policy Rules Based on Real-Time Data, American Economic Review, 91, pp. 964-985.

Orphanides, A., Porter R.D., Reifschneider, D., Tetlow, R. and F. Finan (2000): Errors in the Measurement of the Output Gap and the Design of Monetary Policy, Journal of Economics and Business, 52, pp. 117-141.

Orphanides, A. and S. van Norden (2003): The Reliability of Inflation Forecasts Based on Output Gap Estimates in Real Time, CIRANO Working Paper 2003s-01, January.

Orphanides, A. and J.C. Williams (2003): Imperfect Knowledge, Inflation Expectations, and Monetary Policy, NBER Working Paper 9884, July.

Reckwerth, J. (1997): Inflation and Output in Germany: The Role of Inflation Expectations, Discussion Paper 5/97, Economic Research Group of the Deutsche Bundesbank, October.

Richter, R. (1999): German Monetary Policy as Reflected in the Academic Debate, in: Deutsche Bundesbank (ed): Fifty Years of the Deutsche Mark, Oxford University Press, Chapter X, pp. 525-571.

Rudebusch G. (2002): Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia, Journal of Monetary Economics, 49, pp. 1161-1187.

Sauer, S. and J.-E. Sturm (2003): ECB Monetary Policy: How Well Does the Taylor Rule Describe it?, University of Munich, mimeo.

Schächter, A. (1999): Die geldpolitische Konzeption und das Steuerungsverfahren der Deutschen Bundesbank, J.C.B. Mohr (Paul Siebeck), Tübingen.

Schlesinger, H. (1980): Die geldpolitische Konzeption der Deutschen Bundesbank, mimeo, Fernuniversitat Hagen.

Schlesinger, H. (1985): Monetary Control: the German experience, in: van Ewijk, C. u. J.J. Klant (eds): Monetary Conditions for Economic Recovery, Martinus Nijhoff Publishers (Dordrecht/Boston/Lancaster), pp. 85-94.

Schlesinger, H. (2002): Die Bundesbank und ihre Geldmengenpolitik, B. Schefold (ed): Exogenität und Endogenität, Metropolis (Marburg), pp. 137-153.

Seitz, F. (1998): Geldnachfrage, Zinsen und Zinsstruktur, Konjunkturpolitik – Applied Economics Quarterly, Vol. 44, pp. 256-286.

Siklos, P. (2004): Central Bank Behavior, the Institutional Framework and Policy Regimes: Inflation vs. Non-Inflation Targeting Countries, Contemporary Economic Policy, forthcoming.

Smant, D.J.C. (2002): Has the European Central Bank Followed a Bundesbank Policy? Evidence from the Early Years, Kredit und Kapital, 35, pp. 327-343.

Solveen, R. (1998): Der Einfluss der Unabhängigkeit auf die Politik der Zentralbanken, Kieler Studien, J.C.B. Mohr, Tübingen.

Srour, G. (2001): Why do Central Banks Smooth Interest Rates?, Bank of Canada Working Paper No. 2001-17, October.

Surico, P. (2003a): How Does the ECB Target Inflation? ECB Working Paper No. 229, May.

Surico, P. (2003b): Asymmetric Reaction Functions for the Euro Area, Oxford Review of Economic Policy, 19, pp. 44-57.

Svensson, L. (1999): Inflation Targeting: Some Extensions," Scandinavian Journal of Economics 101(3), p. 337-361.

Taylor, J. B. (1993): Discretion versus Monetary Policy Rules in Practice, in: Carnegie Rochester Conference Series on Public Policy, 39, pp. 195-214.

Taylor, J. B. (2001): The Role of the Exchange Rate in Monetary Policy Rules, American Economic Review, Papers and Proceedings, 91(2), May 2001, p. 263-267.

Tchaidze, R.R. (2002): Analyzing Monetary Policy in a Real-Time Setting, Dissertation submitted to Johns Hopkins University, October.

Tietmeyer, H. (1998): The euro: a challenge to, and opportunity for, the financial markets, speech delivered at the 21st colloquium of SUERF and CFS in Frankfurt on 15/10/1998, reprinted in BIS Review 84/1998, p. 1-6.

Tobin, J. (1980): Stabilisation Policy after Ten Years, Brookings Papers on Economic Activity, 1, 19-72.

Walsh, C. E. (2003): Speed Limit Policies: The output gap and optimal monetary policy, American Economic Review 93/1, 265-278.

Walsh, C. E. (2004): Implications of a Changing Economic Structure for the Strategy of Monetary Policy, in: Monetary Policy and Uncertainty, Jackson Hole Symposium 2003, Federal Reserve Bank of Kansas City, forthcoming.

Wesche, K. (2003): Monetary Policy in Europe: Evidence from Time-Varying Taylor Rules, paper presented at the annual meeting of the Verein für Socialpolitik in Zürich, October 2, 2003.

Weymark, D.N. (2001): Using Taylor Rules as Efficiency Benchmarks, University of Vanderbilt, Department of Economics Working Paper No. 00-W43R, September 2001.

Table 1: Structure of the real-time data set for GNP/GDP

Reported for quarter t ↓ \ Month of Publication τ →	71/12	72/01	72/02	72/03	72/04	72/05	72/06	72/07	72/08	72/09	72/10	72/11	72/12	...	99/03
1962Q1	Y_{62Q1}	...													
...	...	...	...	...	...	...	...	...	...	...	...	...	...		
1971Q3	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	Y_{71Q3}	...	...
1971Q4			Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	Y_{71Q4}	...	...
1972Q1							Y_{72Q1}	Y_{72Q1}	Y_{72Q1}	Y_{72Q1}	Y_{72Q1}	Y_{72Q1}	Y_{72Q1}	...	...
1972Q2										Y_{72Q2}	Y_{72Q2}	Y_{72Q2}	Y_{72Q2}	...	...
1972Q3													Y_{72Q3}	...	...
...														...	...
1998Q4															Y_{98Q4}

Figure 1 : Initial and ex post data on growth of real GNP/GDP

Change from previous year in %, quarterly data
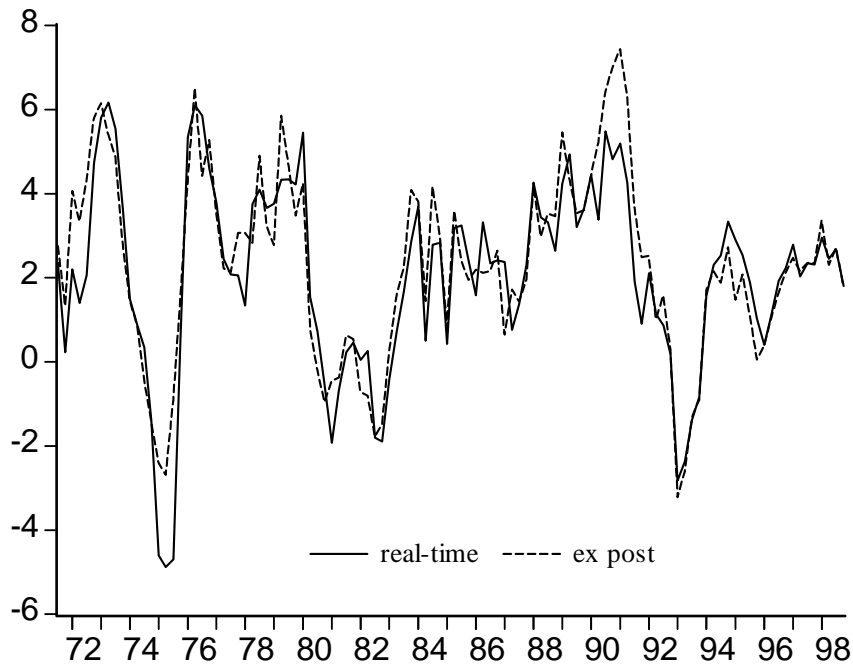
Figure 2 : Initial and ex post data on change of GNP/GDP deflator

Change from previous year in %, quarterly data
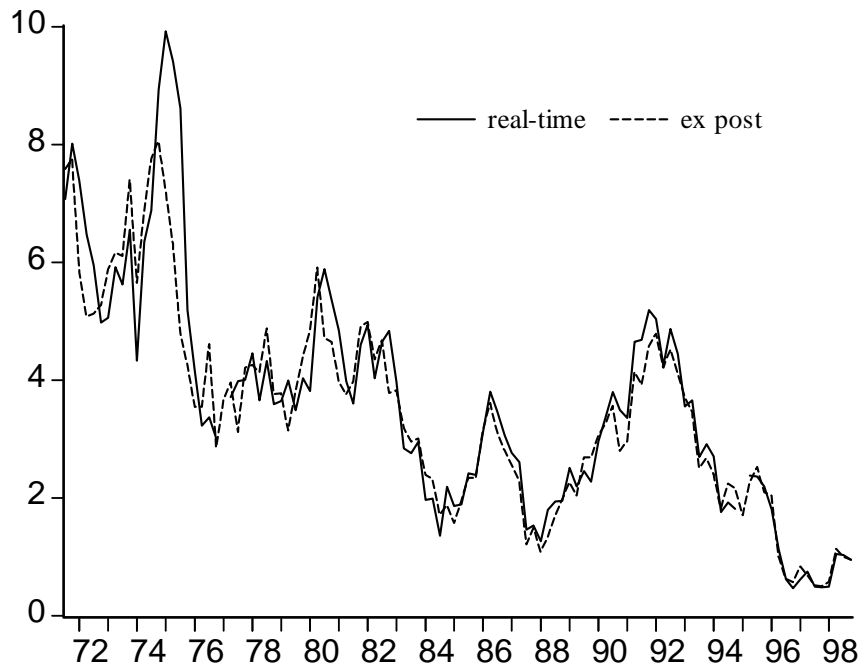
Table 2: Structure of the real-time data set for potential output

Estimates from Source → / Reported for year t ↓	72/04 Annual Report	73/04 Annual Report	73/10 Monthly Report	74/04 Annual Report	74/12 Briefing Material*	...	79/06 Briefing Mat. Review*	79/12 Briefing Material*	...	98/06 Briefing Mat. Review*	99/01 Final Estimates
1962			Y^*_{62}			...	...	...	...		
...	...	...	...	...	...	...	...	...	...	...	...
1971	Y^*_{71}	Y^*_{71}	Y^*_{71}	Y^*_{71}	Y^*_{71}	...	Y^*_{71}	Y^*_{71}	...	Y^*_{71}	Y^*_{71}
1972		Y^*_{72}	Y^*_{72}	Y^*_{72}	Y^*_{72}	...	Y^*_{72}	Y^*_{72}	...	Y^*_{72}	Y^*_{72}
1973				Y^*_{73}	Y^*_{73}	...	Y^*_{73}	Y^*_{73}	...	Y^*_{73}	Y^*_{73}
1974				Y^*_{74}	Y^*_{74}	...	Y^*_{74}	Y^*_{74}	...	Y^*_{74}	Y^*_{74}
1975					Y^*_{75}	...	Y^*_{75}	Y^*_{75}	...	Y^*_{75}	Y^*_{75}
...							...	...	...	...	...
1979							Y^*_{79}	Y^*_{79}	...	Y^*_{79}	Y^*_{79}
1980								Y^*_{80}	...	Y^*_{80}	Y^*_{80}
...									...	...	...
1999										Y^*_{99}	Y^*_{99}

*Briefing material for the Central Bank Council's discussions on the monetary target for the year to come and for the mid-year review of the monetary target.

Table 3: Structure of the real-time data set for the output gap

Reported for quarter $t\downarrow$ \ Month of Publication $\tau\rightarrow$	74/04	74/05	74/06	74/07	74/08	74/09	74/10	74/11	74/12	75/01	75/02	75/03	...	99/03
1962Q1	y_{62Q1}													
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1973Q4	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	y_{73Q4}	...	y_{73Q4}
1974Q1			y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	y_{74Q1}	...	y_{74Q1}
1974Q2						y_{74Q2}	y_{74Q2}	y_{74Q2}	y_{74Q2}	y_{74Q2}	y_{74Q2}	y_{74Q2}	...	y_{74Q2}
1974Q3									y_{74Q3}	y_{74Q3}	y_{74Q3}	y_{74Q3}	...	y_{74Q3}
1974Q4											y_{74Q4}	y_{74Q4}	...	y_{74Q4}
...													...	...
1998Q4														y_{98Q4}

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Figure 3: Initial and ex post estimates of the output gap
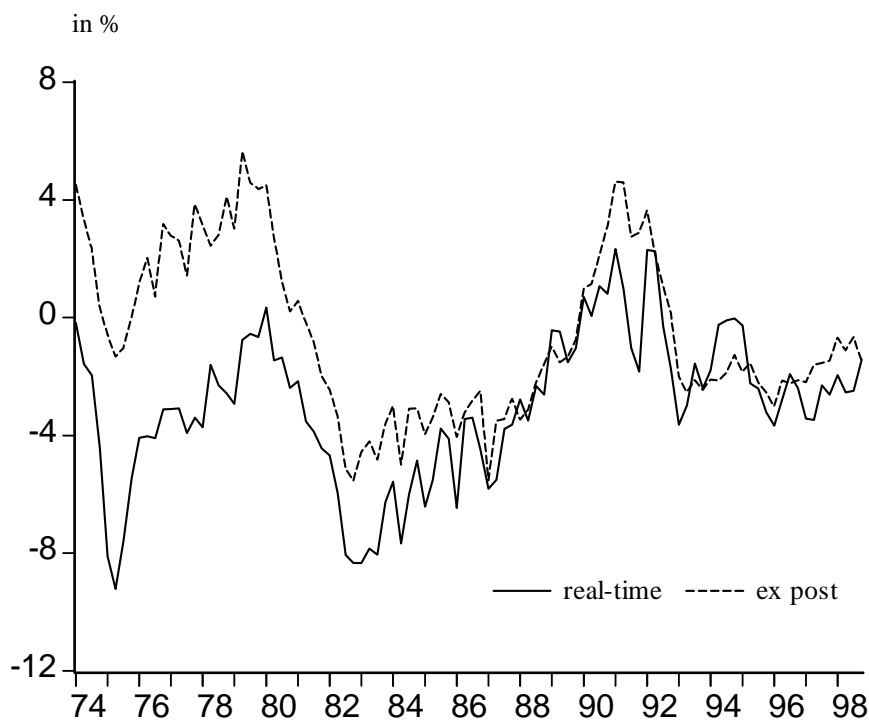
Table 4: Summary statistics on revisions of real-time output gaps

output gap series → sample ↓	mean revision $(y_t^{final} - y_t^{realt})$	of which actual GDP	potential GDP
1974Q1 – 1979Q4	+ 5.75	- 0.43	- 6.18
1980Q1 – 1984Q4	+ 2.94	- 1.00	- 3.94
1985Q1 – 1989Q4	+ 0.77	- 1.42	- 2.19
1990Q1 – 1994Q4	+ 0.99	+ 0.92	- 0.07
1995Q1 – 1998Q4	+ 0.67	- 0.73	- 1.40
1974Q1 – 1998Q4	+ 2.43	- 0.52	- 2.95

Figure 4: Initial and ex post estimates of the change in the output gap

Change from previous year in %, quarterly data
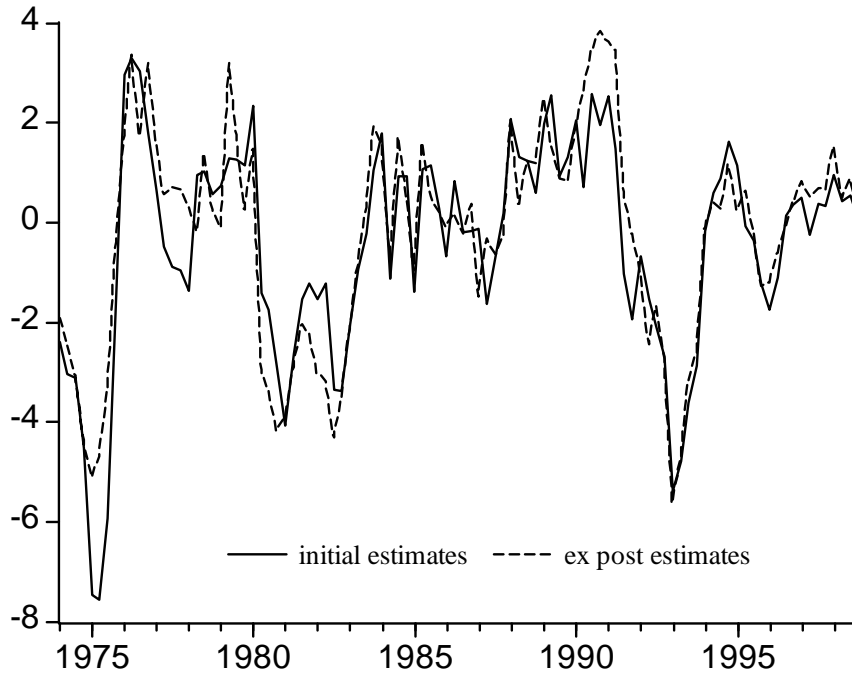
Figure 5: Measurement errors of output gap and change in the gap

percentage points
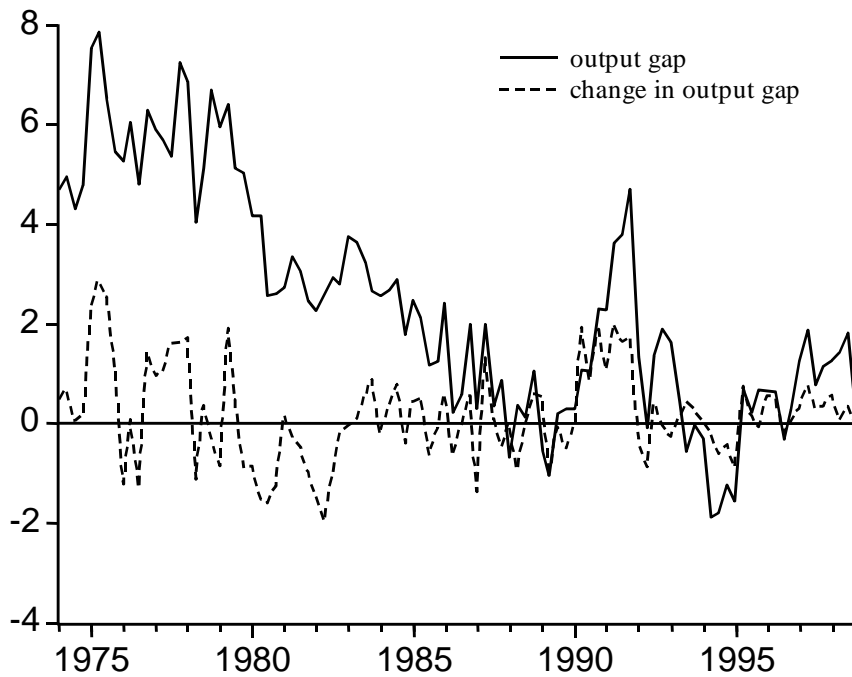
Table 5: Structure of the real-time data set for CPI inflation

Month of Publication $\tau \rightarrow$ Reported for quarter $t \downarrow$	74/01	74/02	74/03	74/04	...	95/09	95/10	...	99/01
1972/11	$\pi_{72/11}$	$\pi_{72/11}$	$\pi_{72/11}$	$\pi_{72/11}$	...				
...	...	...	...	...	...				
1973/12	$\pi_{73/12}$	$\pi_{73/12}$	$\pi_{73/12}$	$\pi_{73/12}$	...				
1974/01		$\pi_{74/01}$	$\pi_{74/01}$	$\pi_{74/01}$	...				
1974/02			$\pi_{74/02}$	$\pi_{74/02}$	...				
1974/03				$\pi_{74/03}$	...				
...					...				
1992/01						$\pi_{92/01}$	$\pi_{92/01}$	$\pi_{92/01}$	$\pi_{92/01}$
...						...	...	...	...
1995/08						$\pi_{95/08}$	$\pi_{95/08}$	...	$\pi_{95/08}$
1995/09	...	...	...	...			$\pi_{95/09}$	...	$\pi_{95/09}$
...								...	...
1998/12								·	$\pi_{98/12}$

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Figure 6: Initial and ex post data on CPI inflation

Change from previous year in %, quarterly averages
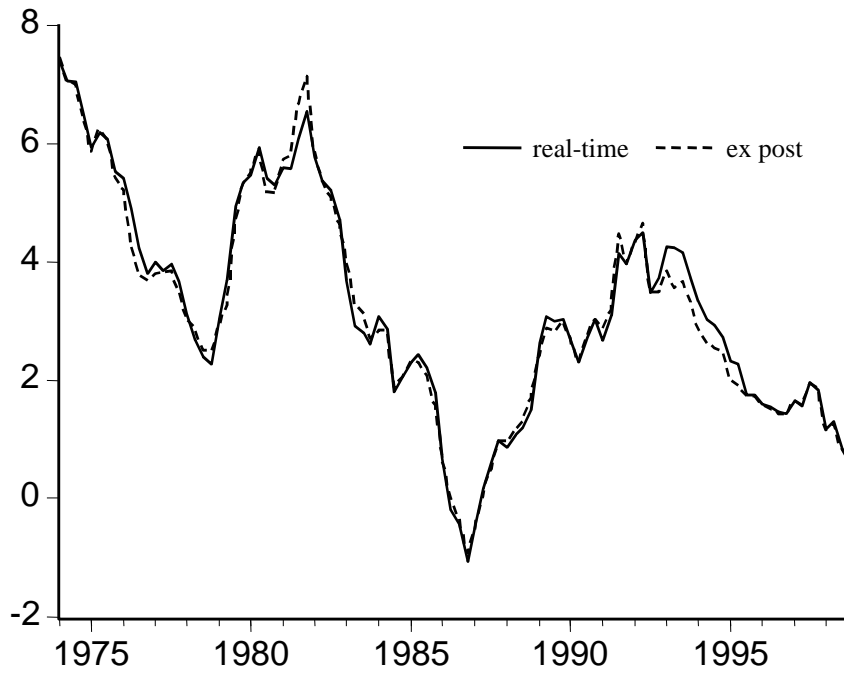
Figure 7: Real-time inflation gaps - CPI versus output deflator

Change from previous year in %, quarterly values
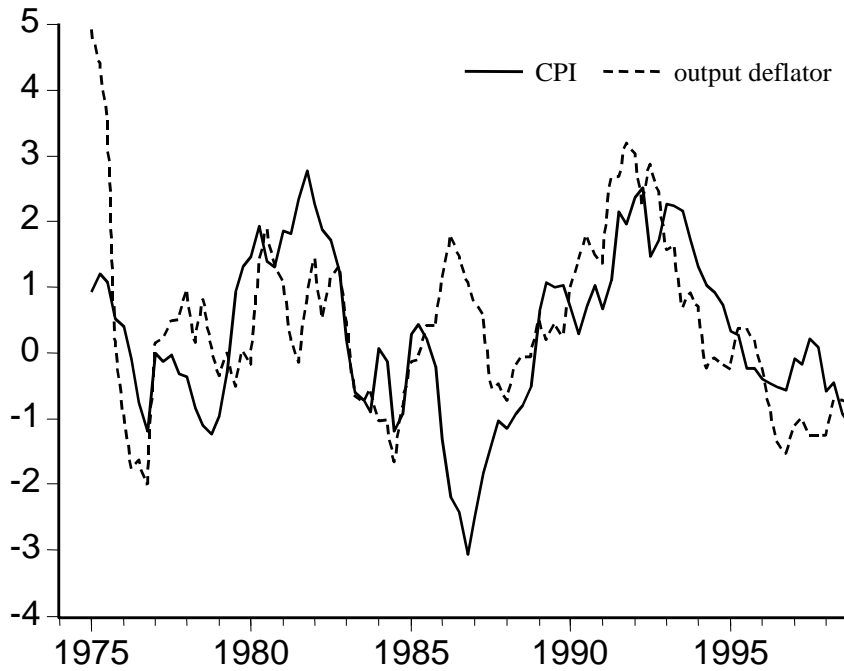
Table 6: Medium-term price assumption 1975 - 1998

Year	Price Assumption	Year	Price Assumption	Year	Price Assumption
1975	**5.0**	1983	**3.5**	1991	**2.0**
1976	**5.0**	1984	**3.0**	1992	**2.0**
1977	**3.5*/4.0****	1985	**2.0**	1993	**2.0**
1978	**3.5**	1986	**2.0***	1994	**2.0**
1979	**4.0**	1987	**2.0**	1995	**2.0**
1980	**4.0**	1988	**2.0**	1996	**2.0**
1981	**3.5-4.0**	1989	**2.0**	1997	**1.5-2.0**
1982	**3.5***	1990	**2.0**	1998	**1.5-2.0**
*Explicit reference to GNP deflator; **explicit reference to consumer price index.					

Figure 8: Initial and ex post data on money growth (as measured by the Bundesbank's respective target variable)

Change from previous year in %, quarterly averages
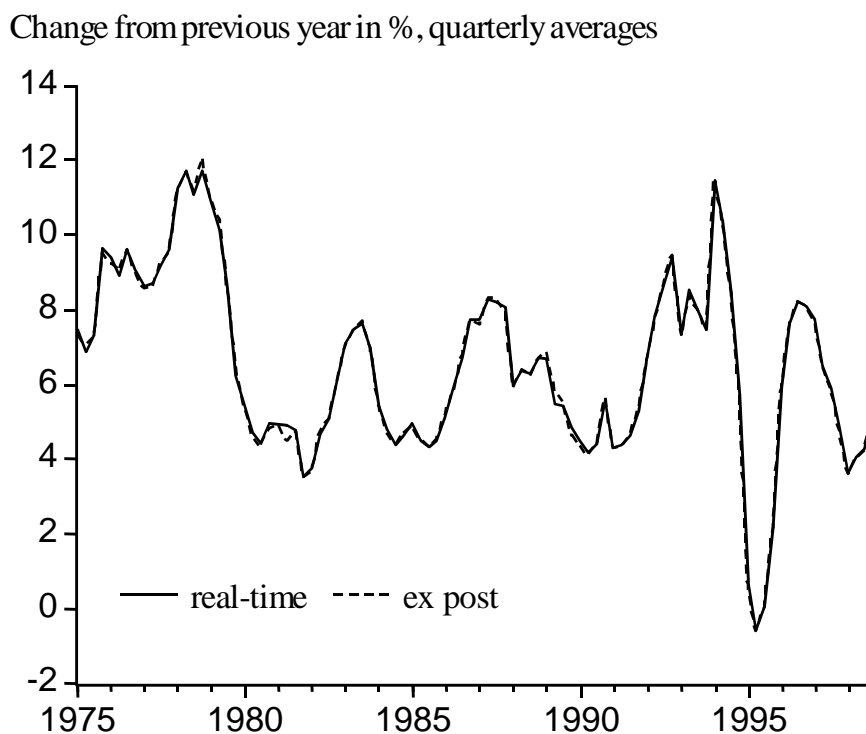
Table 7: Structure of the real-time data set for the rate of growth of the respective monetary target variable

Reported for quarter t ↓ \ Month of Publication τ →	74/10	74/11	74/12	...	87/12	88/01	88/01	88/02	...	99/01	99/02	99/03
1969/01	$cbm_{69/01}$	$cbm_{69/01}$	$cbm_{69/01}$									
...	...	...	...									
1974/09	$cbm_{74/09}$	$cbm_{74/09}$	$cbm_{74/09}$	...								
1974/10		$cbm_{74/10}$	$cbm_{74/10}$	...								
1974/11			$cbm_{74/11}$	...								
...				...	...	...	...	...				
1987/11					$cbm_{87/11}$	$cbm_{87/11}$	$M3_{87/11}$	$M3_{87/11}$	...			
1987/12						$cbm_{87/12}$	$M3_{87/12}$	$M3_{87/12}$	...			
1988/01								$M3_{88/01}$	...			
...										...	...	...
1998/12										$M3_{98/12}$	$M3_{98/12}$	$M3_{98/12}$

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Figure 9: Overnight and three-month interest rates in Germany (end-of-quarter values)

Figure 10: The time pattern for i and π

Table 8: Parameter estimates of the baseline reaction function with ex post revised data

Estimation equation:

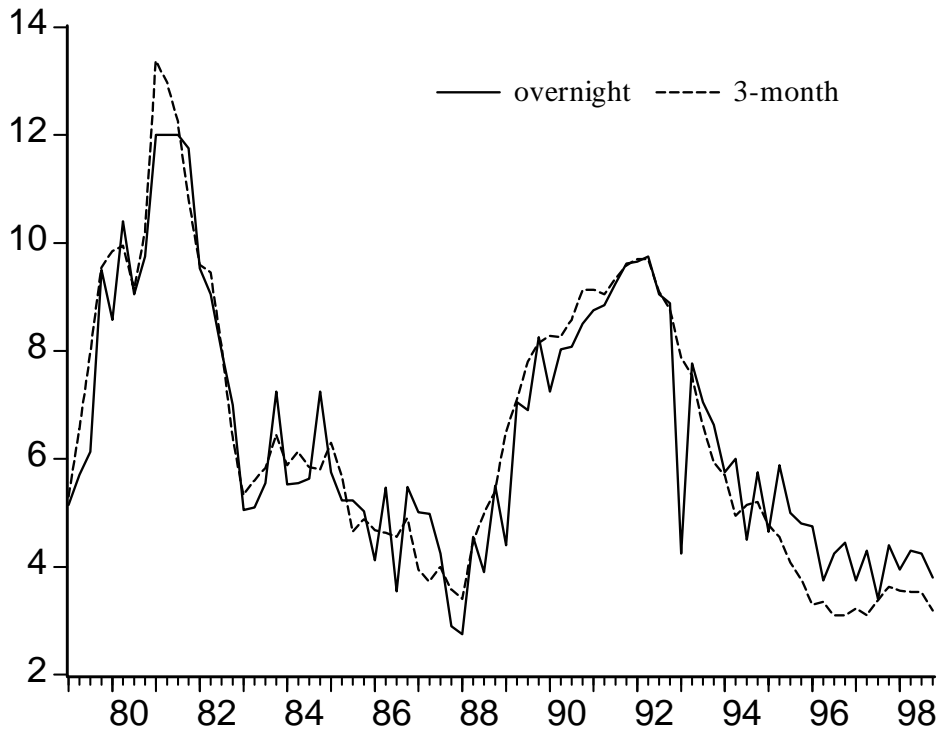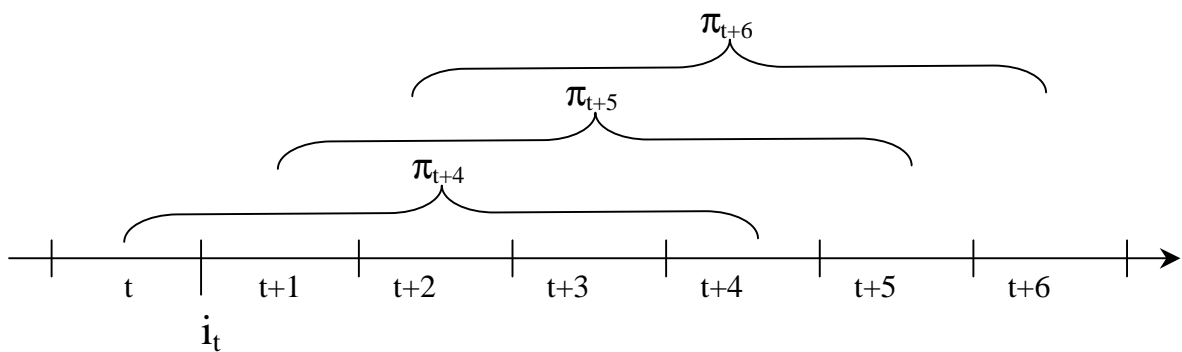$$i_t = (1 - \rho)\left(\alpha + E(\pi^*_{t+n}|\Omega_T) + \beta E((\pi_{t+n} - \pi^*_{t+n})|\Omega_T) + \gamma E(y_t|\Omega_T)\right) + \rho i_{t-1} + c \cdot d81Q1 + \varepsilon_t \text{ [1]}$$

Estimation period: 1979Q1 to 1998Q4, T=1999Q1, estimation method: GMM; HAC-robust standard errors in parentheses[2]

	n=4	n=5	n=6
α	3.79***	3.47***	3.38***
	(0.28)	(0.26)	(0.24)
β	0.82**	1.43***	1.61***
	(0.34)	(0.32)	(0.28)
γ	0.76***	0.53***	0.51***
	(0.19)	(0.15)	(0.13)
ρ	0.81***	0.79***	0.81***
	(0.02)	(0.02)	(0.02)
R²	0.95	0.95	0.95
SEE	0.55	0.59	0.55
J-stat (p-values)	0.78	0.86	0.87
Jarque Bera (p-values)	0.81	0.26	0.52

***(**/*) denotes significance at the 1% (5%/10%) level; values in brackets are robust standard errors.

1) 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 by a new special lombard facility which cost 3 percentage points more. See Bundesbank (1982), p. 5. 2) 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.

R²: 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.

Table 9: Parameter estimates of the baseline reaction function with real-time data

Estimation equation:

$$i_t = (1-\rho)\left(\alpha + E(\pi_{t+n}^*|\Omega_{t+n}) + \beta E((\pi_{t+n} - \pi_{t+n}^*)|\Omega_{t+n(+1)}) + \gamma E(y_t|\Omega_{t+1})\right) + \rho i_{t-1} + c \cdot d81Q1 + \varepsilon_t^{\,1)}$$

Estimation period: 1979Q1 to 1998Q4, T=1999Q1, estimation method: GMM; HAC-robust standard errors in parentheses[2]

	n=4	n=5	n=6
α	12.48 (10.95)	7.63*** (2.15)	5.89*** (1.60)
β	-5.26 (9.03)	-0.60 (1.20)	0.60 (0.83)
γ	4.16 (5.26)	1.59** (0.77)	1.03** (0.51)
ρ	0.97*** (0.04)	0.92*** (0.03)	0.92*** (0.03)
R²	0.93	0.94	0.95
SEE	0.66	0.60	0.57
J-stat (p-values)	0.75	0.69	0.73
Jarque Bera (p-values)	0.23	0.28	0.41

***(**/*) denotes significance at the 1% (5%/10%) level; values in brackets are robust standard errors.

1) 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 by a new special lombard facility which cost 3 percentage points more. See Bundesbank (1982), p. 5. 2) 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.

R²: 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.

Table 10: Monetary targets and their implementation

in %

| Year | Target: growth of central bank money stock (1975-1987) or money stock M3 (from 1988) | | | Assumption | | Actual growth (rounded figures) | |
	in the course of the year[1]	annual average	midyear review	Q1, Q2	Q3, Q4	in the course of the year	annual average
1975	8			8	8	10	
1976		8					9
1977	(6-7)[2]	8		6.5	6.5		9
1978	(5-7)[2]	8		6	6		11
1979	6-9		lower limit	7.5	6	6	
1980	5-8	6	lower half	6.5	5.75	5	
1981	4-7	5-5 ½	lower half	5.5	4.75	4	
1982	4-7	4 ¾	upper half	6.25[3]	6.25	6	
1983	4-7		upper half	6.25[3]	6.25	7	
1984	4-6	5		5	5	5	
1985	3-5	4 ½		4	4	5	
1986	3 ½ - 5 ½	4 ½		4.5	4.5	8	
1987	3-6			4.5	4.5	8	
1988	3-6			4.5	4.5	7	
1989	about 5	just under 5		5	5	5	
1990	4-6	about 5		5	5	6	
1991	4-6	5/5 ¼	3-5	4.5[4]	4	5	
1992	3 ½- 5 ½	5-5 ¼		4.5	4.5	9	
1993	4 ½ - 6 ½	6		5.5	5.5	7	
1994	4-6	5 ½		5	5	6	
1995	4-6	5 ¾		5	5	2	
1996	4-7	5 ½		5.5	5.5	8	
1997[5]	3 ½- 6 ½			5	5	5	
1998[5]	3-6			4.5	4.5	6	

1 Between the fourth quarter of the previous year and the fourth quarter of the current year; 1975: Dec. 1974 to Dec. 1975. – 2 According to Annual Reports for 1977 and 1978. – 3 In 1982 and 1983, the Bundesbank made it clear that it targeted the upper half of the corridor at the beginning of the year. - 4 In 1991, the Bundesbank made it clear that it targeted the lower half of the corridor at the beginning of the year. -5 Embedded in a two-year orientation for 1997/1998 of about 5% per year.

Table 11: Parameter estimates of the reaction function with additional variables

Estimation equation:

$$i_t = (1-\rho)\Big(\alpha + E(\pi^*_{t+n}|\Omega_{t+n}) + \beta E(\pi_{t+n} - \pi^*_{t+n}|\Omega_{t+n}) + \gamma_1 E(y_t|\Omega_{t+1})$$
$$+ \gamma_2 E(\widehat{y}_t|\Omega_{t+1}) + \lambda_1 E((\widehat{m}_t - \widehat{m}^*_t)|\Omega_{t+1})\Big) + \rho i_{t-1} + \varepsilon_t$$

Estimation period: 1979Q1 to 1998Q4, T=1999Q1, estimation method: GMM; HAC-robust standard errors in parentheses[1)2)]

	n=4	n=5	n=6
α	3.64***	3.65***	3.17***
	(0.53)	(0.60)	(0.41)
β	2.07***	1.88***	1.70***
	(0.26)	(0.29)	(0.20)
γ_1	0.05	0.13	-0.01
	(0.15)	(0.16)	(0.11)
γ_2	2.02***	1.90***	1.08***
	(0.41)	(0.39)	(0.20)
λ	0.44***	0.54***	0.49***
	(0.09)	(0.08)	(0.07)
ρ	0.88***	0.88***	0.84***
	(0.02)	(0.01)	(0.01)
R²	0.95	0.95	0.96
SEE	0.55	0.56	0.53
J-stat (p-values)	0.93	0.91	0.90
Jarque Bera (p-values)	0.86	0.52	0.16

***(**/*) denotes significance at the 1% (5%/10%) level; values in brackets are robust standard errors.

1) 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. 2) 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.

R²: 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.

Table 12: Robustness of results for different horizons of the money growth variable (with n=5)

Estimation equation:

$$i_t = (1-\rho)\left(\alpha + E(\pi^*_{t+5}|\Omega_{t+5}) + \beta E(\pi_{t+5} - \pi^*_{t+5}|\Omega_{t+5}) + \gamma_1 E(y_t|\Omega_{t+1})\right.$$
$$\left. + \gamma_2 E(\widehat{y}_t|\Omega_{t+1}) + \lambda_1 E((\widehat{m}_t - \widehat{m}^*_t)|\Omega_{t+1})\right) + \rho i_{t-1} + \varepsilon_t$$

Estimation period: 1979Q1 to 1998Q4, T=1999Q1, estimation method: GMM; HAC-robust standard errors in parentheses[1)2)]

coefficients ↓	money gap measured by		
	log money stock relative to target path (CGG)	*(annualised) six-month rate of money growth relative to target*	*annual rate of money growth relative to target*
α	3.32***	3.90***	3.65***
	(0.53)	(0.63)	(0.60)
β	2.57***	2.13***	1.88***
	(0.33)	(0.40)	(0.29)
γ_1	-0.03	0.31*	0.13
	(0.14)	(0.18)	(0.16)
γ_2	1.70***	2.42***	1.90***
	(0.34)	(0.51)	(0.39)
λ	0.59***	0.51***	0.54***
	(0.10)	(0.12)	(0.08)
ρ	0.86***	0.89***	0.88***
	(0.01)	(0.02)	(0.01)
R²	0.95	0.95	0.95
J-stat (p-values)	0.94	0.83	0.91
Jarque Bera (p-values)	0.46	0.42	0.52

***(**/*) denotes significance at the 1% (5%/10%) level; values in brackets are robust standard errors.

1) 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. 2) 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.

R²: adjusted coefficient of determination; 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.

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