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Stability issues in German money multiplier forecasts

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Stability Issues in German

Money Multiplier Forecasts

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Abstract

This paper investigates the stability of the German money supply focusing on the period 1991 - 1998. It is shown that the standard ARIMA-Transfer model approach in the literature needs to be augmented by a cointegration term to adequately model the dynamics of money supply in Germany. Additional analysis with regard to the influence of financial innovations on the control of money supply yields evidence that the influence of financial innovations on the multiplier has increased steadily during the observation period
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JEL:E4, E5

Keywords: Money Supply, Financial Innovation, Forecasting Money Multiplier

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1 Introduction

The strategy of monetary targeting, as pursued by the Deutsche Bundesbank until 1998 and the European Central Bank since January 1999, relies on two basic assumptions. One, the targeted monetary aggregate has to be a stable function of a few indicators (GDP, interest rate, etc.). This condition is commonly referred to as the necessary stability of money demand. Two, the money supply has to be controllable by the monetary authorities. Otherwise unpredicted changes in the growth rate of the money multiplier can jeopardise the usefulness and success of monetary targeting. As far as the first condition is concerned, in recent years several studies confirmed the existence of a stable German money demand function with adequate statistical properties. With regard to controllability, far less studies have been presented, however, the Bundesbank had documented difficulties in meeting its growth targets for the observed broad aggregate M3. Most studies on German money supply focus on the problems of controlling the latter during the unstable monetary period of German unification in 1990/91. None explicitly cover the problematic period during the ERM crisis in 1992/93 and the volatile phase of the run-up to the European Monetary Union, where European matters potentially impacted national monetary policy. Moreover, none of these studies takes into account the increasingly widespread use of new financial instruments – like derivatives, CDs, CPs, E-Cash – which are likely to affect the targeted monetary aggregates.

Therefore the aim of this paper is twofold. First, we will provide a detailed picture of the controllability of German money supply under the reign of the Deutsche Bundesbank from the beginning of its monetary targeting period in 1974 until the first quarter of 1998. Given the substantial problems in controlling the money supply in recent years, we present an alternative approach to forecasting the money multiplier, which proves to be more accurate for forecasting money growth in periods of policy instability. Second, we try to assess the importance of financial innovations in conjunction with monetary targeting. Since the ECB basically employs the same framework for its strategy as the Bundesbank did before these results also pertain to any strategy aimed at ensuring price stability in Euroland.

2 Methodology

Similarly to other investigations of money demand we analyse a broad (M3) and a narrow (M1) monetary aggregate in order to detect possible differences in these two money measures. The origin of any money supply process investigation is the relationship of the (adjusted) monetary base and the money multiplier. The (whole) monetary base or source base can be divided into two parts. One part is supposed to be exogenous, i.e. it is directly controllable by the monetary authorities. The other part is supposed to be partly or fully endogenous, i.e. the central bank cannot exert direct and/or full control over this part of the monetary base. If one defines the source base from its use, it can be divided into three major components:[1]

$$B^{Source} = C + RR + ER \qquad (2\text{-}1)$$

C ... Cash

RR ... Required Reserves

ER ... Excess Reserves

Decomposing the source base leads to the following definition:

$$B^{Source} = NFA + RF + NCG + FDA - D^{NBP} - LP - SP - P \qquad (2\text{-}2)$$

NFA ... Net Foreign Assets of the central bank

RF ... Refinancing Facilities

NCG ... Net Claims on Government

FDA ... Further Domestic Assets

D^{NBP} *... Nonbank private deposits at the Central Bank*

LP ... Money Market Papers of commercial banks/financial institutions

SP ... Difference between resulting Active and Passive Positions

P ... Profit of the Central Bank

Subtracting the endogenous part from the source base provides the (supposedly) exogenous adjusted monetary base. Taking equation 2-1 and adding the amount of money market papers of banks/financial institutions, while simultaneously deducting the refinancing facilities which cannot be fully controlled by the monetary authorities in the short run, provides us with the adjusted monetary base B^a:

$$B^a = B^{Source} + LP – RF \quad (2\text{-}3)$$

Equation 2-2 shows that the source base can be split into an external component (NFA) and an internal component (B^{Source}-*NFA)*. If the domestic currency is fully convertible and there are no mandatory interventions in the foreign exchange market or interventions are fully sterilized, the whole NFA component can be added to the exogenous part of the source base. The refinancing facilities as well as money market papers of banks have to be considered endogenous, leaving the definition of the adjusted base:

$$B^a = NFA + NCG + FDA - D^{NBP} - SP – P \quad (2\text{-}4)$$

Earlier empirical work on the money supply process primarily focused on the analysis of variations in the endogenous part of the monetary base and subsequent variations in the exogenous part of the base in order to offset involuntary changes in the money supply.[2] However, more recent studies focus on money multiplier models, particularly their forecasting properties, as a basis for controlling the money supply process.[3] The primary econometric tools in this context are ARIMA X and SARIMA models (Autoregressive Integrated Moving Average with eXogenous variables – and Seasonal Autoregressive Integrated Moving Average Models). Both approaches are presented and contrasted in the following section.

Starting point for our investigation of endogenous and exogenous components of the monetary base is the following reaction function of the Bundesbank

$$\Delta B^a_t = \upsilon_1 + \upsilon_2 \Delta (B^{Source}_t - B^a_t) + \varsigma_t \quad (2\text{-}5)$$

ΔB^a ... *Variation of the Adjusted Monetay Base (exogenous part of the Monetary Base)*

$\Delta (B^{Source} - B^a)$...*Variation of the endogenous part of the Monetary Base*

ς ... *Residual*

[1] The following definitons are based on three main sources: cf. Moritz (1996), p.20-27, Issing (1993), p. 62 and Büttler et al. (1979).

[2] Cf. Volbert/Loef (1974), p. 508-542

[3] Cf. Johannes/Rasche (1979 and 1981), Hafer/Hein (1984), von Hagen (1993), Krämer (1994), Zaki (1995)

Regression (2-5) investigates if the Bundesbank responded to variations in the endogenous part of the monetary base with countermeasures in the exogenous part of the base. It follows that in such a case one expects ν_2 to be negative.

Analogously to a recent study by Zaki 1995[4], we distinguish between the money multiplier of the source base and the multiplier of the adjusted monetary base. While the first type of multipliers will be labelled m1 (for the narrow aggregate M1) and m3 (for the broad aggregate M3), the latter will be assigned the notation m1a and m3a respectively. Combining the money multiplier and the monetary base provides the monetary aggregate:[5]

$$M?_t = m?_t \; B^{Source}{}_t = m?a_t \; B^a{}_t \qquad (2\text{-}6)$$

M? ... Monetary Aggregate M1 or M3

m? ... (Common) Money Multiplier

m?a ...Adjusted Money Multiplier

B^{Source} *... Source Base*

B^a *... Adjusted Monetary Base*

According to the assumption that the multiplier contains all components which are not fully or directly controllable by the monetary authorities, m1a and m3a reflect the relevant multiplier in the very short run. If one uses the more general multipliers m1 and m3 in order to evaluate the forecast performance of a monetary aggregate, the formerly presented "neutralisation coefficient" υ_2 should reach the value of –1. If that is not the case, i.e. $0>\upsilon_2>-1$, it means that variations in the endogenous part of the base are not fully offset by variations in the exogenous part of the base. Then the performance results will overestimate the central bank's ability to control the money supply. This is due to the fact that – in the very short run – variations in the monetary base triggered by changes in the commercial bank's behaviour are considered as monetary policy measures.

The Bundesbank's main operational instrument variable is the overnight rate.[6] Therefore a possible long-run relationship between the overnight rate and the money multipliers m1, m1a, m3 and m3a is examined using an OLS-Regression. Since the Bundesbank primarily controls

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[4] Cf. Zaki (1995). Zaki investigates the controllability of money supply through the multiplier-monetary base framework in Egypt, but the methodology is fully compatible with an investigation in Germany.

[5] The question mark „?" represents the different monetary aggregates, i.e. M1, M3 and m1, m3 respectively.

[6] The Bundesbank controls the overnight rate between the lombard rate (upper band) and the discount rate (lower band) (cf. Deutsche Bundesbank (1994), p.62f.).

the money market since spring 1980 by adjusting the amount of repo transactions (Wertpapierpensionsgeschäfte) we introduced a dummy variable which takes the value of 1 from Q2 1980 onwards, 0 otherwise. Stationarity tests for the residuals will be conducted by using the ADF test or, if the ADF test result provides marginal results, by using the Phillips-Perron-Test (PP).

The forecast performance of German money multipliers is evaluated in the framework of an aggregate approach. Here the money multiplier is estimated as a whole, compared to the alternative component approach, where separate estimates for each individual component, e.g. the ratio of demand deposits, time deposits and savings deposits are estimated.[7] Again, the order of integration of the variables needs to be determined first, since we require stationarity of the data. If the partial autocorrelation function as well as the autocorrelation function show high order of seasonality, e.g. due to monthly or quarterly figures, seasonal differences are calculated additionally. Assuming non-stationarity of the variables in levels and stationarity of first differences of the money multiplier we get the following basic ARIMA X SARIMA model:[8]

$$\Delta m?_t = \phi_0 + \sum_{i=1}^{p} \phi_i \Delta m?_{t-i} + \sum_{i=0}^{q} \theta_i \varsigma_{t-i} + \sum_{\substack{i=1 \\ s=2}}^{p} \Phi_i \Delta m?_{t-s} + \sum_{\substack{i=0 \\ s=2}}^{q} \Theta_i \varsigma_{t-s} \qquad (2\text{-}7)$$

$\Delta m?$ *... First Difference of the dependent variable, i.e.* Δ *m1,* Δ *m1a,* Δ *m3,* Δ *m3a*

ϕ_0 *... Constant*

$\sum_{i=1}^{p} \phi_i \Delta m?_{t-i}$ *... AR component with maximum lag (p), AR(p)*

$\sum_{i=0}^{q} \theta_i \varsigma_{t-1}$ *... MA component with maximum lag (q), MA (q)*

$\sum_{\substack{i=1 \\ s=2}}^{p} \Phi_i \Delta m?_{t-s}$ *... Seasonal AR component with maximum lag (p), SAR (p)*

$\sum_{\substack{i=0 \\ s=2}}^{q} \Theta_i \varsigma_{t-s}$ *... Seasonal MA component with maximum lag (q), SMA (q)*

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7 Zaki (1995) and Hafer/Hein (1984) compare the forecast performance of both approaches. Von Hagen (1993) estimates both approaches, but the forecast errors rely on the aggregate approach. None of the comparable studies confirmed the superiority of the component approach. In order to make our results comparable with von Hagens, we therefore chose the aggregate approach.

In addition to (seasonal) AR components and (seasonal) MA components one can include further explanatory variables in order to improve the forecasting quality of the model. Since the Bundesbank's main operating variable under its monetary targeting regime was the overnight rate,[9] we included in a first approach the overnight rate and lagged values of the overnight rate as transfer input.[10] Together with the ARIMA X SARIMA terms we get the following ARIMA-transfer model:[11]

$$\Delta m?_t = ARIMA \quad X \quad SARIMA + \sum_{i=0}^{3} \chi_{1i} \Delta O/N_{t-i} \qquad (2\text{-}8)$$

Δ *overnight... First difference of the overnight rate*

In the following we compare the results of the transfer model with the proposed model combining ARIMA and cointegration methodology. In addition to the overnight rate and lagged values of the overnight rate we consider the lagged error correction term of the static long-run relationship between the money multiplier and the overnight rate (instrument variable) as explanatory variable in our approach.[12] The error correction term can be determined by calculating the following regression:

$$m?_t = \kappa_1 + \kappa_2 O/N_t + \kappa_3 DUM1 + \kappa_4 DUM2 + ECT_t \qquad (2\text{-}9)$$

m? ... Money Multiplier m1, m1a, m3, m3a
OVERNIGHT... Overnight Rate
DUM1 ... Dummy German Unification
DUM2 ... Dummy Introduction of Repo Transactions
ECT ... Residual

The basic idea of including the lagged error correction term of the long-run relationship in the forecasting equation is to use as much information for the next quarterly forecast of the

[8] ARIMA X SARIMA models cf. Box/Jenkins (1976), Johnston/DiNardo (1997), p. 204-243 and Enders (1995)
[9] Cf. Müller/Worms (1995), p. 1f., Krämer (1994), p. 6f.
[10] Cf. Von Hagen (1993), p. 815
[11] Lag structures larger than 3 turned out to be not significant.
[12] Contrarily to Läufer, who refers to cointegration theory in order to explain a new macroecnomic hypothesis of German money supply, we use cointegration theory as input in a forecasting model (cf. Läufer (1988), p. 143-173).

money multiplier as is available: The ARIMA X SARIMA term provides all information contained within the time series “money multiplier” itself (AR and MA components). The current and lagged variations of the operational overnight rate provide information about the short-run dynamic reaction of the multiplier on monetary policy measures or market forces. The lagged error correction term finally considers necessary information of the static long-run relationship between the short term interest rates and the multiplier. All together we get the following second forecasting model:

$$\Delta m?_t = ARIMA \quad X \quad SARIMA + \sum_{i=0}^{3} \chi_{1i} \Delta O/N_{t-i} + \chi_2 ECT_{t-1} \qquad \textit{(2-10)}$$

ECT_{t-1} ... Lagged Residual (Error Correction Term) of the long-run relationship

In order to identify the most adequate lag structure of the forecasting model for the German money multiplier we use the Akaike Information Criteria as well as the Ljung-Box statistic. As selection criteria for the quality of our forecasts we referred to the (relative) Root Mean Squared Error.

Since the forecasting performance of our model is primarily dependent upon the difference between the actual and forecasted values of the multiplier we continue with One-step-forward forecasting tests for the last seven quarterly values of the observation period (Q3 1996 – Q1 1998). This procedure will be applied to all our forecast models. Basically we made ex-ante forecasts, i.e. coefficients of each model have been estimated including Q2 1996. Subsequently a forecast has been made without changing the structure of the model. After each quarterly forecast we just updated the model in order to proceed with the next quarterly forecast. As far as the ARIMA-cointegration model is concerned this procedure implies that we used the latest available residual of our static regression (which ended in Q2 1996) as (lagged) error correction term for the Q3 1996 forecast. For the Q4 1996 forecast we used the (now available) Q3 1996 residual as additional explanatory variable and so on. Since the overnight rate is an instrument variable (it can be set by the Bundesbank) one can add the respective current values of the overnight rate for the current forecast, i.e. the Q3 1996 overnight rate for the Q3 1996 forecast.

3 Empirical results

The data set has been taken from the Bundesbank CD-ROM "Monetary Statistics 1948-1997". Money supply figures are used in quarterly frequency and have been seasonally adjusted with the additive Census X-11 method. Regression results are presented for the whole observation period from Q1 1974 – Q1 1998 as well as for subperiods before and after the unification, i.e. subperiod I (Q1 1974 – Q1 1989) and subperiod II (Q1 1991 – Q1 1998). The reason for the partition is that the split into 2 separate subsamples eliminates the distortionary period around German unification and thus gives a clearer picture of the controllability of money supply especially after 1991. Also, this split is sensible with regard to financial innovations, which were more widespread in the 1990s than between 1974 and 1989. Thus the second subsample is appropriate to capture the effects of the latter on recent German money supply dynamics.

In order to determine the order of integration of the explanatory and response variables in our regression on endogenous and exogenous components of the source base we used the Augmented Dickey Fuller (ADF) test. Table 3-1 shows that the first differences of all variables turn out to be stationary.

Table 3-1: Stationarity tests of the endogenous and exogenous parts of the source base[13]

	Q1 1974 – Q1 1998	Q1 1974 – Q1 1989	Q1 1991 – Q1 1998
Δ B^a-c	-5.8504	-3.7189	-1.9217
Δ B^a-c-t	-5.2375	-3.1372	-1.3438
Δ (B^{Source} –B^a)-c	-5.8344	-3.3626	-1.9822
Δ (B^{Source} –B^a)-c-t	-5.2321	-2.8971	-1.2711

Regression results based on equation 2-5 are presented in table 3-2. The OLS regression confirms the expected significant relationship between the exogenous variation in the source base ΔB^a and variations in the endogenous component $\Delta(B^{Source}-B^a)$. The p-values of the F-statistic[14] are below 0.001. The t-statistics of the endogenous component are significant and have the expected sign. Over the whole observation period the Bundesbank responded to

[13] Test results for the stationarity test are the difference between the ADF test value and McKinnon's critical value for rejection of a unit root a the 10% level with lag 1. If the derived test statistic shows a negative sign, we conclude stationarity. „c" and „c-t" mean test for a unit root with constant and time trend. The test statistic for the Phillips-Perron test is derived similarly.

[14] Newey-West HAC standard errors are used throughout this paper

variations in the endogenous part of the base to more than 75% with variations in the exogenous component. However, "neutralisation" figures were significantly higher before the German unification than afterwards (86.17% vs. 80.48%).

Table 3-2: Results of the static regression – money supply[15]

Dependant Variable Δ B^a			
	Q1 1974 – Q1 1998	Q1 1974 – Q1 1989	Q1 1991 – Q1 1998
F-statistic	173.5565	142.7246	55.5337
DW	2.3665	2.7539	2.2378
R^2 adj.	0.6449	0.7061	0.6607
Constant	1.5743	1.2777	2.1807
	(2.9251*)	(2.8123*)	(1.5034)
Δ (B^{Source} –B^a)	-0.7579	-0.8617	-0.8048
	(-7.3840*)	(-12.3984*)	(-6.2406*)
ADF-c	-5.3505	-4.0359	-1.5207
ADF-c-t	-4.7748	-3.4837	-1.0872

In preparation for the ARIMA-cointegration model we tested the common and adjusted multipliers and the overnight rate for stationarity. Table 3-3 shows that all variables are I(1). Since the stationarity condition has to be met for the initial sample from Q1 1974 – Q1 1996 through the latest sample (Q1 1974 – Q1 1998), we present the test results for both periods.

Table 3-3: Stationarity tests – multipliers and overnight rate[16]

	Q1 1974 – Q1 1996		Q1 1974 – Q1 1998	
	m?	**m?a**	**m?**	**m?a**
m1?-c	2.8012	1.1098	3.3266	1.3566
m1?-c-t	1.6353	0.4521	2.4305	0.2713
Δ m1?-c	-4.9895	-3.3127	-5.5225	-3.5695
Δ m1?-c-t	-4.4457	-2.7093	-5.0620	-2.9748
m3?-c	1.4891	1.0764	1.8416	1.2050
m3?-c-t	0.5674	0.6079	0.7003	0.4256
Δ m3?-c	-5.9769	-3.4579	-6.4745	-3.7289
Δ m3?-c-t	-5.3466	-2.8572	-5.8585	-3.1274
	Q1 1974 – Q1 1996		**Q1 1974 – Q1 1998**	
overnight-c	1.0548		1.0269	
overnight-c-t	1.6393		1.5806	
Δ overnight-c	-1.6364		-1.8237	
Δ overnight-c-t	-1.0356		-1.2302	

[15] For explanation cf. table 3-1
[16] For explanation cf. table 3-1.

The results of the static regression specified according to equation 2-9 are shown in table 3-4. The OLS regression confirms the cointegration relationship for the common money multiplier m3 and the overnight rate. The two dummy variables take into account the effect of German unification as well as the introduction of the repo transactions in Q2 1980. DUM 1 and DUM 2 take the value of 1 from Q2 1990 and Q2 1980 respectively and 0 before. The ADF tests rejects the existence of a unit root. The coefficients are significant, the p-value of the F-statistic is smaller than 0.001.

Table 3-4: Results of the static regression – multipliers[17]

Q1 1974-Q2 1996	m1	m3	m1a	m3a
F-statistic	168.5570	179.8408	50.3418	45.5265
DW	0.6450	1.0952	0.2949	0.3050
R^2 adj.	0.8496	0.8577	0.6245	0.6001
Constant	1.9746	5.4055	1.5381	4.0873
	(41.6854*)	(51.5252*)	(1.6419)	(1.5440)
Overnight rate	-0.0450	-0.0934	0.0810	0.2786
	(-5.5430*)	(-5.699*)	(0.4753)	(0.5786)
DUM1	0.4094	0.4668	4.887	11.6456
	(7.3786*)	(4.4763*)	(4.0707*)	(3.5263*)
DUM2	0.3120	1.1297	2.9834	9.0078
	(8.2085*)	(13.2805*)	(5.1900*)	(5.6661*)
ADF-c	-0.7396	-2.1014	0.0600	0.0574
ADF-c-t	-0.2397	-1.5721	0.6550	0.6617
PP-c			-0.0729	-0.0985
PP-c-t			0.5236	0.5082
LM(1)		0.1796		
LM(4)		0.3259		

For the alternative money multipliers m1a and m3a no cointegration relationship can be found by applying either the ADF or the Phillips-Perron test to reject the non-stationarity of the residuals. As far as m1 is concerned a significant cointegration relationship between m1 and the explanatory variables (overnight rate, DUM1, DUM2) seems to exist for the first subsample Q1 1974 – Q2 1996. However the extension of the sample period until Q1 1998 prompts non stationary residuals for the m1 equation. Therefore we estimate the suggested combined ARIMA-cointegration model solely for the m3 multiplier.

[17] For explanation cf. table 3-1. The F statistic and the adjusted R^2 measure the overall fit of the regression; DW = Durbin Watson statistic, where the Newey-West option provides BLUE estimators under the presence of autokorrelation and heteroskedasticity. LM=Lagrange Multiplier test on serial correlation in the residuals. „*“ and „**“ represent significance at the 5%-level and the 10%-level respectively.

Following similar studies on the controllability of money supply we specify a corresponding forecasting model for each of the four money multipliers m1, m1a, m3 and m3a. The stationarity tests for the multipliers revealed that they are all integrated of order 1, therefore the models are specified in first differences.

According to equations 2-7 and 2-8 the following ARIMA-transfer models provides the best fit for the individual money multipliers (Table 3-5). The two alternative models for the cointegrated multiplier m3, are denoted by the ARIMA-transfer model "m3-I" (cf table 5) and the combined ARIMA-cointegration model "m3-II".

Table 3-5: Specification of the ARIMA transfer model - multipliers[18]

Q1 1974 – Q2 1996	m1	m3-I	m1a	m3a
F-statistic	16.0279	10.8584	2.2711	2.2566
Akaike Info	-2.6162	-0.4629	3.1337	5.1727
Constant	0.0114	0.0251	0.0978	0.2442
Δ overnight rate			0.1086	0.3524
Δ overnight rate (-1)	-0.0321	-0.0469		
MA(1)	-0.7215	-0.5390	0.1855	
MA(8)	-0.4365			0.2503
MA(5)	-0.3344			
SMA(2)		0.1596		
SMA(6)		0.3793		
SMA(8)		-0.4102	0.2714	
Q 12	0.2180	0.6980	0.7160	0.5710
Q 24	0.4830	0.7170	0.9190	0.8940

The lag structure of the ARIMA model, following the inspection of the ACF and the PACF, suggests that solely moving average terms and lagged values of the instrument variable (overnight rate) are significant and improve the fit of the model.[19] These findings confirm earlier work of von Hagen who detected similar significance of ARMA terms and the instrument variable for the multiplier model up to 1991.[20]

Table 3-6 displays the results for the multiplier model m3-II, where the lagged error correction term is included as additional explanatory variable, since m3 is cointegrated with the overnight rate (equation 2-10):

[18] The Akaike-Criteria is used to identify the lag structure. The Ljung-Box statistic (Q) tests serial correlation in the residuals at lag 12 and lag 24. Figures are probabilities for rejection of the Null.

[19] Detailed t-statistics are available upon request.

[20] Cf. Von Hagen (1993), p. 816

Table 3-6: Specification of the ARIMA cointegration model for m3

Q1 1974-Q2 1996		m3-II	
F-statistic	11.1731	**Constant**	0.0317
Akaike Info	-0.5351	**ECT m3(-1)**	-0.5997
Q 12	0.7590	**Δ overnight-rate (-1)**	-0.0445
Q 24	0.9430	**MA(5)**	-0.2443
		MA(6)	0.3411
		MA(15)	0.4972
		SMA(8)	-0.2086

Table 3-5 and table 3-6 show that the ARIMA-transfer model and the ARIMA-cointegration model have similar lag structures and regression results. The F-statistic and the Akaike Information criteria are slightly higher for the combined model. The comparison of the forecast performance of both models (cf. table 3-7) provides further evidence:

Table 3-7: Forecast evaluation

Q3 1996 – Q1 1998	m1	m3-I	m3-II	m1a	m3a
RMSE	0.0879	0.1340	0.0856	0.2997	0.8786
Relative RMSE	0.0302	0.0187	0.0120	0.0280	0.0333
MAE	0.0681	0.1117	0.0629	0.2399	0.7765
MAPE	2.29%	1.55%	0.87%	2.27%	2.92%
Theil‘s U	0.0153	0.0094	0.0060	0.0141	0.0168
- Bias proportion	59%	7%	3%	53%	40%
- Variance	29%	75%	14%	0%	0%
- Covariance	12%	18%	83%	47%	60%

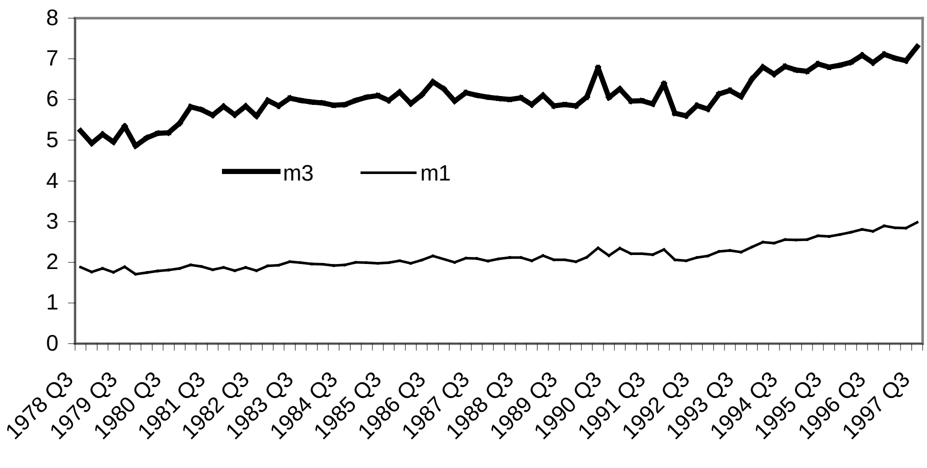
A useful measure for evaluating the forecast quality of a money multiplier model is the relative RMSE which provides information on the ability of the central bank to minimise deviations of the forecast values from the actual values. A band of □2 · relative RMSE represents a 95% confidence interval around the growth rate of the money multiplier.[21] Since the Bundesbank’s yearly monetary target corridor in recent years has been 3%, the whole forecast error should remain within this bound in order to provide sufficiently precise data for targeting the development of the monetary aggregate. While von Hagen found average quarterly forecast errors of 1.8% (m1) and 1.6% (m3),[22] the above errors are considerably higher. Only the ARIMA-cointegration model still provides results where the forecast error

[21] Cf. Johannes/Rasche (1981), p. 305 and Poole (1976), p. 247-259
[22] Cf. Von Hagen (1993), p. 816 and 825

for m3 (2.4%) remains within the 3% target corridor.[23] Thus adding the cointegration term proves necessary as well as sufficient (in this example) with regard to the standard ARIMA-transfer model. Given the importance of accurate forecast data for the money multiplier especially in a volatile economic environment, the improvement by 1.34 percentage points of the latter model allows the central bank a more precise control of the money supply. Since both, the bias proportion and the variance proportion for m3-II are substantially lower than for m3-I, the combined model is not only more precise than the ARIMA transfer model but it is also more robust. More than 80% of the error in m3-II are due to "normal" fluctuations in the multiplier rather than to the misspecification of the model, while for m3-I the corresponding figure is 18%. Hence, the ARIMA-cointegration model can be considered allround as an improved approach to forecast the money multiplier.

Independently from the model choice, however, the forecast errors for the multipliers increased since the beginning of the 1990s. An inspection of the development of m1 and m3 multipliers (chart 1) reveals, that variations in the "common" multiplier m3 did not diminish at all after the German unification.

Chart 1: German Money Multipliers

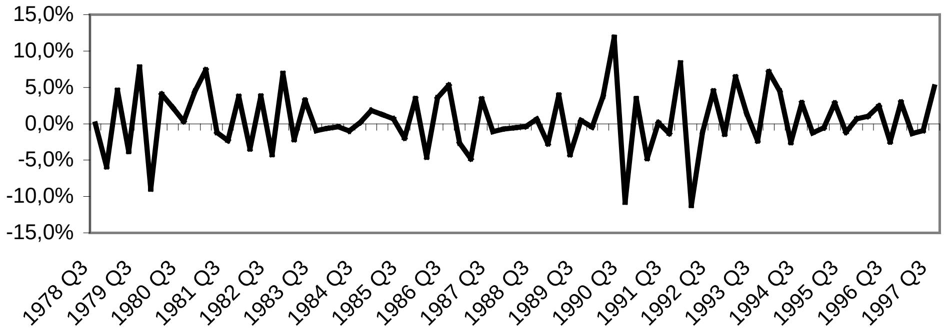


Source: Deutsche Bundesbank, Monetary Statistics, Own Calculations

Especially the common m3 multiplier reveals substantial variations after 1991 (chart 2), even if the variance in the m3 multiplier decreased slightly during the period Q1 1974-Q1 1990 compared to period Q4 1991-Q3 1997 from 0.18% to 0.17%

[23] Total forecast error: 2*1.2%=2.4%

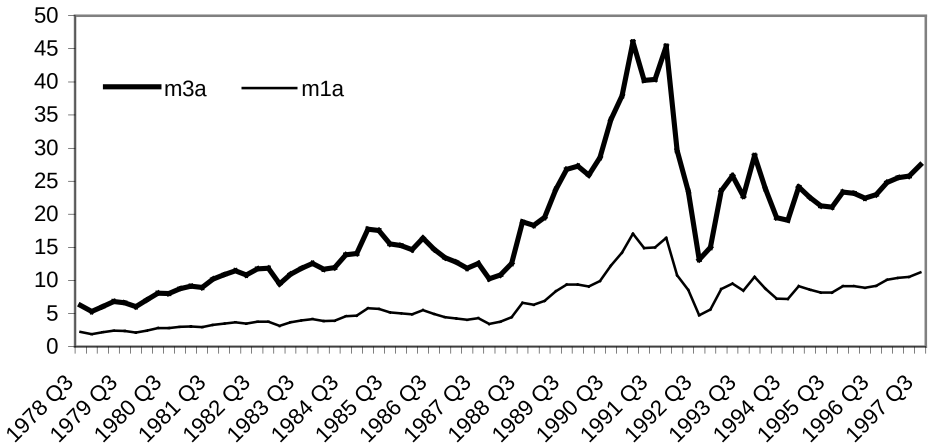
Chart 2: Changes in the money multiplier m3



Source: Deutsche Bundesbank, Monetary Statistics; Own calculations

The development of the adjusted multipliers (chart 3) which provides a better picture of the short term aspects of the monetary policy environment, suggests that controlling the money supply had become substantially more difficult during the period of German unification and in the course of the ERM crisis in 1992/93. The results of the first regressions showed that after 1991 only 80% of the variations in the exogenous part of the source base have been compensated by variations in the endogenous part of the source base. Hence the controllability of German money supply during the period 1990-1995 remains questionable. Interestingly, some of the recent and most significant deviations from actual developments of the monetary aggregates from the Bundesbank's target values coincide with this period of serious disturbances in the money supply process.

Chart 3: German Adjusted Money Multipliers



Source: Deutsche Bundesbank, Monetary Statistics, Own Calculations

4 Modelling financial innovation

The difficulties in controlling German money supply may be due to exogenous shocks like the German unification, the de facto breakdown of the ERM and/or the increasing use of financial innovations in Germany. We present a simple regression approach to take into account the effects of financial innovation on the supply side. The possibility of tracking the development of financial innovation with a linear deterministic trend has been presented by Arrau et al. in 1991.[24] They applied this technique to the demand side of the money market and presented a deterministic as well as a stochastic measure for the dissemination of financial innovation. We disregard the latter in the context of this paper since we assume a deterministic trend to be appropriate for tracking the dissemination process of financial innovations in Germany due to the early step-by-step deregulation of financial markets.

$$m?_t = \kappa_1 + \kappa_2 O/N_t + \kappa_3 DUM2 + \kappa_4 FI_t + \varsigma_t \qquad (4\text{-}1)$$

m? ... Money multiplier m1, m1a, m3, m3a

overnight-Rate ... overnight rate

DUM2 ... Dummy introduction of repo transactions

FI ... Trend variable for FI (monotone, linear increasing)

ς *... Residual*

Since the dummy variable for the German unification turned out to be not significant for the model, we just include a dummy variable for the introduction of repo transactions (DUM 2). A priori we expect the FI variable to have a positive sign, reflecting the increasing influence of financial innovations on the endogeneity of the money supply process, i.e. an increasing money multiplier. Stationarity tests of the variables in the model were presented in table 3-3; the deterministic linear increasing FI variable is necessarily integrated of order 1. The results of the regresssion are displayed in table 4-1.

[24] Cf. Arrau et al. (1991)

Table 4-1: Results – Static regression with financial innovations[25]

Q1 1974 – Q1 1998	m1	m3	m1a	m3a
F-statistic	385.9566	293.3482	90.0679	113.5061
DW	0.4750	0.6983	0.3518	0.3332
R^2 adj.	0.8891	0.8590	0.7357	0.7009
Constant	1.7171	4.9703	-2.0482	-4.3205
	(28.8349*)	(29.3763*)	(-1.5159)	(-1.2111)
Overnight rate	-0.0313	-0.0418	0.3977	0.9530
	(-3.1279*)	(-1.6057)	(1.9514**)	(1.8657**)
DUM2			-2.0032	
			(-2.1526*)	
FI	0.0114	0.0232	0.1419	0.2991
	(14.6523*)	(16.1136*)	(6.8868*)	(9.2071*)
ADF-c	1.0588	-0.3217	-1.0759	-0.7464
ADF-c-t	1.7094	0.2626	-0.4834	-0.1565
PP-c	-0.0693			
PP-c-t	0.5618	-1.0443		

The results confirm the expected relationship between the multiplier, the interest rate and the FI variable. The F-statistics for m3, m3a, m1 and m1a are considerably higher than for the model without the FI variable, which is significant for all multipliers and shows the expected positive sign in all regressions. The ADF and Phillips-Perron statistics reveal that by considering the FI variable in the regressions for m1a and m3a one now finds a significant rejection of the non-stationarity of the residuals, indicating a cointegration relationship. Hence, the inclusion of the FI variable provides useful information for the evolution of German money supply. However, the same variable is of no discernible use in the forecasting model, since the forecast errors remain virtually the same (not reported). Given that the influence of financial innovations on the money supply should have long term character, this finding should not be too surprising, either.

5 Conclusion

The static regression results as well as the forecast models for the money multiplier suggest that the controllability of money supply deteriorated significantly during the last third of the observation period 1974 - 1998. From 1992 to 1998 the Bundesbank met only 3 out of its 7 monetary targets. The static long-run relationship between the target money multiplier m3 and

[25] For explanation cf. table 3-1. Results for the regression without FI variable for the period Q1 1974-Q1 1998 are shown in the appendix.

the Bundesbank's main operating instrument variable - the overnight rate - seems to be confirmed. However the increasing money multiplier reflects the rising importance of influences on the German money supply which are not fully controllable by the Bundesbank. In this context the deterministic FI variable is shown to have significant explanatory power. The forecast errors for the period 1996 - 1998 seem high compared to earlier studies which ended shortly after the German unification. This is related to a misspecification of the ARIMA-Transfer model, which can be remedied by adding a cointegration term. The resulting lower forecast errors are sufficient to the extent that all of the Bundesbank's announced monetary targets would have been met (disregarding external factors such as the ERM crisis which can cause a deliberate deviation from the target corridor). Hence, although controlling the money supply may have become more difficult in recent years and the influence of financial innovations is steadily increasing the Bundesbank should still be in a position to guarantee price stability after the German unification.

Appendix

Results of the static regression – money supply

Q1 1974-Q1 1998	m1	m3	m1a	m3a
F-statistic	194.0078	212.3051	65.0900	55.9577
DW	0.4759	0.9447	0.2948	0.3056
R^2 adj.	0.8578	0.8685	0.6670	0.6320
Constant	2.0406	5.4895	1.7232	4.1992
	(32.4866*)	(45.9554*)	(1.8306**)	(1.5790)
Overnight rate	-0.0570	-0.1086	0.0473	0.2582
	(-5.2245*)	(-5.6891*)	(0.2772)	(0.5346)
DUM1	0.4856	0.5648	5.1061	11.7934
	(7.5408*)	(5.4085*)	(4.8724*)	(4.1564*)
DUM2	0.3238	1.1447	3.0163	9.0277
	(7.5157*)	(12.5938*)	(5.2131*)	(5.6168*)
ADF-c	-0.0387	-1.7477	0.0076	-0.0652
ADF-c-t	0.4480	-1.2315	0.5506	0.4936
PP-c			-0.1166	
PP-c-t	0.1049		0.4253	0.3480

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