The information content of German discount rate changes

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Abstract

Discount rate changes always receive considerable attention in financial markets. Two hypotheses compete to explain financial market reactions: the direct 'borrowing cost effect' and the announcement effect. This paper examines the issue for the Bundesbank's discount rate changes after 1979. Summing up we find that market reactions cannot be attributed to a direct borrowing cost effect but exclusively to announcement effects. The empirical results indicate that interest rates react to changes in the discount rate to the extent that they are unanticipated. In contrast, the response to anticipated changes in the discount rate is small and insignificant. We proxy market anticipations by a multinomial logit-model combined with a dummy variable capturing non-quantifiable factors reported by the financial press. Moreover, we show that the response of interest rates declines along the term structure and with the switch to greater emphasis on repurchase operations in early 1985.

JEL-Classification: E43, E52

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1 Introduction

Financial market participants pay a considerable amount of attention to announcements of discount rate changes. Among economists, however, a continuing controversy is going on about why and to what extent financial markets respond to such announcements. There are two major strands of thought. A first, more traditional approach holds that any change of the discount rate has a 'direct

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effect’ on financial markets as it changes the cost of borrowing at the discount window. If discount window borrowing is sensitive to the spread between the short-term interest rate and the discount rate, a change in the latter will directly affect borrowing, therefore, the supply of base money and interest rates. Obviously, the empirical relevance of the direct effect is contingent upon the degree of interest sensitivity of discount window borrowing as well as the relative size of this source of base money creation. Studies for the US suggest that the direct effect is negligible if it exists at all, see, e.g., Thornton (1994).

A competing explanation of why financial markets may immediately respond to changes of the discount rate concentrates on information or announcement effects. If financial market participants perceive discount rate changes as signalling a switch in the future stance of monetary policy, they may alter expectations about future economic conditions and thus affect the demand for credit. An alternative view, suggested by Friedman (1959), assumes that the central bank possesses private information on the course of economic activity and may use discount rate changes to signal its predictions. For the information effect to work, markets must regard discount rate changes as conveying *new* and *useful* information. Once this line of thought is accepted, it follows that the effects of discount rate changes on market interest rates may vary considerably from announcement to announcement depending on their information content and on the degree to which they were anticipated or not.

The first systematic empirical study of market reactions to changes in the discount rate goes back to Waud (1970). He finds that discount rate changes negatively affect equity values. Lombra and Torto (1977) extend Waud’s analysis by accounting for the possible endogeneity of the discount rate. Despite them finding the discount rate to be endogenous in the post-1967 period, they observe a significant market reaction.

Starting with Thornton (1982), the empirical literature (e.g. Smirlock and Yawitz 1985, Cook and Hahn 1988, Dueker 1992, and May 1992) has made a conceptual distinction between *technical* and *non-technical* changes of the discount rate. A technical change carries no information about the stance of monetary policy or the economy. It just serves to realign the discount rate with money market rates. Non-technical changes of the discount rate, in contrast, concur with a change in the policy stance, and hence those discount rate movements carry relevant information. Thus, theoretically, technical changes are passive adjustments that should be predictable while non-technical changes, at least to some extent, result from pure discretion that cannot be anticipated. Yet the empirical evidence produced by Roley and Troll (1984), Hakkio and Pearce (1986, 1992), Dueker (1992), and Thornton (1994) suggests that both types of discount rate changes are equally (un-)predictable. This may be due to the fact that it is difficult to differentiate technical from non-technical changes of the discount rate at the empirical level. In the literature, the distinction is based on the wording of the Federal Reserve Board's press releases where as a rule the reasons for discount rate changes are explicitly stated. As Smirlock and Yawitz (1985) note one should be aware that this method of classifying discount rate changes "[...] implicitly assumes that the reasons given by the Fed are accurate, or at least that the market perceives that they are accurate."

The general hypothesis that financial markets react to non-technical changes is well supported by the evidence (see e.g. Roley and Troll 1984, Smirlock and Yawitz 1985, and Cook and Hahn 1988). This confirms that non-technical changes of the discount rate are considered as relevant carriers of information though the nature of this information remains in the dark. A systematic link between discount rate changes and future changes in monetary policy has not been found yet. Thornton (1994), for example, empirically rejects the notion that non-technical discount rate changes signal a change in the stance of monetary policy.

The existing empirical literature exclusively deals with the discount rate policy of the Federal Reserve. The question is whether financial markets in other countries react similarly. This paper investigates the discount rate policy of the German Bundesbank. This may be of particular interest given that the Bundesbank is an important international player.

At the outset, note that as a rule the Bundesbank does not explain the exact reasons that have led to the decision of a discount rate change. Therefore, there is no direct way to differentiate technical from non-technical changes. In all likelihood most changes are technical in nature. We argue that there is no need for the Bundesbank to use the discount rate neither as a signalling device nor to exert a direct influence on money market rates. There are several observations supporting this conjecture: first, the dominant component of the Bundesbank's lending to commercial banks is effected by open market transactions with repurchase agreements while rediscount credit has become much less important a source of base money creation during the 1980s. Second, the Bundesbank sets the discount rate below the market clearing level and rations the borrowing at the discount window by rediscount quotas that almost always are fully used up. Third, the discount rate is changed infrequently while the money market rate can be controlled quasi continuously by changing non-borrowed reserves as well as by the auctioning of repurchase agreements at changed repo rates.

The remainder of the paper is organised as follows: In the next section we examine if discount rate changes directly affect borrowing at the discount window. In section 3 and 4, we investigate the announcement effect. As a first step we need to determine whether discount rate changes contain new information. This is done in section 3 where we study the predictability of discount rate changes using a multinomial logit model. This permits predicting the direction and timing though not the magnitude of a change in the discount rate. In extension of the existing literature, we also incorporate the information contained in the financial press by scrutinising the German daily *Handelsblatt* several days before each Bundesbank board's meeting. Proceeding in this way allows us to capture non-quantifiable factors, e.g. official statements, presumably affecting market participants' expectations. Then, in section 4, the predictions and the information collected from the press are used for studying the reaction of money market rates to the anticipated and non-anticipated components of discount rate changes. Finally, section 5 gives some conclusions.

2 Testing for the direct effect

The existence of a direct effect is linked to the interest responsiveness of discount window borrowing. Only if the demand for rediscount credit responds negatively and significantly to variations in the spread between the short-term interest rate and the discount rate, a change in the discount rate affects directly the volume of borrowing and, consequently, the supply of money and market interest rates. To check for the interest sensitivity of rediscount borrowing we estimate the following equation:

$$DB_t = \alpha + \beta(i_t - DR_t) + \phi(L)DB_{t-1} + \varepsilon_t\,, \tag{1}$$

where DB_t denotes discount window borrowing in percent of the rediscount quotas, i_t the overnight rate and DR_t the discount rate at time t. $\phi(L)$ is a polynomial in the lag-operator and ε_t represents a random disturbance.[1]

Our sample covers the period January 1979 to December 1995. The starting point coincides with a change in the Bundesbank's policy regime. In 1979 the Bundesbank switched to credit rationing by squeezing the banks' free liquid reserves. This resulted in a drastic fall of unused refinancing facilities and in an increased variability of this base money source. Within the sample period we identify two events that may have affected the system's structure, i.e. caused a structural break. The first potential structural break relates to the shift towards a more flexible money market control in early 1985. At this date, the emphasis shifted from refinancing at the discount window to refinancing by weekly repurchase operations. The second potential structural break is associated with German monetary union (GMU) of July 1st, 1990. To formally test for structural breaks in equation (1) we compute Chow-tests for the two potential break points. Table 1 lists the results.

<Table 1 about here>

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[1] Preliminary unit-root tests showed that the variables in equation (1) are stationary so that we do not have to resort to cointegration analysis. In general, only the first lag of *DB* was significant in equation (1) and hence we restrict our analysis to $\phi(L) = \phi_1$.

While the move towards a more flexible money market control via repurchase operations in February 1985 did not affect parameter constancy of equation (1), the null of structural stability is clearly rejected when GMU is taken as sample split date. In the light of these findings, we split our sample in a pre- and post-unification period. Table 2 presents the estimates of equation (1) for the two sub-periods considered.

<Table 2 about here>

The estimates reveal that the spread significantly affects rediscount borrowing in both sub-periods. But note that both size and significance of the estimated coefficient differ largely between the two sub-periods. The coefficient in the post-unification period is around four times larger than in the pre-unification period and significant. A formal test on parameter equality between the two sub-periods rejects the null at the 1% significance level. Statistical significance, however, does not necessarily imply economic significance. According to the results presented in Table 2, in the pre-unification period a discount rate increase of 100 basis points leads *ceteris paribus* only to a 2 basis point long-run decrease in discount quota utilisation. In the post-unification period this figure is doubled. Summing up, the impact of discount rate changes on the monetary base appears to be negligible.

If the direct effect really mattered, one should find for the first sub-period – when discount window borrowing responded significantly less to the spread – that the effect of discount rate changes on interest rates was smaller than during the most recent sub-period. To investigate this issue we estimate the following equation for the two sub-periods:

$$\Delta i_t = \alpha + \beta \Delta DR_t + \varepsilon_t \qquad (2)$$

In equation (2) Δi_t designates the change in the overnight rate from day t-1 to day t and ΔDR_t stands for the change in the discount rate announced between t-1 and t. Discount rate changes are decided by the Bundesbank board every other Thursday, with announcements usually being made on Thursday afternoon. Days on which the discount rate was left unchanged are not considered in the regression, i.e. we perform an event-study. The results are given in Table 3 and do not lend support to the direct effect: While the overnight rate reacts significantly to discount rate changes in the pre-unification period, the market reaction is insignificant in the more interest sensitive post-unification period. Therefore, we conclude that, as in the U.S., the direct effect is not a relevant phenomenon in Germany.

<Table 3 about here>

3 Are discount rate changes anticipated?

Investigating the potential announcement effect of discount rate changes requires first to determine whether and to which extent those policy actions were anticipated by market participants, because only the unanticipated component represents new information that affects asset prices on the spot if markets are informationally efficient.

There are essentially two statistical methods available for splitting discount rate changes into anticipated and non-anticipated components. A first method, applied by Smirlock and Yawitz (1985), is to regress the discount rate changes on explanatory variables and to equate the unanticipated component with the error term of the empirical model. However, this approach suffers from the shortcoming that the estimated predictions do not comply with the fact that discount rate changes are limited to discrete steps of 25, 50, 75, and 100 basis points. A preferable, second method is estimating a logit (or probit) model. This permits taking explicitly the discrete nature of actual discount rate changes into account.

In this study we rely on the second method, as our main concern is whether and in which direction the Bundesbank changes its discount rate while the numerical size of a change is of less importance here. Anyway, the bulk of German discount rate changes is of uniform size, i.e. 50 basis points. This underlines the appropriateness of a logit model. Consequently, in our empirical application we estimate a three-choice situation (discount rate increase, decrease, or no change). The statistical model is a multinomial logit of the form:

(3)

$$P(DR = i | X_t) = \frac{\exp(\alpha_i + \beta_i X_t)}{\sum_{j=1}^{3} \exp(\alpha_j + \beta_j X_t)}, \; i = 1,2,3 \text{ and } \alpha_3, \beta_3 = 0$$

where i takes the values 1, 2, and 3 depending on whether the discount rate was increased, decreased or left unchanged. X_t represents a vector of explanatory variables, β_i the corresponding coefficient vector, and α_i the intercept. $P(DR=i|X_t)$ is the probability of a discount rate change in direction i conditioned on the realisation of X_t. The restriction on α_3 and β_3 is needed for the unequivocal parametrisation of the model.

The selection of the set of variables used as regressors is not guided by a specific model but is broadly in line with the literature on reaction functions.[2] The monetary authority is assumed to respond to the real economy, inflationary developments, market interest rates and the exchange rate. Specifically, we conjecture that the market's strength of sentiment that the discount rate will be changed, i.e. the probability of a discount rate change, depends on the spread between the overnight rate and the discount rate, the annual growth rate of industrial production, the logarithmic change in the deutsche mark-US dollar rate and a variable measuring the inflationary stance. Regarding the latter we choose the change in annual inflation (CPI) over the last 12 months. All variables are lagged one period.[3]

<Table 4 about here>

While all coefficients reported in Table 4 exhibit the expected sign, not all of them are significant at standard levels of significance. Notably, the rate of change of the exchange rate has no significant predictive value. Production growth, in contrast, appears to be a significant trigger of motivating discount rate adjustments, upwards as well as downwards. A rise in the inflation rate

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[2] See, e.g., Roley and Troll (1984), Smirlock and Yawitz (1985), Hakkio and Pearce (1986, 1992) and Dueker (1992) for similar specifications.

[3] Due to reasons of data availability the model was estimated using monthly data. This requires to assume that the likelihood of a discount rate change stays constant within each month. The assumption does not constitute a serious restriction as (i) market participants have no access to

significantly increases the probability of a positive discount rate change. Finally, if the overnight rate declines towards the discount rate, that is the spread narrows, the probability of a discount rate cut, that serves to keep the discount rate in line with market interest rates, rises significantly.

To check the robustness of these results to alternative specifications and to investigate further the reaction function of the Bundesbank, we include some supplementary variables in the analysis and test their significance. The first factor we study are interest smoothing motives. In a study of the interest rate targeting behavior of the Federal Reserve, Rudebusch (1995) finds that target changes are guided by interest rate smoothing motives. This implies that policy actions are spread over time and targets are adjusted only gradually. Statistically, interest rate smoothing behavior leads to serial correlation in discount rate changes and can be tested by the inclusion of a dummy variable being set to one if a discount rate change occurred in the last n months.

Given the distribution of time lags between discount rate changes of same sign, we let n vary from one to four. In all cases was the sign of this dummy variable negative rejecting interest smoothing motives. The negative sign rather indicates that the Bundesbank abstains from changing the discount rate too often, i.e. within short time intervals; presumably because too frequent a use of this signaling device risks to lessen its effect. Since the dummy variable is significant at the five percent significance level in only one of eight cases ($n=2$, increase), we decide against including it in the empirical model.

Moreover, we study the explanatory power of two additional variables. First, to capture potential reactions of the Bundesbank to tensions in the European Monetary System (EMS) we test the explanatory power of the deutsche mark-French franc exchange rate. Second, to see whether discount rate policy takes unemployment into account, in addition to the growth rate of production, we also add the unemployment rate (and changes in it) to the set of explanatory variables. All these variables are not found to exert a significant influence, signifying that the

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higher frequency data for most explanatory variables and (ii) the exact timing of a discount rate

Bundesbank does not appear to react systematically to external and internal pressures by changing its discount rate. Since the remaining results prove robust to the inclusion of these variables they were omitted from subsequent analysis.

<Figures 1a and 1b about here>

Figures 1a and 1b depict the estimated probabilities of a discount rate increase or decrease. The predicted prior probabilities often peak in or close to the months when discount rate changes (indicated by bars) took place. However they rarely top 50 percent except in the post-unification period. For this most recent period the model predicts quite accurately the 1993 discount rate cuts. But note that the model also generates some few ‘false signals,’ i.e. relatively high estimated probabilities when no discount rate change actually occurred. Yet these ‘false signals’ generally show up close to months when the discount rate was changed in the same direction. This illustrates the fact that the exact timing of discretionary policy decisions is hard to predict anyway – which could also be due to the fact that supposedly the Bundesbank randomises its responses to some extent – even though they are not completely unanticipated by market participants.

Overall our findings are in conformity with the results of studies on US discount rate changes, e.g. Hakkio and Pearce (1986, 1992) and Dueker (1992). The explanatory power of such empirical models is low and the estimates do not permit to predict reliably the exact timing of discount rate changes.

To this point, we have not used the information contained in the financial press to ameliorate our model’s predictions. The exploration of this source of information allows us to capture non-quantifiable factors such as statements by Bundesbank officials. In order to evaluate the press’s assessment of the likelihood of a discount rate change, we checked the economic daily *Handelsblatt* three days preceding the Bundesbank’s central bank council meetings, i.e. Monday through Wednesday, for reports on expected discount rate decisions. A dummy variable serves to capture the Handelsblatt’s predictions. It takes the value 1 if a discount

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change is arduous to predict anyway.

rate change was predicted and zero otherwise. Altogether, 15 discount rate changes out of 37 were coded as anticipated by the financial press.

This raises another question. Are the 'newspaper anticipations' related to the predictions of our logit model or do they carry independent, complementary information, extracted from statements by Bundesbank officials or market moods? Even so it is conceivable that the policy evaluations of those sources resulted from the same set of variables we have used above in estimating the prior probabilities of discount rate changes. Table 5 presents the discount rate changes, the estimated probabilities and the newspaper anticipation dummy variable. A casual inspection of the data suggests that high estimated probabilities of our logit-model are not linked to the newspaper anticipations. This presumption was formally corroborated by a statistical test. To this aim we regressed our prior probability on newspaper anticipations in a logit model. The null hypothesis of no influence was not rejected.[4] The result permits us to treat the newspaper anticipations and our estimated probabilities as complementary sources of information about oncoming changes of the discount rate.

<Table 5 about here>

4 Discount rate changes and market rates

In this section we investigate the hypothesis that changes of the discount rate convey *new and useful* information to financial markets about a change in the stance of monetary policy and, therefore, affect market interest rates. To create a benchmark case, we begin by testing the counter-hypothesis that the information content in German discount rate changes is zero and that in addition discount rate

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[4] The results of this testing procedure have to be interpreted with some caution since the testing is based on the second step of a two-step procedure. Although the second-stage parameters are consistently estimated by OLS under fairly general conditions, their estimated standard errors are ordinarily underestimated. Pagan (1984) shows that the estimator of the parameter's variance is consistent and the asymptotic t-statistic valid only if the hypothesis to be tested is that their coefficients are zero (see also Murphy and Topol 1985). Anyway, as we were unable to reject the null of no influence, a possible second step bias would even strengthen our results. This caveat also applies to the estimation of equation (4) in the next section where probabilities estimated in the first-step enter equation (4) as regressors.

changes have no direct effect on market interest rates. The test is based on event-time regression (2).

Disregarding the extent to which a discount rate change was anticipated, equation (2) simply states that interest rates react to changes in the discount rate. Under the null of no direct effect *and* no announcement effect β should be zero. Given that we have already rejected the existence of any direct effect in section 2, a significant market reaction would constitute evidence in favour of the hypothesis that a change in the discount rate carries new information. However, only the unanticipated component should matter. To discriminate between anticipated and unanticipated changes we split discount rate changes into the two components and run the following event-time regression:[5]

$$\begin{aligned} \Delta i_t &= \alpha + \beta^e \Delta DR_t^e + \beta^u \Delta DR_t^u + \varepsilon_t \\ \text{where } \Delta DR_t^e &= P_t S_t \text{ and} \\ \Delta DR_t^u &= \Delta DR_t - \Delta DR_t^e . \end{aligned} \tag{4}$$

In equation (4) ΔDR^e is the anticipated component of a given discount rate change while ΔDR^u designates the unanticipated component. The anticipated component can be thought of being composed of two subcomponents. The first subcomponent is the market's strength of sentiment that a discount rate change will be decided at the next meeting of the central bank council, *P*. In the empirical application this sentiment is proxied by a combination of the estimated probability of a discount rate change implied by our logit-model and the dummy variable representing the newspaper anticipations as follows: *P* equals the estimated prior probability of a discount rate change for any date of a change when the *Handelsblatt* did not provide a prediction. It equals one when a prediction was published.[6]

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[5] Theoretically, there could be anticipations of discount rate changes when actually no change took place. However, in our sample we did not find any such anticipation in the financial press and restrict our analysis to the days neighbouring the meeting days of the Bundesbank central bank council.

[6] As an alternative approach we also used the newspaper anticipation dummy as a regressor in the logit-model and proxied *P* by the re-estimated probabilities from this specification. This did not lead to qualitatively different results.

The second subcomponent is the expected size of a discount rate change denoted by *S*. We follow the straightforward assumption of the literature that market participants always anticipate the correct magnitude of a change in the discount rate; see e.g. Hakkio and Pearce (1986). Thus we set $S = \Delta DR$. This, of course, is not literally true. As an alternative one might assume, for example, that the market has constant expectations regarding the size of a discount rate change equal to the median of all changes in our sample, i.e. 50 basis points. But note that this alternative assumption does not yield substantially different empirical results.

As already discussed above, the switch towards a more flexible money market control as well as GMU constitute potential structural breaks that should be tested for. Thus before moving on with the examination of market reactions to discount rate changes, we study the structural stability of equation (2) with a Chow-test. The results are reported in Table 6. The null of structural stability is overwhelmingly rejecting if February 1985 is taken as sample split date. In contrast, GMU does not seem to have influenced market reactions to discount rate changes. In view of these results, we proceed with two sub-periods: The first spanning the period from January 1979 to January 1985, the second covering the time from February 1985 to December 1996. Note however, that due to few observations in sub-period 1 these period's results should be interpreted with caution.

Table 7 reports the estimates of equations (2) and (4) for the two sub-periods and different maturities. The results can be summarised as follows: Market reactions to changes in the discount rate decrease considerably along the term structure. According to the emphasis on repurchase operations in sub-period 2, a comparison between the two sub-periods reveals a more pronounced interest rate reaction in sub-period 1. The reaction to the anticipated component of changes in the discount rate is never significant and typically many times smaller than that to the unexpected component. Apart from one exception the coefficient of the unexpected component is always significant at the 5 or 1% significance level. To formally test the hypothesis that the market reacts differently to anticipated and non-anticipated discount rate changes, we compute an F-test of coefficient equality. For sub-period 1 we cannot reject the null of an equal response, whereas for sub-period 2 it is clearly rejected. Furthermore, the adjusted R^2 is generally higher when the distinction between anticipated and non-anticipated discount rate changes is made. This also indicates that the separation contains some additional information. A comparison with the studies on U.S. discount rates shows that market reactions in Germany and the U.S. are qualitatively similar, especially regarding the differences between the reaction to anticipated and non-anticipated changes in the discount rate.

<Table 7 about here>

5 Conclusions

In this paper we have studied the response of German money market rates to changes in the Bundesbank's discount rate. Similar to results found for U.S. data, the response cannot be attributed to a direct 'borrowing cost effect' but to the existence of announcements effects. Our results suggest that changes in the German discount rate are unexpected to a considerable extent and the unexpected component translates into simultaneous changes of the money market rate. The size of the market reaction declines along the term structure. With the switch to flexible money market control in early 1985 – when repurchase operations took over the role as dominant money market instrument – market reaction was reduced. Notwithstanding, changes in the discount rate still have a significant announcement effect despite the availability of more flexible signalling devices such as changes in repo rates or public announcements.

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We are indebted to Dan Thornton and two anonymous referees for insightful comments. After having revised the paper we became aware of a similar study by Hardy (1996). Though some of his results are in line with ours, he does not test for the direct effect. Moreover, he finds, that market rates significantly respond to

anticipated changes in official rates. This may be due to a different proxy for market expectations.

Appendix: Data sources

The monthly data for rediscount borrowing and rediscount quotas are from the Bundesbank's Monthly Reports. All other monthly data used throughout this paper are taken from the IMF's International Financial Statistics. Interest rates and exchange rates are monthly averages. The daily observations of the money market rates used in section 4 are Frankfurt Interbank rates and have been gathered by the Deutsche Bundesbank before noon of the corresponding day.

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Tables and Figures

Table 1. Chow-test for structural breaks in equation (1)

Breaking date	*F*-statistic	p-value
February 1985	1.31	0.27
July 1990	10.14	0.00

Table 2. Test of the direct effect

Sample	Constant	Spread	DB_{-1}	$\overline{R}^2$	DW
80:1-90:6	0.22**	0.005†	0.75**	0.62	2.03
	(4.15)	(1.93)	(13.35)		
90:7-95:12	0.47**	0.02**	0.48**	0.46	2.22
	(4.90)	(2.58)	(4.63)		

Note: t-statistics in parenthesis. **, *, and † means that the null can be rejected at a risk of 1%, 5%, and 10% respectively.

Table 3. Money market reaction in pre- and post-unification period

Sample	Constant	ΔDR	$\overline{R}^2$	DW
80:1-90:6	0.04	0.48**	0.29	1.61
	(0.49)	(3.48)		
90:7-95:12	0.03	0.16	0.07	1.87
	(0.58)	(1.52)		

Note: t-statistics in parenthesis. **, *, and † means that the null can be rejected at a risk of 1%, 5%, and 10% respectively.

Table 4. Multinominal logit coefficients

Description	Parameter	Estimate	t - Statistic	Parameter	Estimate	t - Statistic
	Discount rate decrease, *i*=1			Discount rate increase, *i*=2		
Intercept	b_{11}	-0.25	-0.36	b_{21}	-3.78	-3.86**
Spread	b_{12}	-2.48	-2.71**	b_{22}	0.30	0.56
Production	b_{13}	-27.86	-3.47**	b_{23}	20.13	2.02*
Inflation	b_{14}	-40.94	-1.25	b_{24}	64.04	2.06*
Exchange rate	b_{15}	-17.19	-1.40	b_{25}	15.41	1.46

Notes: Estimation period: 1979:1 to 1995:12. Production and DM/USD exchange rate are expressed as logarithmic changes. The 1984:6 (strikes) and 1985:6 (burst of dollar bubble) outliers in the production series are excluded from the analysis, i.e. set missing. Production is the logarithmic change in industrial production and exchange rate stands for the logarithmic change in the monthly average of the DM/USD exchange rate. Inflation is the annual change in the annual inflation rate (CPI). All variables are lagged one period. **, *, and † means that the null can be rejected at a risk of 1%, 5%, and 10% respectively.

Table 5. Discount rate changes and market anticipations

Date	ΔDR	Dum	P(DR│x)	Date	ΔDR	Dum	P(DR│x)
30.03.79	1.0	0	0.051	06.10.89	1.0	1	0.233
13.07.79	1.0	0	0.237	01.02.91	0.5	0	0.167
02.11.79	1.0	1	0.417	16.08.91	1.0	1	0.257
29.02.80	1.0	0	0.385	20.12.91	0.5	1	0.052
02.05.80	0.5	0	0.245	17.07.92	0.75	1	0.016
27.08.82	-0.5	1	0.150	15.09.92	-0.5	0	0.139
22.10.82	-1.0	1	0.346	05.02.93	-0.25	0	0.651
03.12.82	-1.0	0	0.432	19.03.93	-0.5	1	0.780
18.03.83	-1.0	0	0.424	23.04.93	-0.25	0	0.585
29.06.84	0.5	0	0.078	02.07.93	-0.5	0	0.445
16.08.85	-0.5	1	0.061	10.09.93	-0.5	0	0.652
07.03.86	-0.5	1	0.166	22.10.93	-0.5	1	0.545
23.01.87	-0.5	0	0.042	18.02.94	-0.5	0	0.219
04.12.87	-0.5	0	0.136	15.04.94	-0.25	0	0.152
01.07.88	0.5	0	0.203	13.05.94	-0.5	1	0.071
26.08.88	0.5	1	0.161	31.03.95	-0.5	0	0.108
20.01.89	0.5	1	0.148	25.08.95	-0.5	1	0.173
21.04.89	0.5	0	0.276	15.12.95	-0.5	0	0.380
30.06.89	0.5	0	0.244				

Notes: Date designates the first day of validity (usually the Friday after the announcement*)* of a discount rate change. *Dum* is a dummy variable that takes the value 1 if the change in the discount rate has been anticipated by the press an 0 otherwise. *P(DR%X)* is the estimated probability of a discount rate change.

Table 6. Chow-test for structural breaks in equation (2)

Split date	*F*-statistic	p-value
February 1985	8.69	0.00
July 1990	1.37	0.26

Table 7. Interest rate reactions to changes in the discount rate

Maturity	ΔDR	ΔDR^e	ΔDR^u	*F*-test	$\overline{R}^2$
		Sub-period 1 (Jan. 1979 – Jan. 1985			
overnight	0.68**				0.50
	(3.74)				
		0.38	1.01**	1.29	0.51
		(1.17)	(2.95)		
1 month	0.33*				0.36
	(2.86)				
		0.14	0.54*	1.27	0.37
		(0.68)	(1.47)		
3 months	0.20				0.08
	(1.48)				
		0.08	0.33	0.32	0.03
		(0.33)	(1.24)		
		Sub-period 2 (Febr. 1985 – Dec. 1995)			
overnight	0.12				0.03
	(1.39)				
		0.02	0.42*	2.76†	0.08
		(0.16)	(2.11)		
1 month	0.12**				0.23
	(3.21)				
		0.06	0.29**	6.26*	0.35
		(1.34)	(3.76)		
3 months	0.09**				0.19
	(2.88)				
		0.04	0.21**	4.27*	0.27
		(1.22)	(3.17)		
12 months	0.07**				0.18
	(2.78)				
		0.04	0.16**	3.02†	0.23
		(1.29)	(2.80)		

Notes: To safe space the constant is not reported. *F-Test* is a *F*-distributed test of the null hypothesis that the coefficients of the expected and unexpected component are equal. Maturities up to 1 year are taken from the Frankfurt Interbank market (gathered by the Deutsche Bundesbank before 12:00 noon). Data on 12 months were not available for the first sub-period. All data were provided by the Deutsche Bundesbank. t-statistics in parenthesis. **, *, and † means that the null can be rejected at a risk of 1%, 5%, and 10% respectively.

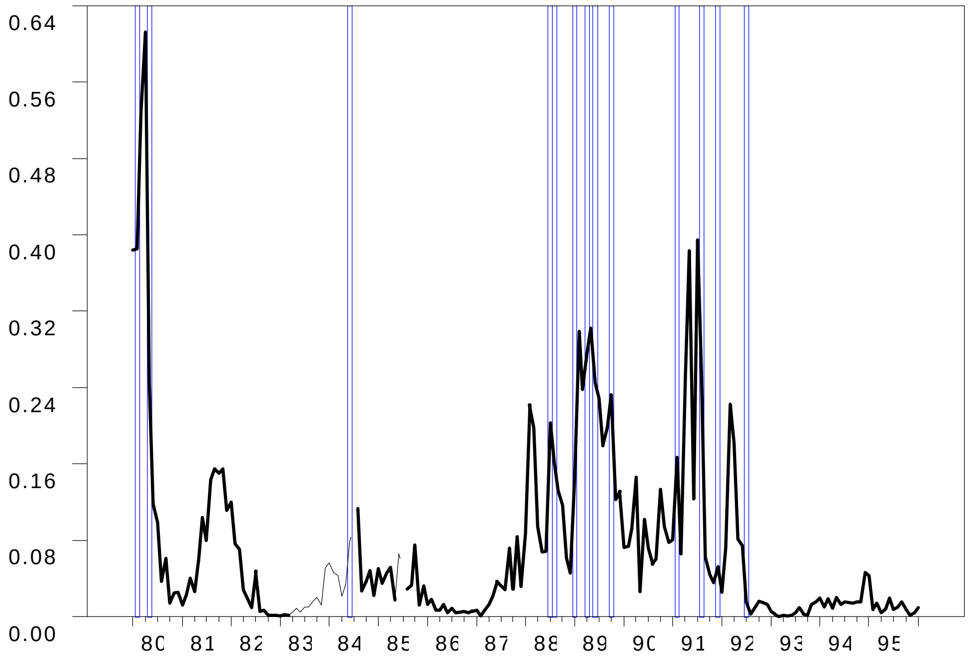

Figure 1a. Estimated probability of a discount rate increase

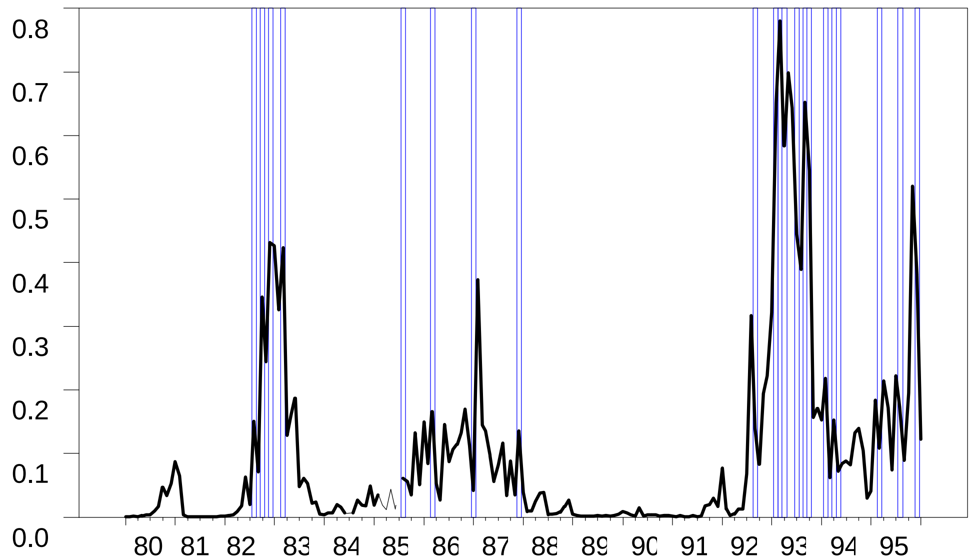

Figure 1b. Estimated probability of a discount rate decrease