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The link between interest rates on interbank money and for credit lines: are asymmetric interest rate adjustments empirically evident?

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**The Link Between Interest Rates on
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ABSTRACT

The Link Between Interest Rates on Interbank Money and for Credit Lines: Are Asymmetric Interest Rate Adjustments Empirically Evident?

by Petra Korndörfer*

The paper investigates the behaviour of banks with regard to the pricing of commercial short term loans over the period from 1975 until 1997. Due to the inclusion of interest rate quotes by banks located in east Germany in 1991 we distinguished between the subperiods from 1975 – 1989 and 1991 – 1997. In the context of the price setting for credit lines we focus on the commonly held belief of asymmetric interest rate adjustments. In order to raise the markup on credit lines banks adjust rates on credit lines slower when refinance rates are decreasing. Estimating error correction models a long-term relation between the rate for interbank money and for credit lines is established. In order to test for asymmetric interest rate adjustments non-symmetric error correction models as well as error correction models with asymmetric short-term dynamics are estimated. The hypothesis of asymmetric interest rate adjustments is confirmed largely by the estimation results of the latter specification while in the former specification no asymmetry is found.

ZUSAMMENFASSUNG

Der Zusammenhang zwischen den Geldmarkt- und Kontokorrentzinsen: Sind asymmetrische Zinsanpassungen empirisch nachweisbar?

In diesem Beitrag wird das Preissetzungsverhalten von Banken bezüglich kurzfristiger Unternehmenskredite untersucht. Der Untersuchungszeitraum beginnt 1975 und endet 1997. Aufgrund der Berücksichtigung von Banken aus den neuen Bundesländern ab 1991 werden zwei Teilperioden (1975 – 1989 und 1991 – 1997) unterschieden. Kernpunkt der Untersuchung ist die Überprüfung der weitverbreiteten Annahme asymmetrischer Zinsanpassungen. Die Asymmetriehypothese beruht auf der Annahme, daß Banken um ihre Zinsmargen zu erhöhen, während Zinssenkungsphasen die Kreditzinsen langsamer an Veränderungen der Refinanzierungssätze anpassen als sonst. Durch das Schätzen von Fehlerkorrekturmodellen werden langfristige Beziehungen zwischen Geldmarkt- und Kontokorrentzinsen hergestellt. Um die Annahme asymmetrischer Zinsanpassungen zu untersuchen werden nicht-symmetrische Fehlerkorrekturmodelle und Fehlerkorrekturmodelle mit Asymmetrie in der kurzfristigen Dynamik geschätzt. Die Ergebnisse letzterer Schätzung stützen im allgemeinen die Asymmetriehypothese, während in der ersten Spezifikation keine Asymmetrie nachweisbar ist.

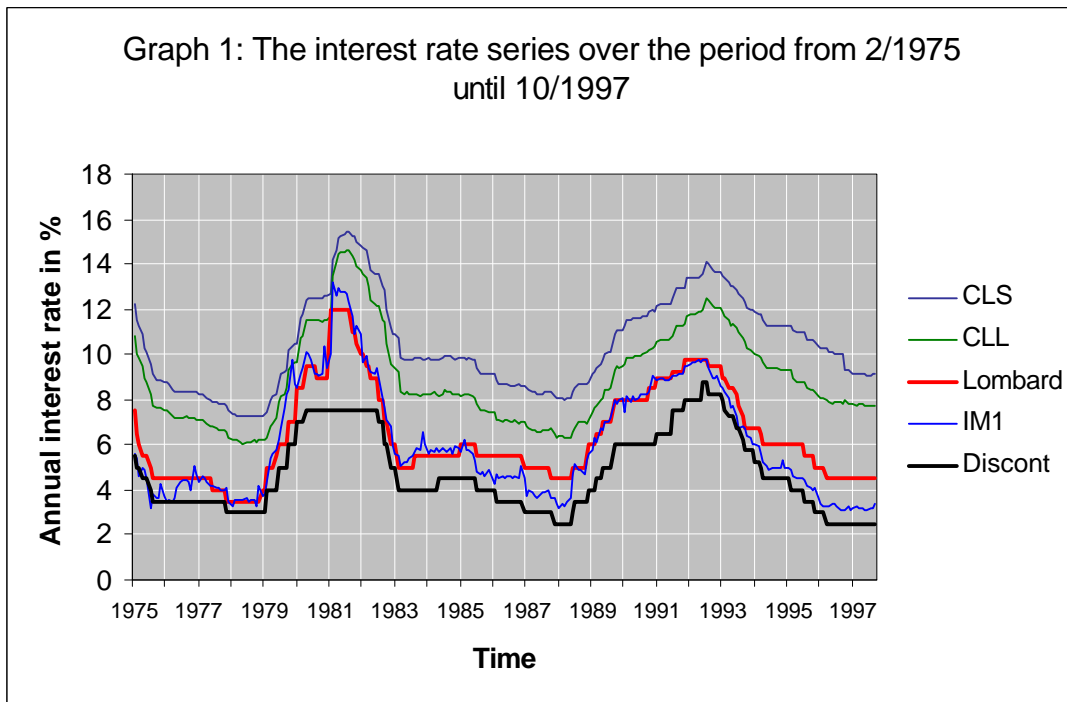
* The paper has benefited from suggestions by Jürgen Wolters. I am indebted to Uwe Hassler for comments on an earlier draft of the paper. The author is responsible for any errors that remain.

1. Introduction

During the period of 1992 to 1997 Germany experienced a strong decrease in interest rates. The key interest rates which are fixed by the Bundesbank, the lombard and discount rate, came down from their all time high¹ in July 1992, with 9.75% and 8.75%, respectively, to rates of 4.5% and 2.5% in April 1996. The key interest rates only once before in the Bundesbank history, in 1987, have been fixed by the Bundesbank on such low levels. As a consequence the interbank money (IM) market rates dropped. For example, the rate for interbank money traded with a one month maturity decreased to 3.06% in October 1996, the lowest rate within the last 22 years. During the following months the rate only increased marginally. Focusing now on short-term loans to corporate customers, we found that in October 1996 the average interest rates on credit lines (CLs) went down from its previous peak of 12.46% in August 1992 to 7.84% for large loan volumes (loans in the range of one to five million DM) and from 14.08% to 10.05% for small loan volumes (loans accounting for less than one million DM), only. As we can observe in graph 1 the differences in the magnitude of decline lead to an increase of the spread between the rates on credit lines and interbank money.

Varying interest rates enable us to investigate the price setting behaviour of banks. In this context, we focus on the commonly held belief that interest rates charged (in the case of loans) and paid (in the case of savings) are adjusted asymmetrically to IM rate variations. In other words, interest rates to customers are adjusted such that banks realize additional profits. Before empirically estimating the link between IM rates and rates on CLs we specify each type of market. Then we define the hypothesis we investigate in the empirical part. In section 4 the data used for this analysis is presented. Section 5 contains the empirical analysis. Here, we first give a short introduction into testing for nonstationarity and on the

¹ The regular lombard rate never went above 9.50 %. But during the interest rate peak from 2/1981 until 5/1982 the Bundesbank decided not to provide the banking sector with regular lombard loans at all. A special lombard loan was introduced at a rate of 12%.



concept of cointegration. We also test for a structural break in the 1990s. The main hypothesis of asymmetric interest rate adjustments is then tested in a cointegration framework.

2. The association of key interest rates, interbank money rates, and rates on customer business.

With the *key interest (KI) rates* the Bundesbank implements its policy decisions with regard to the money supply. The KI rates aim at the liquidity condition in the money market. There are three main instruments used by the Bundesbank to provide the banking sector with money. *Discont and lombard lending* are the traditional instruments. However, the share of discont loans in the refinance structure of banks with respect to central bank loans decreased from 83.5% in 1980 to 29.5% in 1994. The share of lombard loans decreased during the same period from 10.5% to 0.8%.² Both types of Bundesbank loans decreased in favour of a certain type of open market operations which is called

² Deutsche Bundesbank, Die Geldpolitik der Bundesbank, Frankfurt 1995, p. 109

*Wertpapierpensionsgeschäfte*³ and now often referred to as the third KI rate. The main switch to the more flexible money market control system as given by open market operations took place in 1985. Still, measuring changes in Bundesbank policy we only refer to changes in the traditional key interest rates which give the price banks have to pay to the Bundesbank for borrowing through the discount or lombard window. The reason for only referring to these KI rates is that the Bundesbank assigns them a signal function with regard to the money market: The traditional KI rates provide longer run landmarks as compared to *Wertpapierpensionsgeschäfte*.⁴ The latter have the main feature that changes in the money market conditions implied by them may not be interpreted as a fundamental change in the Bundesbank's assessment of the development of the monetary condition. Therefore, *Wertpapierpensionsgeschäfte* enable the Bundesbank to guide the money market rates „silently“.⁵ The traditional KI rates, on the contrary, are believed as not being changed as long as the Bundesbank regards increasing money market rates as temporary liquidity frictions which can be resolved by using flexible open market operations. Therefore, if the Bundesbank announces an increase in either of both key interest rates after several previous announcements of decreasing key interest rates we may conclude that the Bundesbank believes that the observed changes in the monetary situation are permanent and have to be responded to.

In order to always comply to an unexpected outflow of money a bank can either borrow money from the Bundesbank or from other banks through the *interbank money market*. At the IM market the horizontal liquidity adjustment within the banking system is carried out.⁶ The existence of this market⁷ is due to the fact that for banks in and out flows of money are

³ *Wertpapierpensionsgeschäfte* are the mostly used open market operations of the Bundesbank: By selling and simultaneously agreeing on terms for rebuying securities Banks receive loans from the Bundesbank. Only collaterals which meet certain conditions which are defined by the Bundesbank will be accepted as an underlying.

⁴ Deutsche Bundesbank, *Die Geldpolitik der Bundesbank*, Frankfurt 1995, p. 99 and p.105

⁵ Deutsche Bundesbank, *Die Geldpolitik der Bundesbank*, Frankfurt 1995, p. 99 and p. 115

⁶ Deutsche Bundesbank: *Die Geldpolitik der Bundesbank*, Frankfurt, 1995, p.46 f.

⁷ Actually, the money market is not a market where all communication and trades take place centrally through an auctioneer as in the Walrasian model. But it is characterized

uncertain. Therefore, banks always have to maintain a certain liquidity position to meet the needs of their customers and the liquidity requirements of the authority in charge which in the case of German banks is the Bundesbank. It is the task of the liquidity management of a bank to partition the banks liquid funds into return bearing assets and cash. In order to minimize liquidity costs, the liquidity management invests as much of its liquid funds in assets of high quality and liquidity, like interbank assets, as possible. In general, the price for the high quality and liquidity of interbank assets are low returns. The advantage of taking part in the interbank market is that banks are enabled to adjust their liquidity positions rather quickly. Refinancing the banking system by providing loans the Bundesbank offers a substitute to interbank borrowing and lending and, therefore, strongly influences the IM rate while fixing the KI rates. The KI rates provide boundaries for the IM rate with maturities up to three months since the maturities of Bundesbank lending go up to three months as well. As a consequence, the influence of the KI rates declines with increasing IM maturities. The discount rate functions as the lower and the lombard rate as the upper limit for IM rates.⁸ The discount rate is the lowest rate the Bundesbank charges to banks. In order to limit borrowing the Bundesbank uses contingencies. These contingencies are settled individually for every bank. In order to discourage banks to borrow money through lombard loans if not really necessary under liquidity requirements the lombard rate is in general fixed above short-term IM rates. Since the IM market is used for the re-allocation of savings, which have been already collected by the banking sector, the IM rate is usually higher than the rate paid to customers for savings with equivalent maturities.⁹

As we already learned the Bundesbank influences the IM rates through its policy decisions. Competition among banks results in transmitting Bundesbank stimuli to the economy. In other words, the supply of loans to the economy and the rates on loan agreements with *non-bank customers* are affected by Bundesbank policy decisions. If, for example, the Bundesbank lowers refinance costs for banks then, without passing the

by bids and offers being published through a centrally organized computer information system and decentralized trade which takes place via telecommunication.

⁸ Deutsche Bundesbank, Die Geldpolitik der Bundesbank, Frankfurt 1995, p. 105 f.

⁹ Standard maturities in the interbank money market range from one day (Tagesgeld) over one, two, three months up to one year

cost advantage to its customers with demand for loans, a bank will lose these customers to competitors which calculate customer rates on a closer relation to money market rates. The same must be true for rising refinance costs. Therefore, if banks are not willing to pay interest on savings close to money market conditions it will not attract savers.¹⁰ Summarized, this implies a one-sided causal relation between those three types of interest rates. By changing the key interest rates the Bundesbank directly influences the pricing in the interbank money market, i.e. it affects the refinance costs of banks. Customer rates, on the other hand are determined by the refinancing conditions in the money market.

Up to here, we have no reason for justifying asymmetric interest rate adjustments regarding the rates in the customer business. Still we have to take into account the fact that there are major differences between the IM market and the market on savings and loans. In the IM market a limited group of highly homogenous players partitions. They are characterized by a high level of information and information processing. Moreover, banks publish quotes indicating their own liquidity on a computer system and trade in a very liquid market. All these factors contribute to the efficiency of bank responses to the real money supply/demand situation and to a high speed of adjustment of market rates to Bundesbank policy actions. In the customer business, on the other hand, the players are rather heterogeneous: In general, banks are faced by private and corporate customers, with large differences in the informational level and in market power within both groups. From the differences regarding customer characteristics variations in price can be explained.¹¹ As non-bank customer business takes place in localized markets it is apt to conclude that the dissemination of information takes more time implying longer adjustment periods. Moreover, adjustments might not always, i.e. for all customers, be fully accomplished. As Hadjimichalakis (1981) concludes, the differences in the IM market and the market for customer loans and savings leads to transitory market power of banks.¹² This gives a reasonable explanation for the existence of asymmetric price adjustments.

¹⁰ Deutsche Bundesbank, Die Geldpolitik der Bundesbank, Frankfurt 1995, p. 63 f.

¹¹ As, for example, Harhoff and Körting (1997) found, in Germany the prices on credit lines (CL) depend on the size and age of a company.

¹² Hadjimichalakis (1981) p. 259

3. The main hypothesis

In this section we describe in which way the interest rate on CLs is determined by the interest rate on IM, assuming congruent maturities. With regard to the pricing behaviour of banks it is a widely held assumption that in response to cost changes prices are adjusted asymmetrically. That is, increasing refinance rates are accompanied by closer adjustments of loan rates than decreasing refinance rates. In order to prove this assumption we need information on specific loans and their corresponding refinance costs. Since we are not able to determine the actual rate a bank has to pay for refinancing certain loans¹³ we use the IM rate as a proxy for refinance costs. For the following reasons we believe that this measure is quite satisfactory. The first reason is that banks, although they naturally prefer financing loans through collecting savings since less expensive¹⁴, especially in the case of credit lines strongly depend on the IM market for refinancing. The reason for this pronounced dependence on the IM market liquidity is that banks granting CLs have to face a high level of uncertainty about the outflow of money. This is due to the fact that agreements regarding CLs only contain the maximum amount the borrower is able to dispose of, the annualized lending rate, and the period the agreement is valid for, which is usually three months. The lender does not know in advance in which amount and when, if at all, the customer will lay claim on the loan. Considering that for economic reasons banks will first make use of their own excess liquidity before buying assets in the IM market, the IM rate, actually, can be regarded as the marginal rate for refinancing CLs. The second reason for using the rate on IM as a proxy for the actual refinance rate is that banks often use the IM rate as a base interest rate¹⁵. A bank, calculating the interest rate on a CL, will take the current IM rate as a guideline for fixing the interest rate on CL agreements. On the base interest rate a constant is added, determining

¹³ In the bank management literature the problem of assigning liabilities to assets is widely treated, also. The various ways to deal with this problem are covered in great detail by Schierenbeck (1997), p. 43 – 259. Altogether we can state that banks in general are able to match certain loans and savings only approximately.

¹⁴ see above, p. 4

¹⁵ Greenbaum and Thakor (1995) p. 262 f.

the banks profit regarding the CL.¹⁶ Based on this sketch a very simplistic method for determining the interest rate on a CL might be:

$$(1) \quad i_{CL} = p + i_{IM},$$

with π being the interest rate markup, or spread, regarding the banks CL business, i_{CL} the interest rate on the credit line, and i_{IM} the rate on interbank money. In π the fee for the provision of money is included. This equation easily can be transformed into the following price/cost relationship:

$$(2) \quad p = q + c,$$

with $p = 1 + i_{CL}$, the annualized price customers have to pay per unit of CL¹⁷, with $c = 1 + i_{IM}$, the marginal unit cost for refinancing a CL, and with an interest rate markup per unit of θ .

Equation (1) will be the starting point of our empirical analysis. The rate on CLs, gained by (1) will not necessarily be the one charged to all customers. Differences might come into effect by credit risk and bargaining powers. For example, a risk premium depending on customer specific risks might be added or customers might be able to convince the bank on a lower spread. The amount of such a discount given by the bank would depend on the customers bargaining powers towards the bank. Moreover, the relationship given by equation (1) implies an impact of i_{IM} on i_{CL} which is restricted to the value of one. We will give up this restriction in the empirical part but the estimated coefficient which is measuring the impact of i_{IM} is expected to be of a value close to one.

We will refer to equation (1) as the long-term relationship between lending and refinance rates. This long-term relationship may not hold at all periods, i.e. short-term deviations are possible but have to be followed by movements which neutralize them. If, for example, the rate on IM rises banks might not always immediately follow with an increase in the rate on CLs if they expect the increase to be temporary.¹⁸ If their expectation is

¹⁶ This is only a rough sketch of the pricing scheme. The exact internal pricing scheme, i.e. the IM rate used, may vary from bank to bank. The markup includes risk premium and fees charged for the provision of money.

¹⁷ In our case per DM

¹⁸ There are various reasons for the assumption of price rigidities. As pointed out by Hannan and Berger (1991) adjustments do not take place if the costs of the price

correct, then with decreasing IM rates the relationship goes back to its long-term equilibrium. If their expectation is wrong and the IM rates continue to increase they will adjust rates on CLs. This idea forms the basis for error correcting mechanisms which we will employ in the empirical part in order to investigate the adjustment process of interest rates.

Based on equation (1), the following hypotheses are going to be tested in this paper:

(1) *A long-term relationship between CL and IM interest rates as given by equation (1) exists*

The validity of this hypothesis is the prerequisite of our analysis and, therefore, has to be tested first. Means of cointegration are used in order to test if equation (1) is empirically valid.

(2) *Adjustments are asymmetric, i.e. adjustments to decreasing refinance rates are weaker*

This is actually our core hypothesis. It implies that adjustments to changes in the IM rates take place at a lower pace during periods of downward movements as during periods of upward movements. In order to test this hypothesis we use an asymmetric error correcting model (ECM) as well as an ECM allowing for asymmetric short-term dynamics.

(3) *Interest rate markups are higher during periods of decreasing interest rates*

If we find that hypothesis 2 is true then we expect to find higher interest rate markups when the interest rates follow a negative trend. Because cost reductions, which are not as well as cost increases passed through on prices for customers, lead to increasing markups. Keeping this in mind we attempt to prove evidence that markups increase during downturns of interest rates. In order to do so we fall back on interest rate spreads estimated in the ECMs.

A further assumption we are considering is that larger customers are expected to have better bargaining powers. We differ between large and

adjustments are higher than the loss implied by not adjusting. Taking up the argumentation of Hadjimichalakis (1981) the availability of information and the degree of homogeneity on both sides of the market determine the speed of adjustment.

small customers according to the size of their CL volumes. In order to find out if banks are more prone to exploit small customers we compare the sizes of the estimated spreads of the long-run relation.

Before we can test the hypotheses we first have to check if the time series we are working with fulfill the requirements for using the method of cointegration, i.e. we have to test them for nonstationarity. Before explaining the basic methods of testing for nonstationarity, cointegration, and error correcting models we introduce the data we use in the empirical analysis.

4. The Data

For the lack of data on interest rates paid and charged by individual banks, we have to estimate the relation between input and output rate on an aggregated level. In order to analyse the link between the rate on the banks output „CLs“ and interest rates on inputs with matching maturities, as represented by IM rates, we use monthly data provided by the Bundesbank¹⁹. The period for our investigation begins with February 1975 and ends in October 1997 which supplies us with 273 observations for each time series. The statistical surveys of the Bundesbank are conducted in the following way:

Regarding the *interest rates on interbank money* 12 major banks which are known as actively operating in the IM market have to report for various maturities on a daily basis the rates most often paid during each business day. The monthly averages of the rates on maturities most commonly traded in the IM market are then published by the Bundesbank. In empirical studies maturities most likely for refinancing short-term loans „Tagesgeld“ and „Dreimonatsgeld“ have already been used. Jaenicke and Kirchgässner (1992) used the IM rate with a maturity of one day. The Bundesbank (1996), on the other hand, relied on IM with a maturity of three month.²⁰ We decided not to use the IM rate with a maturity of one

¹⁹ Deutsche Bundesbank Monatsberichte, Statistischer Teil, VI.4 und VI.5

²⁰ Deutsche Bundesbank, Monatsbericht Oktober 1996 p. 47

day since price conditions on CLs usually are valid for a period of three months and, therefore, this rate does not seem to be congruent to the rate on CLs with respect to the period of time it covers. Moreover, the IM rate with a maturity of one day is too much determined by short-term frictions in the liquidity of the banking sector, which should not affect the loan rates because of existing price rigidities. We estimated the link between the rates on CLs and IM rates, with both, maturities of three and one month. We found that the results are not significantly different but slightly better while using „Monatsgeld“, i.e. interbank money with a maturity of one month (IM1). Therefore, in the following, the empirical results using i_{IM1} are given.

The interest rates on credit lines charged to non-bank customers are collected by the Bundesbank²¹ from about 480 banks. In the interest rate statistics reporting banks are supposed to quote the rate **most commonly used on new agreements** or on prolongations of already existing agreements. As a consequence, risk and bargaining power which are debtor specific will not show in the data, and the adjustment to changes of the refinance rates should, at least partly, take place immediately. In the case of CLs reporting banks are supposed to provide the Bundesbank with information on the net interest rate they charge, i.e. the provision payment for the allocation of money has to be included in the quoted rate. The Bundesbank differs between CLs amounting to less than DM 1 Million (small CLs) and CLs in the range of DM 1 Million to DM 5 Million (large CLs). For both types of CLs three rates are published, the lowest, the highest, and the rate averaged over all 480 reported rates. For not taking outliers into account the Bundesbank does not use the highest and lowest five percent of each months quotes. All interest rates are quoted as annualized rates in percent.

In table 1 the variables we use are described and the variable names we refer to are given. As you can see we treat minimum and maximum rates on CLs separately. The reason for not only referring to average rates is that we believe that the difference between minimum and maximum rates

²¹ For more information on the selection criteria regarding the interest rate statistics consult: Deutsche Bundesbank, Monatsbericht Februar 1997, p.26 and Deutsche Bundesbank, Statistische Sonderveröffentlichungen 1: Bankenstatistik Richtlinien, Frankfurt 1996, p.198f

is due to regional effects. As the Bundesbank states in its monthly report of February 1997 it chooses the 480 reporting banks out of various bank types and sizes mainly from regional financial centers. Furthermore, banks with a large branching network have to report by main branches and not the bank as a whole in order to register regional differences. Moreover, during the sample period the difference between minimum and maximum rates became significantly larger. In the first year of our sample the maximum rate for large CL was on average 1.89 percentage points higher than the minimum rate. This difference increased over the years more or less continuously until it reached in 1990 a yearly average of 2.29 percentage points. With the inclusion of east German banks in the interest rate statistics of the Bundesbank in 1991 the difference between minimum and maximum rates jumped up to 2.80 percentage points. By 1997 the difference has increased up to a value of 4.40 percentage points. We believe that this observation is due to the inclusion of east German banks. In order to find out the implications on the long-run relationship between CL and IM rate implied by the inclusion of east German banks we will test for a structural break in January 1991 in this paper. Building on the finding of Harhoff and Körting (1997) that east German firms have to pay higher rates than west German firms we are interested in which way the minimum, average, and maximum CL rates are affected by the inclusion of east German banks. Therefore, we decided not only to take the unweighted average over all quotes as the representative rate on CLs but put our analysis on a slightly broader basis by using three rates.

Table 1: Variable Definitions

| | |
|--------------|--|
| i_{CLSmin} | The lowest interest rate quoted on small credit lines |
| i_{CLSav} | The average over all interest rates quoted on small credit lines |
| i_{CLSmax} | The highest interest rate quoted on small credit lines |
| i_{CLLmin} | The lowest interest rate quoted on large credit lines |
| i_{CLLav} | The average over all interest rates quoted on large credit lines |
| i_{CLLmax} | The highest interest rate quoted on large credit lines |
| i_{IM1} | The interbank money rate with a maturity of one month |

CLS* volumes go up to 1 million DM, CLL* volumes range between 1 and 5 million DM

5. Empirical analysis

In the empirical part we start with testing the data for nonstationarity.²² In the next subsection we explain the concept of cointegration and error correcting models. As already mentioned, we suspect a structural break in 1991 induced by the inclusion of banks located in east Germany. This leads us to the following procedure: First, we estimate the relationship between IM1 and CL rates ignoring the potential break. Second, we test for a structural break in 1991. Then we again estimate the relationship between the variables now taking the results of the previous step into account. In subsection 5.4 we allow for asymmetries in the error correcting models. Modeling these asymmetries we will apply the method of asymmetric ECMs as done by Granger/Lee (1989) and Nautz (1993) as well as the procedure employed by Kirchgässner/Kübler (1992) and Borenstein et al. (1992) allowing for asymmetries in the short-term adjustment. In subsection 5.5 we check if the asymmetries in fact lead to higher markups during periods of decreasing interest rates.

5.1. Testing the data for nonstationarity

Economic time series often need to be differenced in order for stationarity assumptions to hold.²³ Therefore, before estimating the link between IM and CL rates, we test the selected data for nonstationarity. A process is called weakly stationary when its expected value, variance and autocovariance are time-invariant.²⁴ A process, which is nonstationary while its change is stationary, is integrated of order 1, i.e., $\sim I(1)$. The change of a process y_t is denoted by $\Delta y_t = y_t - y_{t-1}$.

Interest rate series are often claimed as following a process without linear time trend but drifting around a non-zero mean. Based on this, the supposed process generating the interest rate time series is given by:

$$(3) \quad y_t = \mathbf{a} + \mathbf{r}y_{t-1} + u_t.$$

or equivalent

²² All estimations are done with Econometric Views version 2.0.

²³ Engle/Granger (1987), p. 252

²⁴ Hamilton (1994), p. 45f

$$(4) \quad \Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + u_t,$$

with $\alpha_1 = \rho - 1$

If $\rho = 1$ (i.e. $\alpha_1 = 0$), then the series y_t follows a nonstationary process. In order to test for the hypothesis $H_0: \rho = 1$ (or: $\alpha_1 = 0$) we employ the Dickey-Fuller unit root test.²⁵

When the residuals gained from OLS estimation of equation (3), u_t , display evidence of autocorrelation it suggests itself to include lagged differences of y_t to make sure that the resulting residual series can be referred to as being approximately white noise. This leads us to the augmented Dickey-Fuller (ADF) t- test for testing H_0 .²⁶ The ADF t- test is based on the following regression:

$$(5) \quad \Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \Delta y_{t-1} + \alpha_3 \Delta y_{t-2} + \dots + \alpha_p \Delta y_{t-p} + e_t.$$

If $y_t \sim I(1)$, i.e. $H_0: \rho = 1$ is valid then the level variable α_1 should have a coefficient value of zero. Equation (5) is then estimated with OLS. T gives the number of observations. The estimated ζ_i converge at rate \sqrt{T} to the standard limiting distributions and the standard t- and F- statistics for hypotheses testing are asymptotically valid. The estimated unit root coefficient ρ converges with T and α_0 converges at rate \sqrt{T} to nonstandard distributions.²⁷ The MacKinnon (1991) asymptotic critical values for the Dickey-Fuller t- statistic of the hypothesis $\rho = 1$ (i.e. $\alpha_1 = 0$) are -2.57 at the 10%, -2.87 at the 5%, and -3.46 at the 1% level. If the coefficient α_1 is significantly different from zero then $H_0: \rho = 1$ is rejected, and therefore, H_1 : the series is stationary is valid. The null hypothesis has to be accepted for t-values larger than the critical values.

An alternative test for nonstationarity which is correcting for serial correlation in the residuals is the Phillips-Perron (PP) Z_t - test.²⁸ With the PP Z_t - test on the hypothesis $\rho = 1$ equation (3) is estimated by OLS. The resulting t- value testing for $\rho = 1$ is then corrected for serial correlation in

²⁵ Dickey/Fuller (1979)

²⁶ Said/Dickey (1984)

²⁷ Hamilton (1994) p.527

²⁸ Phillips/Perron (1988)

u_t .²⁹ The critical values are the same as for the ADF t- test. We use the PP Z_t - statistic in order to confirm the results of the ADF t- statistic.

As already expected the test results, in general, support the hypothesis of nonstationarity for the interest rate series we focus on. By comparing the ADF t- statistic for α_1 in table 2 with the MacKinnon asymptotic critical values it is easily seen that in most cases the null can not be rejected even at the 10% level. Only for i_{CLSmax} and i_{IM1} the null hypothesis is rejected at the 5% level. The PP Z_t - statistics confirm our results except in the case of i_{CLSmax} and i_{IM1} . According to the PP Z_t - test we can not reject H_0 for any series tested. In the following we will regard all series as $I(1)$ and use means of cointegration in the next steps of our analysis.

Table 2: Results for the augmented Dickey/Fuller and Phillips/Perron tests for unit roots

| | i_{CLSmin} | i_{CLSav} | i_{CLSmax} | i_{CLLmin} | i_{CLLav} | i_{CLLmax} | i_{IM1} |
|-----------------|--------------|-------------|--------------|--------------|-------------|--------------|------------|
| α_1 | -0.016 | -0.014 | -0.023 | -0.016 | -0.014 | -0.023 | -0.031 |
| ADF t-stat. | (-2.323) | (-2.369) | (-3.209)** | (-2.231) | (-2.372) | (-2.488) | (-3.096)** |
| p | 4 | 4 | 11 | 4 | 10 | 6 | 12 |
| PP Z_t -stat. | (-2.058) | (-2.040) | (-2.005) | (-2.083) | (-2.085) | (-2.041) | (-1.809) |

The results of the ADF test are based on OLS estimation of equation (4) including p lags. The results for the PP test are based on OLS estimation of equation (3) with truncation lag 12 for the Newey-West correction.

For * (**, ***) H_0 : The series is nonstationary, is rejected at the 10% (5%, 1%) level.

5.2 The concept of cointegration and error correcting mechanisms

Using the definition of Engle/Granger (1987, p.253) the components of the vector $x_t = (i_{CL} \ i_{IM1})$ are said to be *cointegrated* if (a) both components of x_t are $I(1)$; (b) there exists a vector $\alpha (\neq 0)$ so that $u_t = \alpha'x_t \sim I(0)$. The vector α is called the cointegrating vector. In our context this implies:

$$(6) \quad i_{CL(t)} = a_0 + a_1 i_{IM1(t)} + u_t,$$

²⁹ Eviews uses the Newey-West procedure for adjusting the t- statistics.

with $i_{CL(t)} \sim I(1)$, $i_{IM1(t)} \sim I(1)$, and $u_t \sim I(0)$. For this case $\alpha' = (1 - a_1)$.

The static regression in (6) is estimated by OLS. In the case that the two series are cointegrated, then the OLS estimator of the slope parameter \hat{a}_1 is superconsistent, i.e. \hat{a}_1 converges at rate T to the true value a_1 .³⁰

If an equilibrium occurs then $\alpha'x_t = 0$. Therefore, u_t can be referred to as the equilibrium error. The concept of cointegration allows for short-term deviations, i.e. $u_t \neq 0$, from the long-run equilibrium. For testing if the components of x_t are cointegrated we can again employ the Dickey/Fuller test for unit roots as u_t needs to be $\sim I(0)$ to meet cointegration requirements. The null hypothesis is that the static regression given by equation (6) is spurious which implies $u_t \sim I(1)$.³¹ If the ADF or PP test statistic on the residual autoregression is smaller than the critical values we have to reject the null hypothesis. If the null hypothesis can not be rejected we conclude that there is no cointegration between i_{CL} and i_{IM1} as specified by the regression producing the residual series. Regarding the critical values for the test statistics we now have to take into account that the Dickey-Fuller t-statistics calculated from \hat{u}_t differ from those calculated from raw data, as e.g. i_{CL} and i_{IM1} . Moreover, the critical values depend on the number of regressors, k, of the cointegrating regression which produced \hat{u}_t . Trend or constant are excluded in k. Therefore, for testing for cointegration between i_{CL} and i_{IM1} we have to refer to the MacKinnon asymptotic critical values for unit root tests applied to residuals from spurious cointegrating regression with $k = 1$. These are: -3.05 at the 10%, -3.34 at the 5%, and -3.90 at the 1% level, respectively.

Following Grangers representation theorem³² cointegration implies the specification of an *error correcting mechanism*. In the error correcting model, changes in the endogenous variable can be explained by past changes of both, exogenous and endogenous, variables and a proportion of the previous deviation from the long-run equilibrium, $\hat{u}_{(t-1)}$, i.e.:

$$(7) \quad \Delta i_{CL(t)} = g\hat{u}_{(t-1)} + \sum_{j=0}^p b_{1j}\Delta i_{IM1(t-j)} + \sum_{j=1}^p b_{2j}\Delta i_{CL(t-j)} + e_t$$

³⁰ A detailed introduction to the concept of cointegration and its application is given by Wolters (1995)

³¹ Granger/Newbold (1974)

³² Engle and Granger (1987), p. 255 – 258

with $\hat{u}_t = i_{CL(t)} - \hat{a}_0 - \hat{a}_1 i_{IM1(t)}$.

The coefficient γ is measuring the influence of deviations from the long-term equilibrium of the previous period and the coefficients β_{1j} and β_{2j} are measuring the influence of lagged changes in the exogenous and endogenous variables on the change of the endogenous variable.

Now, if the two time series are cointegrated, which implies the existence of a long-run equilibrium, then short-term deviations from this equilibrium have to be adjusted for. If, for example, in one period an increase in i_{IM1} is not (completely) accompanied by an increase in i_{CL} then the long-run equilibrium is violated with $u_t < 0$. In order for the long-run equilibrium to hold i_{CL} has to adjust in the next period to the deviation, therefore it is substantial that γ is significant with a negative sign. The number of lagged differences should be chosen so that ε_t follows a white noise process. For estimating long-run equilibrium and short-term dynamics in two distinct regressions the Engle/Granger procedure is known as a two step estimation of an error correcting model.

Stock (1987) proposed a non-linear estimator (NLS) of the cointegrating regression by estimating the long-run equilibrium and short-run dynamics in one step:

$$(8) \quad \Delta i_{CL(t)} = d_0 + d_1 i_{CL(t-1)} + d_2 i_{IM1(t-1)} + \sum_{j=0}^p b_{1j} \Delta i_{IM1(t-j)} + \sum_{j=1}^p b_{2j} \Delta i_{CL(t-j)} + e_t \cdot$$

Based on this regression the long-run equilibrium can be computed from the OLS estimators of the coefficients on the lagged level terms. The NLS estimators of the long-run coefficients are

$$\hat{a}_1^* = -\frac{\hat{d}_2}{\hat{d}_1} \quad \text{and} \quad \hat{a}_0^* = -\frac{\hat{d}_0}{\hat{d}_1} \cdot$$

Testing for cointegration we now have to check if δ_1 in (8) is significantly different from zero. This is done by comparing the t- statistic of δ_1 to the critical values given by Banerjee et al. (1992). Again the hypothesis of no cointegration will be rejected for t-values smaller than the critical values. The critical values for $k = 1$ are: -2.90 at the 10%, -3.23 at the 5%, and -3.82 at the 1% level, respectively.

The one step ECM is also called unrestricted ECM since, contrary to the two step estimator, it does not assume that the lagged terms are of no influence while estimating the cointegrating vector. Provided that the lagged values are included by the true relationship, the neglectance of lagged values of variables, as done in the static cointegrating relation given by (6), leads in finite samples to efficiency losses with regard to the estimators of the long-run coefficients.³³ Stock also shows that both estimators (restricted and unrestricted ECM) of the coefficients describing the short-run dynamics are asymptotically equivalent.³⁴ Kremers et al. (1992) compare the power of tests of cointegration based on the ECM statistic with those based on the Dickey/Fuller statistic applied to the residuals of a static cointegrating relation.³⁵ They conclude that the ECM statistic is more powerful than the Dickey/Fuller statistic when lagged variables are included in the true long-run relationship. This is due to the fact that the Dickey/Fuller statistic neglects information by „assuming error dynamics rather than structural dynamics.“³⁶

A necessary condition for the validity of the Banerjee test is that in (8) Δi_{IM1} and ε_{t-i} are not correlated, i.e. i_{IM1} is exogenous. Estimating an ECM with Δi_{IM1} as dependent and i_{CL} as independent variables we can check on the exogeneity of i_{IM1} . Exogeneity of i_{IM1} implies that the error correcting coefficient in this specification is not significant. With the error correcting coefficient being significant the error correcting term would be explaining changes in i_{IM1} , and, therefore, i_{IM1} would depend of $i_{CL(t-1)}$. In this case the rate on IM1 would be determined by the rate on CLs and could not be regarded as exogenous.

Because of the advantages of the one step over the two step procedure we will discuss the results estimating the one step ECM in detail. We also computed the static cointegrating regression. But, since these results obviously seem to be biased, we only refer to them in passing. Before allowing for asymmetries in the model we first test for cointegration in a symmetric approach. Then, in order to estimate an asymmetric error correcting model we compute the residuals from the NLS long-run

³³ Stock (1987) p. 1039 - 1043

³⁴ Stock (1987) p. 1044 - 1045

³⁵ Kremers et al. (1992) p. 326 - 334

³⁶ Kremers et al. (1992) p. 341

equilibrium and divide them with regard to their sign into positive and negative equilibrium deviations. Finally, we estimate the one step error correcting model with asymmetries in the short-term dynamics.

5.3 Testing for cointegration in the error correcting framework

While testing for cointegration between the rates on IM1 and CLs we estimate equation (8) with OLS. The change of the CL rates is regressed on a constant, lagged levels of endogenous and exogenous variables, and on lagged changes of both, choosing $p = 3$. In general, for $p = 3$ we can accept $\hat{\epsilon}_t \sim \text{w.n.}$

Table 3 (shown in the appendix) gives the estimation results for the ECMs. In order to model the relationship economically coefficients of lagged changes which have not been significant are eliminated from the estimation. Since at the moment we are only interested in results regarding the long-term equilibrium and the error correcting coefficient (ECC) δ_1 we summarized the results of table 3 with respect to these features in table 3'.

As can be seen in the second column of table 3' we only find cointegration for the minimum CL rates. Here, the cointegrating parameter $\hat{\alpha}_1^*$ is with values of 0.93 and 0.94 relatively close to the predicted value of 1. In order to check if the NLS estimator $\hat{\alpha}_1^* = 1$, we tested this hypothesis with the Wald-test. With F- statistic values of 1.563 for i_{CLSmin} and 2.023 for i_{CLLmin} we can not reject the hypothesis in both cases. The average and maximum CL rates, do not seem to be cointegrated over the whole sample period.³⁷ As already mentioned before, we expect a structural break in 1991 due to the inclusion of quotes by banks located in east Germany.

³⁷ We also estimated to long-run equilibrium in the static approach. With regard to the ADF t- test we can state that IM1 and CL rate are not cointegrated while the PP Z_t - test is in line with the results above by giving evidence that at least the minimum rates are cointegrated. The estimators of the static approach seem to be biased. The coefficient values estimated from the static regression indicate that the influence of IM1 on CL is under estimated taking values of 0.73 and 0.74 and, therefore, it is strongly deviating from the expected value of one. The constant, on the other hand, seems to be over estimated as compared to the NLS estimators.

Therefore, we will first test for a structural break in 1991 by including dummies in equation (8), before we go on with testing for cointegration.

Table 3' Error correcting coefficient and long-run equilibrium computed from the one step ECM

| | 1975/2 – 1997/10 | | | |
|---------------------|---------------------|----------------------|-------|---------------------------------|
| | ECC | long-run equilibrium | | Wald-test on $\hat{a}_1 = 1$ |
| | δ_1 | a_0 | a_1 | <i>F-stat./Prob.</i> |
| Δi_{CLSmin} | -0,12 (-5,74)*** | 3,15 | 0,94 | 1,563 0,212 |
| Δi_{CLSav} | -0,03 (-2,52) | | | |
| Δi_{CLSmax} | -0,02 (-1,81) | | | |
| Δi_{CLLmin} | -0,11 (-4,69)*** | 2,22 | 0,92 | 2,023 0,156 |
| Δi_{CLLav} | -0,04 (-2,77) | | | |
| Δi_{CLLmax} | -0,01 (-0,71) | | | |

The t-values for δ_1 in brackets have to be compared with the asymptotic critical values from Banerjee et al. (1992) For * (**, ***) the hypothesis of no cointegration is rejected at the 10% (5%, 1%) level.

In order to check on the exogeneity assumption regarding i_{IM1} we also estimated the ECM model in (8) with Δi_{IM1} on the left side of the equation:

$$(9) \quad \Delta i_{IM1} = d_0 + d_1 i_{IM1(t-1)} + d_2 i_{CL(t-1)} + \sum_{j=1}^p b_{1j} \Delta i_{CL(t-j)} + \sum_{j=1}^p b_{2j} \Delta i_{IM1(t-j)} + e_t \cdot$$

The results are in favour of our assumption of i_{IM1} as being exogenous, i.e. δ_1 was not significantly different from zero in any case. Remembering the causal relation drawn between the rate on IM1 and on CLs in section 2 this is quite plausible.

5.3.1 Testing for a structural break in 1991

In its 1996 paper the Bundesbank estimated the link between the rate on IM with a three month maturity (IM3) and average CL rates in a two step ECM allowing for a structural break in January 1993.³⁸ It concluded that the long-run relationships between IM3 and the average CL rates have been changed, while with regard to the short-term dynamics no change was evident. The Bundesbank gave no explicit reason for the break in 1993. Since we believe that this break is due to the new sample, which is used as a basis for the interest rate statistics from January 1991 onwards, we allowed for a break in the long-run equilibrium at this point of time. We estimate the following model:

$$(10) \quad \Delta i_{CL(t)} = d_0 + d_1 i_{CL(t-1)} + d_2 i_{IM1(t-1)} + d_0 D_t + d_1 D_t i_{CL(t-1)} + d_2 D_t i_{IM1(t-1)} + \sum_{j=0}^p b_{1j} \Delta i_{IM1(t-j)} + \sum_{j=1}^p b_{2j} \Delta i_{CL(t-j)} + e_t$$

with $D_t = 1$ for 01/1991 until 10/1997 and $D_t = 0$ for 02/1975 until 12/1990. The results for this specification are given in table 4 in the appendix. Summarizing the results we can state that d_0 is always insignificant. d_2 is significant for all but one series indicating a decrease in the impact of IM1 on CL rates. For i_{CLmin} we can not reject the hypothesis of $d_2 = 0$. This is actually in line with our prior finding that i_{CLmin} and i_{IM1} are cointegrated over the total sample. As has been shown in the empirical investigation of Harhoff and Körting (1997), the distribution of CL rates which banks charge to east German firms is situated on the right hand side of the distribution of rates west German companies are charged. This fact might explain why the minimum rate on large CLs has not really been affected by the inclusion of east German banks in the interest rate statistics. Altogether the differences in the estimated interest rate relation evident between both subperiods speak very well for a structural break in 1991. Besides separating the series we will also exclude the year of 1990 from our sample. The reason for this exclusion is that we want to avoid covering in the sample the turbulences during this period. The turbulences were induced by the November 1989 opening of the border

³⁸ Monatsbericht Oktober 1996, p. 47

between east and west Germany and through the announcement of the currency union for October 1990. As a result, we have two subsamples, sample s1 with 179 observations covering the period from 02/1975 until 12/1989 and sample s2 with 82 observations covering the time between 01/1991 and 10/1997. After including the dummies the t- values for δ_1 are now always by far smaller than the critical values so we again test for cointegration now for the two subsamples, separately.

5.3.2 Testing for cointegration over the subsamples

Equation (8) is re-estimated with OLS now over each subsample. We also estimated (8) for i_{CLmin} over the subsamples. But since there was no structural break evident for this series we will later on only give results for the total sample. The complete results for the estimated ECMs can be found in tables 5a and 5b in the appendix. Again, we summarized the test results with respect to the error correcting coefficients and the long-run relation between i_{CL} and i_{IM1} in table 5'.

As already expected, the test results for the subsamples are far more in favour of cointegration. For s1 we can state that δ_1 is always significantly (at the 1% level) different from zero. The estimated coefficients are in the range of -0.16 to -0.23 . The cointegrating parameter \hat{a}_1^* takes values between 0.92 and 0.97 which is rather close to the expected value of 1 . Looking at the results of the Wald-test we can not reject the hypothesis that $\hat{a}_1^* = 1$ in four cases. And, as expected, the spread given by \hat{a}_0^* is in general about 50% higher for small CLs than for large comparable CLs. So bargaining powers seem to be in fact a determinant of the rate on a CL. Moreover, the markups estimated for the maximum rates are about 70% higher than those of the minimum rates.

For s2 the picture has changed dramatically. First, we can not reject the hypothesis of no cointegration for i_{CLSav} . Compared to s1, apart from the average rates, for all series the value of the error correcting coefficient changed only slightly during s2. The main difference is to be found in the new long-run equilibrium. The cointegrating parameter \hat{a}_1^* reaches now

only values between 0.50 and 0.78. Thus, far from the expected value of 1. The F- statistic speaks in all cases against the hypothesis that $\hat{a}_1^* = 1$.

Table 5⁶ Long-run equilibrium computed from one step ECM

| | 1975/2 – 1989/12 | | | | 1991/1 – 1997/10 | | | |
|---------------------|----------------------|----------------------|-------|---------------------------------|---------------------|----------------------|-------|---------------------------------|
| | ECC | long-run equilibrium | | Wald-test on $\hat{a}_1 = 1$ | ECC | long-run equilibrium | | Wald-test on $\hat{a}_1 = 1$ |
| | δ_1 | a_0 | a_1 | <i>F-stat</i> <i>./Prob.</i> | δ_1 | a_0 | a_1 | <i>F-stat</i> <i>./Prob.</i> |
| Δi_{CLSmin} | -0,23 (-11,26)*** | 3,14 | 0,92 | 9,728 0,00 | -0,21 (-6,04)*** | 4,69 | 0,75 | 42,685 0,00 |
| Δi_{CLSav} | -0,17 (-11,69)*** | 4,25 | 0,94 | 4,447 0,04 | -0,06 (-1,83) | | | |
| Δi_{CLSmax} | -0,16 (-8,94)*** | 5,44 | 0,93 | 2,623 0,11 | -0,13 (-3,15)* | 9,40 | 0,60 | 43,291 0,00 |
| Δi_{CLLmin} | -0,19 (-10,80)*** | 2,02 | 0,95 | 2,271 0,13 | -0,17 (-3,59)** | 3,42 | 0,78 | 17,464 0,00 |
| Δi_{CLLav} | -0,19 (-11,39)*** | 2,68 | 0,97 | 1,128 0,29 | -0,11 (-2,91)* | 5,32 | 0,72 | 21,944 0,00 |
| Δi_{CLLmax} | -0,22 (-7,17)*** | 3,79 | 0,96 | 0,624 0,43 | -0,24 (-4,98)*** | 8,82 | 0,50 | 149,921 0,00 |

The t-values for δ_1 in brackets have to be compared with the asymptotic critical values from Banerjee et al. (1992) For * (**, ***) the hypothesis of no cointegration is rejected at the 10% (5%, 1%) level.

Moreover, the interest rate markup \hat{a}_0^* increased over all series but stronger for the maximum rates than for the minimum rates. So now \hat{a}_0^* of the maximum rate on large (small) CLs is about 2.5 (2.0) times \hat{a}_0^* of the minimum rate. The strong increase in the markups of the maximum rates as compared to the markups of the minimum rates is in line with the observation of Harhoff and Körting (1997) that the distribution of CL rates in east Germany is right to the distribution of the CL rates in West Germany.³⁹ The bargaining powers of large customer are smaller during s2 than in s1. This is especially evident for the maximum rates. Here, the markups small customers are charged are only about 7% higher than

³⁹ We also computed the long-run equilibrium for s1 and s2 with the static approach. For s1 the PP test is in line with the test results from the dynamic model. Again the estimators from the static regression seem to be biased in the same way as before, over estimating the constant and under estimating the influence of IM1.

those of large customers. Whereas for the minimum rate the markup on CL for small customers is still about 37% higher.

5.4 Allowing for asymmetries

In this section we build on the hypothesis that banks adjust output rates to marginal refinance rates asymmetrically. As marginal refinance costs change we believe that the effect on interest rates for loans will be smaller if this change has a negative sign compared to positive changes. We use two attempts in order to model asymmetries. First, we follow the procedure used by Nautz (1993) and by Granger and Lee (1989). Then we apply the technique used by Borenstein et al. (1992) and by Kirchgässner and Kübler (1992).

5.4.1 The non-symmetric ECM

In a non-symmetric ECM we consider that the effect of the long-run equilibrium error $\hat{u}_{(t-1)}$ on $\Delta i_{CL(t)}$ might be different with regard to the sign of $\hat{u}_{(t-1)}$. This type of specification has been used by Granger and Lee (1989) in a multi-cointegration context and by Nautz (1993) for measuring the adjustment processes of IM rates on Bundesbank KI rates. In both papers the authors use the residuals computed from the static cointegrating regression. Since we found the results from the static cointegration regression as being biased we modified their procedure by computing the residuals of the long-run equilibrium from the NLS approach from equation (8). Therefore, the residual series \hat{u}_t is given by

$$(11) \quad \hat{u}_t = i_{CL(t)} + \frac{\hat{d}_0}{\hat{d}_1} + \frac{\hat{d}_2}{\hat{d}_1} i_{IM1(t)}.$$

Then, the residual series is split into two series using the rule:

$\hat{u}_t^+ = \max(\hat{u}_t, 0)$ and $\hat{u}_t^- = \min(\hat{u}_t, 0)$. With \hat{u}_t^+ and \hat{u}_t^- the non-symmetric ECM is constructed:

$$(12) \quad \Delta i_{CL(t)} = \mathbf{g}^+ \hat{u}^+_{(t-1)} + \mathbf{g}^- \hat{u}^-_{(t-1)} + \sum_{j=0}^p \mathbf{b}_{1j} \Delta i_{IM1(t-j)} + \sum_{j=1}^p \mathbf{b}_{2j} \Delta i_{CL(t-j)} + \mathbf{e}_t \cdot$$

The hypothesis of asymmetric interest rate adjustments in order to widen the interest rate markups implies that adjustments to positive deviations from the long-run equilibrium, i.e. $i_{CL} > \hat{a}_0 + \hat{a}_1 * i_{IM1}$, will be adjusted slowly compared to adjustments of negative deviations. Therefore, in the case of asymmetric interest rate adjustments, we expect γ^+ to be smaller in absolute values than γ^- . The hypothesis of $\gamma^+ = \gamma^-$ is checked by the Wald-test. The estimated values of γ and the Wald- test statistics are given in table 6.

We only give values for asymmetric ECM regressions if the null hypothesis of no cointegration was rejected when estimating the symmetric ECM. As can be seen in table 6 the predicted asymmetries can not be found. Contrary to our expectations, for most cases the adjustments are stronger to positive than to negative deviations from the long-run equilibrium. Still, the apparent differences in the error correcting coefficients γ^+ and γ^- are not significant for any period and type of CL as indicated by the results of the Wald- test.

Table 6: Asymmetric error correcting terms

| | 1975/2 – 1997/10 | | | 1975/2 – 1989/12 | | | 1991/1 – 1997/10 | | |
|---------------------|-------------------|-------------------|-----------------|-------------------|-------------------|-----------------|-------------------|-------------------|-----------------|
| | γ^+ | γ^- | Wald (Prob.) | γ^+ | γ^- | Wald (Prob.) | γ^+ | γ^- | Wald (Prob.) |
| Δi_{CLSmin} | | | | -0,238 (-9,68) | -0,219 (-8,67) | 0,358 0,551 | -0,221 (-5,99) | -0,191 (-3,72) | 0,238 0,627 |
| Δi_{CLSav} | | | | -0,175 (-6,42) | -0,139 (-5,21) | 1,579 0,211 | | | |
| Δi_{CLSmax} | | | | -0,170 (-6,29) | -0,155 (-5,68) | 0,200 0,655 | -0,150 (-3,30) | -0,124 (-3,33) | 0,214 0,645 |
| Δi_{CLLmin} | -0,107 (-4,67) | -0,100 (-4,02) | 0,063 0,802 | | | | | | |
| Δi_{CLLav} | | | | -0,176 (-6,15) | -0,160 (-4,78) | 0,232 0,631 | -0,135 (-2,50) | -0,103 (-3,29) | 0,293 0,590 |
| Δi_{CLLmax} | | | | -0,198 (-5,25) | -0,184 (-4,47) | 0,085 0,771 | -0,277 (-4,04) | -0,215 (-3,51) | 0,458 0,501 |

In the columns showing the results of the Wald- test the first line gives the value of the F-statistic for the test on $H_0: \gamma^+ = \gamma^-$, while the second line gives the corresponding p- value.

5.4.2 ECMs with asymmetric adjustments to changes in the explanatory variable

In the following we will present two different approaches for modeling asymmetric adjustment in ECMs. The first method has been employed by Jaenicke and Kirchgässner (1992) for investigating the hypothesis of asymmetric adjustment of interest rates. The second approach has been applied by Borenstein et al. (1992) and by Kirchgässner and Kübler (1992) in order to estimate asymmetric price adjustments in the oil market.

Modelling asymmetric interest rate adjustments Jaenicke and Kirchgässner (1992) estimate the following model⁴⁰:

$$(13) \quad \Delta i_{CL(t)} = \mathbf{d}_0 + \mathbf{d}_1 i_{CL(t-1)} + \mathbf{d}_2 i_{IM1(t-1)} \\ + \mathbf{b}_{10} (\Delta i_{IM1}) \Delta i_{IM1(t)} + \mathbf{b}_{11} (\Delta i_{IM1}) \Delta i_{IM1(t-1)} + \mathbf{b}_{21} (\Delta i_{IM1}) \Delta i_{CL(t-1)} + \mathbf{e}_t$$

$$\text{with } \mathbf{b}_{kj}(\Delta i_{IM1}) = \begin{cases} \mathbf{b}_{kj}^+ & \text{for } \Delta i_{IM1} > 0 \\ \mathbf{b}_{kj}^- & \text{for } \Delta i_{IM1} < 0 \end{cases}, k = 1, 2 \text{ and } j = 0, 1.$$

Here, the parameters measuring the impact of the lagged change of the endogenous variable and the impact of the changes of the explanatory variable, β_{21} , β_{10} , and β_{11} , all depend on the sign of the change of the explanatory, i_{IM1} . Jaenicke and Kirchgässner examine the joint hypothesis: $\beta_{10}^+ = \beta_{10}^-$, $\beta_{11}^+ = \beta_{11}^-$, and $\beta_{21}^+ = \beta_{21}^-$ with a F- test. From their empirical results, the conclusion of symmetric interest rate adjustments is drawn.

The procedure for modeling the asymmetries as done above has been criticized by Nautz (1993) as inconsistent. Nautz argues that although the authors deny asymmetric adjustments to deviations from the long-run equilibrium, with $\Delta i_{CL(t-1)}$ depending on the sign of $\Delta i_{IM1(t)}$ they implicitly model asymmetric adjustments to previous deviations from the long-term equilibrium.⁴¹

In contrast to the method of Jaenicke and Kirchgässner the method usually applied (as done by Kirchgässner and Kübler (1992) and Borenstein et al. (1992)) is as follows. In order to test if the adjustment

⁴⁰ Jaenicke and Kirchgässner take the IM rate with a one day maturity as a basis for the reference rate.

⁴¹ Nautz (1993) p. 66 f.

differs with regard to positive and negative changes in the explanatory variable, the changes in the explanatory are split into $\Delta i_{IM1}^+ = \max(\Delta i_{IM1}, 0)$ and $\Delta i_{IM1}^- = \min(\Delta i_{IM1}, 0)$ with $\Delta i_{IM1} = \Delta i_{IM1}^+ + \Delta i_{IM1}^-$. Then, the following ECM is estimated:

$$(14) \quad \Delta i_{CL(t)} = d_0 + d_1 i_{CL(t-1)} + d_2 i_{IM1(t-1)} + \sum_{j=0}^p b_{1j}^+ \Delta i_{IM1(t-j)}^+ + \sum_{j=0}^p b_{1j}^- \Delta i_{IM1(t-j)}^- + \sum_{j=1}^p b_{2j} \Delta i_{CL(t-j)} + e_t$$

The main difference to equation (13) is that in equation (14), asymmetric adjustment is only allowed with regard to the exogenous variable. Again, asymmetric adjustments to deviations from the long-run equilibrium are not taken into account.

For modeling asymmetric interest rate adjustments we found equation (14) as more convincing than (13). Therefore, we estimated equation (14) for i_{CLmin} over the total sample and for all other CL rates over each sub-sample. Detailed estimation results for all series, given the hypothesis of no cointegration was rejected before, are shown in table 7 in the appendix. Allowing for asymmetries in the adjustment process of the ECMs does not really effect the estimated long-run relation ECCs. Table 7' gives the estimated long-run equilibria and ECCs. Comparing the values in table 7' with those from symmetric specification in tables 3' and 5' we see that the results do not change remarkably.

Since we are not able to conclude from table 7 if the asymmetries found are in fact significant we had to fall back on the loglikelihood ratio test. In order to carry out this test we had to estimate for each series two specifications with corresponding lag structure, one with and one without modeling asymmetries. The likelihood ratio test is then performed with the loglikelihood values of both specifications. In table 8 the test results are summarized.

Table 7': Long-run equilibrium computed from one step ECM with asymmetric short-run dynamics

| | 1975/2 – 1997/10 | | | 1975/2 – 1989/12 | | | 1991/1 – 1997/10 | | |
|---------------------|---------------------|----------------------|-------|----------------------|----------------------|-------|---------------------|----------------------|-------|
| | ECC | Long-run equilibrium | | ECC | long-run equilibrium | | ECC | long-run equilibrium | |
| | δ_1 | a_0 | a_1 | δ_1 | a_0 | a_1 | δ_1 | a_0 | a_1 |
| Δi_{CLSmin} | | | | -0,23 (-11,22)*** | 3,14 | 0,92 | -0,16 (-3,62)** | 4,51 | 0,78 |
| Δi_{CLSav} | | | | -0,18 (-11,79)*** | 4,23 | 0,92 | | | |
| Δi_{CLSmax} | | | | -0,17 (-8,04)*** | 5,30 | 0,90 | -0,12 (-3,06)* | 9,21 | 0,61 |
| Δi_{CLLmin} | -0,12 (-6,14)*** | 2,22 | 0,90 | | | | | | |
| Δi_{CLLav} | | | | -0,20 (-11,72)*** | 2,67 | 0,94 | -0,10 (-3,30)** | 5,25 | 0,71 |
| Δi_{CLLmax} | | | | -0,25 (-8,96)*** | 3,87 | 0,94 | -0,21 (-4,03)*** | 8,79 | 0,49 |

The t-values for δ_1 in brackets have to be compared with the asymptotic critical values from Banerjee et al. (1992) For * (**, ***) the hypothesis of no cointegration is rejected at the 10% (5%, 1%) level.

Table 8: Testing for asymmetric short-term dynamics

| | 1975/2 – 1997/10 | | 1975/2 – 1989/12 | | 1991/1 – 1997/10 | |
|---------------------|------------------|---------------------|------------------|---------------------|------------------|---------------------|
| | df | Loglikelihood Ratio | df | Loglikelihood Ratio | df | Loglikelihood Ratio |
| Δi_{CLSmin} | | | 1 | 0,00 | 2 | 5,29* |
| Δi_{CLSav} | | | 1 | 2,46(*) | | |
| Δi_{CLSmax} | | | 1 | 6,81*** | 2 | 6,20** |
| Δi_{CLLmin} | 4 | 9,51** | | | | |
| Δi_{CLLav} | | | 1 | 7,54*** | 2 | 14,66*** |
| Δi_{CLLmax} | | | 2 | 2,26 | 1 | 3,33* |

The loglikelihood ratio has to be compared with the χ^2 statistic according to the number of degrees of freedom (df). *** (**, *) indicates that the hypothesis of no asymmetry in the adjustment of i_{CL} to changes of i_{IM1} can be rejected at the 1% (5%, 10%) level. For the loglikelihood ratio of Δi_{CLSav} with 2.46 being relatively close to the critical value of $\chi^2_{(1, \alpha=0.10)} = 2.71$ we decided to accept the short term adjustment of i_{CLSav} to changes in the explanatory variable as asymmetric as well.

As can be seen in table 8 we found several cases of asymmetric adjustments with varying levels of significance. From table 8 we can not draw any conclusion of which type the asymmetries are, i.e. if they are according to our expectation of faster adjustments to increases of the refinance rate than compared to decreases. In order to find out more about the characteristics of the asymmetries it is advisable to refer to the detailed results in table 7. For s1 table 7 gives us clear evidence that the asymmetries are as expected. That is, the CL rates adjust faster to an increase in the rate on IM1 than to a decrease. For s2 and in the case of i_{CLLmin} over the total sample we can not as easily infer about the type of asymmetry found from table 7. Therefore, we computed the cumulative adjustment of the rates on CLs with respect to positive and negative changes in the rate on IM1. The results are shown in graphs 2 – 6 in the appendix. The adjustment path was computed by rearranging the estimated ECMs with asymmetric short term adjustments (from table 7) into their distributed lag form. The total response to a change in the refinance rate is given by the long-run multiplier of i_{IM1} , \hat{a}_1^* . The cumulative adjustment to positive and negative changes in i_{IM1} has to converge to the long-run multiplier. In graph 2 the adjustment paths of the minimum rate on large CLs responding to changes in the rate for IM1 are displayed. The adjustment paths in this case are based on the estimation results over the total sample. Here, we can see that the minimum rate on large CLs is adjusted faster to increases in the marginal refinance rates than to decreases. In other words, the long-run equilibrium between the rates on i_{CLLmin} and i_{IM1} is reached faster for positive changes in the rate on IM1. Looking at the results over the second subperiod s2 in graphs 3 – 6 you will notice that the impact multiplier for increases in the rate on IM1 ($b_0(\Delta i_{\text{IM1}}^+)$) is always zero contrary to the impact multiplier for decreasing rates on IM1, therefore, $b_0(\Delta i_{\text{IM1}}^-) > b_0(\Delta i_{\text{IM1}}^+)$. Only for the maximum rate on large CLs $b_0(\Delta i_{\text{IM1}}^-) = b_0(\Delta i_{\text{IM1}}^+) = 0$. In the next period at $t = 1$ the CL rates are almost completely adjusted to increases in the rate on IM1. That is, the long-run equilibrium is almost reached at $t = 1$ (in the case of the minimum rate). In the case of i_{CLSmax} the cumulative adjustment path to positive changes in i_{IM1} overshoots the long-run equilibrium for a short period and then converges at $t = 3$ while the adjustment to negative changes converges gradually over a period of 12 months, only. For the

average and the maximum rate on large CLs we observe similar overshooting as reactions to increases in the rate on IM1. But now, the adjustment to the long-run equilibrium takes about the same time as to decreases in the rate on IM1. We can state that the adjustment takes place at similar speed while the reaction to increases in the rate on IM1 is much stronger.

5.5. Estimating the interest rate markup as depending on the interest rate regime

Up to now, we found some evidence for asymmetric interest rate adjustments using error correcting models. In the following we want to find out about the implications of the observed asymmetric shortterm adjustments on the markups in the long-run. In order to do so, we allow the markups to differ with respect to the long-term trends the interest rates follow. We call these trends interest rate regimes. A regime characterized by increasing interest rates will be referred to as an upswing period; one characterized by decreasing interest rates will be called downturn period. First, we explain by which means we define the limits of interest rate regimes. Then, we compute the markups by using the estimates of the long-run equilibrium for all CL series given they are cointegrated with i_{IM1} . Last not least, we test our hypothesis of higher markups during downturn periods.

5.5.1 How to define interest rate regimes

In graph 1 on page 2 you can see that the period of our total sample is characterized by two upswings and three downturns of interest rates. From 1979 until 1982 and during the period of 1988 until 1992 the interest rates were characterized by upswings, whereas the rest of the time downturns are evident. In order to fix switching points, which define the limits of periods described by upswings and downturns, we use Bundesbank policy decisions aiming at the liquidity condition in the money

market. As already mentioned in section 2 we will use the historic key interest rates, lombard and discount rate, as signals with regard to the actual monetary policy of the Bundesbank.

After several announcements of decreasing KI rates with the first Bundesbank announcement of increasing interest rates either on lombard or discount loans we declare to enter an upswing period. The same is done for downturns. As can be seen in table 9, using this rule over the whole period we receive 7 subperiods.

Table 9: Bundesbank key interest rate decisions during 2/1975 and 10/1997

| Date of signal | Sign | Number of signals | Total change of rate | Period |
|----------------|------|----------------------|--------------------------------------|-------------------|
| February 1975 | - | n(D) = 6, n(L) = 8 | $\Delta D = -3.0, \Delta L = -4.5$ | 1975/02 – 1978/12 |
| January 1979 | + | n(D) = 5, n(L) = 8 | $\Delta D = 4.5, \Delta L = 8.5$ | 1979/01 – 1981/09 |
| October 1981 | - | n(D) = 4, n(L) = 9 | $\Delta D = -3.5, \Delta L = -7.0$ | 1981/10 – 1983/08 |
| September 1983 | (+) | n(D) = 1, n(L) = 2 | $\Delta D = 0.5, \Delta L = 1.0$ | 1983/09 – 1985/07 |
| August 1985 | - | n(D) = 4, n(L) = 3 | $\Delta D = -2.0, \Delta L = -1.5$ | 1985/08 – 1988/06 |
| July 1988 | + | n(D) = 10, n(L) = 10 | $\Delta D = 6.25, \Delta L = 5.25$ | 1988/07 – 1992/08 |
| September 1992 | - | n(D) = 14, n(L) = 11 | $\Delta D = -6.25, \Delta L = -5.25$ | 1992/09 – 1996/12 |

The first column gives the year and month in which the Bundesbank changed from decreasing to increasing the key interest (KI) rates and vice versa. The second column indicates the direction of interest rate changes. The third column gives the number of changes of the discount rate (D) and the lombard rate (L)⁴² in the sub period. The fourth column shows the total change in KI rates over the subperiod.

Source: Deutsche Bundesbank Monatsbericht Januar 1997

In graph 1 you can notice that during the subperiod from 9/1983 until 7/1985 the CL rates did not adjust to increases in the IM1 rate. This might be due to the fact that the Bundesbank changed the key interest rates only slightly. Moreover, the second increase of the lombard rate was actually not meant as a contractive impact on the money market. Instead, it was necessary for providing a basis for the switch towards the more

⁴² From February 1981 until May 1982 the German Bundesbank did not provide regular lombard loans to the banking industry. Instead they offered so called special lombard loans with rates significantly higher than the lombard rate. For defining the up swing and down turn periods we ignore the fact of the introduction of the special lombard rate.

flexible open market operations. The increase of the lombard rate in February 1985 was employed by the Bundesbank in order to neutralize the simultaneous expansion of open market operations. Taking this fact into account, we observe only one increase in each of the key interest rates. Additionally, during the decrease of interest rates in the previous period the interest rate markup has reached a historic high. Even without adjusting to the increase of marginal cost the interest rate spread was still very high during this subperiod. Therefore, we conclude that this subperiod was less an upswing period but a break in the downward movement of interest rates.

5.5.2 Computing the interest rate markup and testing it for regime dependence

The interest rate markup on CLs (m_{CL}) is computed by

$$(15) \quad m_{CL^*} = i_{CL^*} - \hat{a}_{1(CL^*)} i_{IM1},$$

with \hat{a}_1 being the long-run multiplier estimated in the symmetric ECM and CL^* all six series of CL rates. Since i_{CL} and i_{IM1} are cointegrated by the vector $(1, -\hat{a}_1)$ we treat m_{CL} as stationary.

Now, allowing for changes in the regression according to interest rate regimes we estimate the following model:

$$(16) \quad m_{CL^*(t)} = \beta^+ s_t^+ + \beta^- s_t^- + \varepsilon_t,$$

$$\text{with } \begin{cases} s_t^+ = 1, \text{ during periods when the sign of the Bundesbank signal is positiv, } 0 \text{ else} \\ s_t^- = 1, \text{ during periods when the sign of the Bundesbank signal is negativ, } 0 \text{ else} \end{cases}$$

From our hypothesis of asymmetric adjustments we conclude that $\beta^+ < \beta^-$. We employ a Wald- test in order to test for symmetry, that is, if the spread is the same during both interest rate regimes. In order to model the dynamics still evident in the residuals we include a first order autoregressive term in the estimation. Moreover, seasonal autoregressive terms were added to take account of seasonality. Using the lag operator L the process estimated is given by

$$(17) \quad m_{CL^*(t)} = \beta^+ s_t^+ + \beta^- s_t^- + (1 - \rho L) (1 - f_1 L^{11} - f_2 L^{12}) m_{CL^*(t)} + \varepsilon_t.$$

In table 10 the results from estimating (17) are displayed. As expected, for all cases $\beta^+ < \beta^-$. The results of the Wald- test indicate for 9 out of 10 regressions that we can reject the hypothesis of $\beta^+ = \beta^-$.

Table 10: Estimation of the interest rate regime depending markup

| Markup | β^+ | β^- | ρ | f_1 | f_2 | R ² k | ser | DW | Wald -Test F-stat./ Prob. |
|-----------------------|------------------|------------------|------------------|-------------------|-----------------|------------------|-------|-------|------------------------------------|
| 1975/2 until 1997/10 | | | | | | | | | |
| m_{CLLmin} | 1,740 (10,88) | 2,384 (17,37) | 0,843 (23,69) | -0,204 (-3,62) | 0,292 (5,19) | 0,855 | 0,297 | 2,127 | 21,026 0,000 |
| 1975/2 until 1989/12 | | | | | | | | | |
| m_{CLSmin} | 2,716 (13,73) | 3,146 (17,76) | 0,829 (18,10) | -0,234 (-3,45) | 0,326 (4,80) | 0,804 | 0,326 | 2,160 | 6,004 0,015 |
| m_{CLSav} | 3,722 (17,84) | 4,269 (22,67) | 0,850 (19,89) | -0,245 (-3,52) | 0,290 (4,18) | 0,833 | 0,324 | 2,195 | 9,834 0,002 |
| m_{CLSmax} | 4,737 (18,76) | 5,295 (22,75) | 0,879 (22,75) | -0,268 (-3,74) | 0,232 (3,26) | 0,848 | 0,357 | 2,315 | 8,242 0,005 |
| m_{CLLav} | 1,377 (9,41) | 2,291 (19,71) | 0,716 (12,76) | -0,244 (-3,67) | 0,289 (4,34) | 0,804 | 0,351 | 2,173 | 33,221 0,000 |
| m_{CLLmax} | 3,219 (15,77) | 3,875 (22,26) | 0,720 (12,78) | | 0,268 (3,64) | 0,724 | 0,416 | 2,336 | 10,604 0,001 |
| 1991/01 until 1997/10 | | | | | | | | | |
| m_{CLSmin} | 4,639 (20,12) | 5,017 (34,54) | 0,852 (16,03) | | | 0,880 | 0,189 | 2,360 | 3,481 0,066 |
| m_{CLSmax} | 9,520 (42,68) | 9,788 (67,83) | 0,870 (20,37) | | | 0,908 | 0,164 | 1,951 | 2,193 0,143 |
| m_{CLLav} | 5,359 (31,19) | 5,642 (51,81) | 0,808 (9,59) | | 0,32 (3,02) | 0,806 | 0,116 | 2,125 | 4,773 0,033 |
| m_{CLLmax} | 8,519 (45,09) | 9,000 (96,57) | 0,713 (8,80) | | | 0,776 | 0,223 | 2,391 | 5,726 0,033 |

For the first subperiod, s1, we can state that the percentage increase in the markup during periods of decreasing interest rates is most pronounced for the minimum and average rate of large CLs. For the

minimum (average) rate β^- is 70% (66%) larger than β^+ . While for the maximum rate the markup increases during downwards regimes only by 20%. For small CLs the increase of β^- as compared to β^+ lies in a lower range between 12% and 16%. The difference between β^- and β^+ lies in absolute values around 0.5 (0.8) percentage points for small (large) CLs. If we take the values of \hat{a}_0 from the symmetric ECM in table 5' into account, too, we come to the conclusion that during s1 smaller markups \hat{a}_0 allow greater latitudes for increasing the markups during downturn periods. During the second subperiod the markup for downward movements of interest rates only is increased by 3% to 8%. The difference between β^- and β^+ in absolute values is around 0.3 (0.4) percentage points for small (large CLs). The smaller increases in s2 could be explained by the already very high markups during the periods of increasing rates also. Moreover, for m_{CLLmin} over the total sample the markup is increased by 37% when the interest rates follow a downward trend, in absolute values the markup is then 0.64 percentage points higher.

6. Conclusions

In our analysis we came to the conclusion that it is very important to take into account that by including interest rate quotes from east German banks in 1991 the basis for the interest rate statistic changed. Only by allowing for a structural break in January 1991 we can accept that between the i_{IM1} rate and the minimum, average, and maximum rates on CLs a long-run relationship exists. With the new statistics the long-run relationship has changed. The markups increased while the interest rate elasticity after the structural break decreased to values significantly different from 1.

With regard to our core hypothesis of asymmetric interest rate adjustments we can state that asymmetries are, although not in all cases, evident and significant. The asymmetries do not come into effect through an asymmetric ECM, i.e. varying adjustments to deviations from the long-run equilibrium relationship with regard to their sign. But transitory market

power of banks shows in the asymmetric short term adjustment to changes in the marginal refinance rate. As expected, in several cases adjustments to increasing IM1 rates obviously take place faster than to decreasing ones.

The findings of asymmetric short term adjustments and interest rate regime depending markups are in line. During periods in which interest rates are following an overall negative trend the delayed adjustment of loan rates in response to decreasing refinance rates in general results in higher markups as compared to periods of increasing interest rates.

Moreover, we found that markups on small CLs are always higher than those on large CLs. Apart from the maximum CL rates the difference between markups for small and large CLs has not really been affected by the inclusion of German banks. For the maximum rates the difference decreased enormously indicating in this case a loss of bargaining powers of large customers at a large extent. Bargaining powers almost disappear.

Building on our empirical findings there are several areas of further research: First, it suggests itself to explain the asymmetrical adjustment in interest rates. This can be done through the supply side by oligopolistic behaviour of banks. Bank competition is said to be strong in Germany. One argument for high competition is the number of banks. This number is with more than 3500 banks in fact very high but 2500 of them belong to the type of cooperative banks and more than 600 are savings banks. These are usually no competitors among each other since they are only local suppliers, comparable to the different branches of one large bank. By explaining the asymmetric price adjustments we should also keep in mind the effect of the interbank liquidity adjustment on collusive outcome. Deviations from the collusive interest rates could be punished by shortening the supply of IM for deviators. Another approach would argue from the demand side. Regarding CL we would expect price elasticity to be smaller for short-term than for long-term loans for corporate customers. This could be explained by the fact that short-term loans usually are used for day-to-day settlement of business transactions. Long-term loans on the other side are used for new investment. Therefore, if the loan interest rates seem to be too high in comparison to the banks refinance rates, investors delay the lending whereas they are not as flexible in their short-

term liquidity demand. It would be nice to extend our analysis on long-term investment loans and savings, but data for commercial long term loans are only available from 11/1996.

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Appendix

Graph 2 – 6: Cumulative partial adjustment of the rate on CL* to changes in IM1

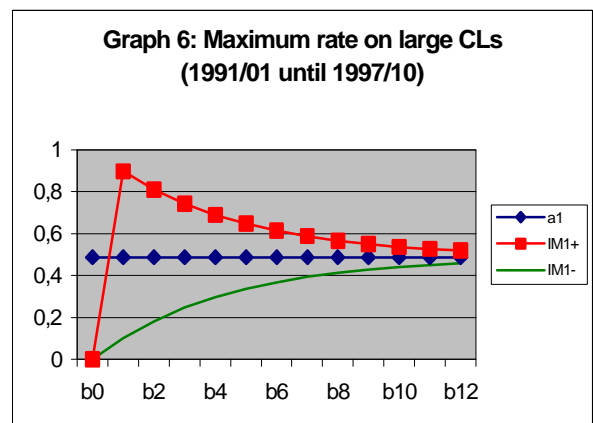
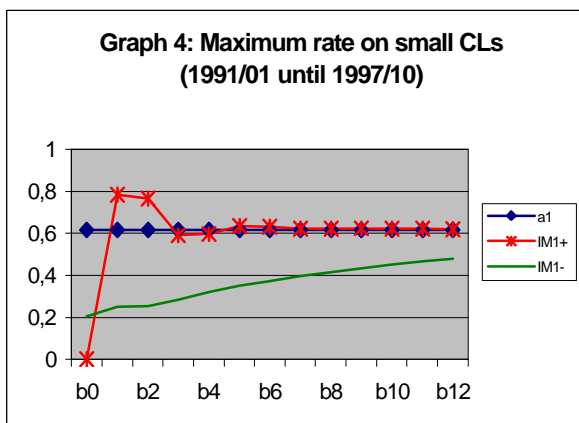
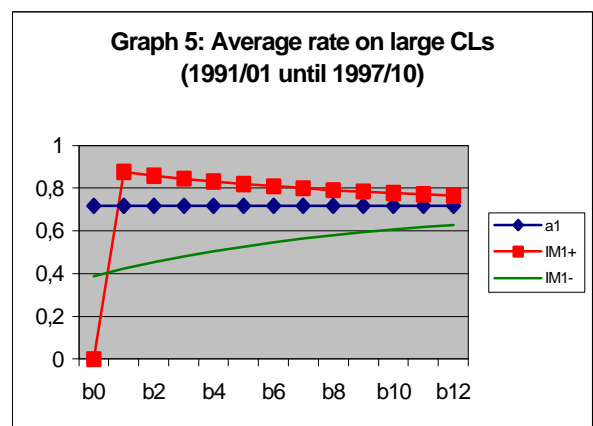
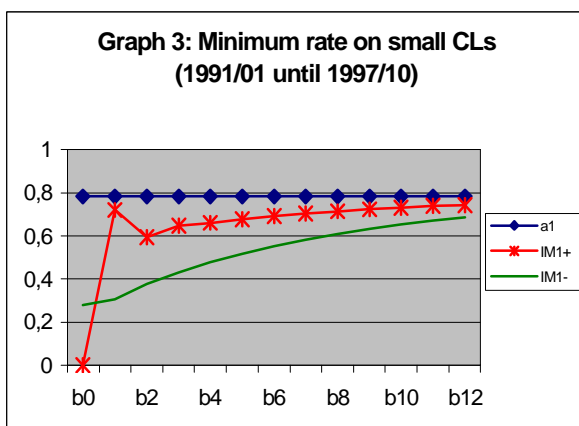
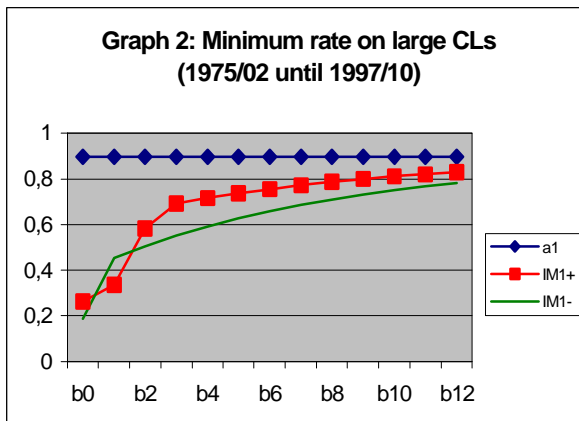


Table 3: Testing for cointegration in the ECM framework over the period from 02/1975 until 10/1997

| | Error correcting term | | | $\Delta i_{IM1(t-j)}$ | | | | $\Delta i_{CL^*(t-j)}$ | | R ² c | ser | DW |
|---------------------|-----------------------|-------------------|-----------------|-----------------------|-----------------|-----------------|-----------------|------------------------|-------------------|------------------|-------|-------|
| | δ_0 | δ_1 | δ_2 | β_{10} | β_{11} | β_{12} | β_{13} | β_{21} | β_{22} | | | |
| Δi_{CLSmin} | 0,375 (4,14) | -0,119 (-5,74) | 0,112 (6,55) | 0,233 (8,44) | 0,100 (2,86) | 0,073 (2,14) | 0,090 (2,95) | -0,102 (-1,82) | -0,158 (-2,84) | 0,481 | 0,176 | 2,011 |
| Δi_{CLSav} | 0,069 (0,99) | -0,029 (-2,52) | 0,037 (3,88) | 0,252 (10,29) | 0,140 (5,42) | 0,104 (4,16) | 0,103 (4,13) | | | 0,526 | 0,158 | 1,984 |
| Δi_{CLSmax} | 0,027 (0,30) | -0,021 (-1,81) | 0,035 (3,65) | 0,253 (8,22) | 0,175 (5,46) | 0,126 (3,62) | 0,124 (3,78) | | -0,184 (-3,08) | 0,400 | 0,198 | 2,072 |
| Δi_{CLLmin} | 0,233 (3,19) | -0,105 (-4,69) | 0,097 (5,18) | 0,247 (8,58) | 0,084 (2,48) | 0,103 (3,24) | 0,066 (2,20) | | | 0,493 | 0,185 | 2,149 |
| Δi_{CLLlav} | 0,063 (1,04) | -0,038 (-2,77) | 0,045 (3,78) | 0,285 (11,53) | 0,174 (6,42) | 0,140 (4,54) | 0,133 (4,88) | | -0,131 (-2,29) | 0,565 | 0,159 | 2,036 |
| Δi_{CLLmax} | -0,063 (-0,66) | -0,010 (-0,71) | 0,029 (2,27) | 0,317 (7,56) | 0,293 (6,11) | 0,186 (3,80) | 0,230 (5,28) | -0,337 (-5,67) | -0,111 (-1,89) | 0,374 | 0,267 | 2,094 |

Insignificant coefficients of lagged changes have been excluded from estimation.

Table 4: Testing for a structural break in January 1991

| | Error-correcting term | | | | | | $\Delta i_{IM1(t-j)}$ | | | | $\Delta i_{CL^*(t-j)}$ | | | R ² c | ser | DW | | |
|---------------------|-----------------------|--------------------|------------------|--------------------|-----------------|-------------------|-----------------------|-----------------|-----------------|-----------------|------------------------|-------------------|-------------------|-------------------|-------------------|-------|-------|-------|
| | Coefficients | | | Dummies | | | β_{10} | β_{11} | β_{12} | β_{13} | β_{21} | β_{22} | | | | | | |
| | δ_0 | δ_1 | δ_2 | d_0 | d_1 | d_2 | | | | | | | | | | | | |
| Δi_{CLSmin} | 0,779 (9,38) | -0,248 (-11,68) | 0,228 (12,07) | -0,072 (-0,33) | 0,090 (2,20) | -0,104 (-3,53) | 0,235 (9,25) | | | | | -0,113 (-2,27) | -0,182 (3,69) | 0,535 | 0,167 | 1,977 | | |
| Δi_{CLSav} | 0,606 (5,54) | -0,150 (-6,85) | 0,145 (7,54) | -0,179 (-0,670) | 0,082 (2,36) | -0,087 (-3,67) | 0,245 (10,66) | 0,061 (2,18) | 0,071 (2,45) | 0,071 (2,77) | | | -0,156 (-2,83) | 0,587 | 0,147 | 2,071 | | |
| Δi_{CLSmax} | 0,814 (6,09) | -0,155 (-7,39) | 0,148 (8,14) | 0,197 (0,44) | 0,045 (1,02) | -0,078 (-3,05) | 0,237 (8,12) | 0,066 (2,05) | | 0,052 (1,69) | | | -0,174 (-3,35) | 0,463 | 0,187 | 2,021 | | |
| Δi_{CLLmin} | 0,353 (5,40) | -0,181 (-8,62) | 0,173 (9,15) | 0,185 (0,93) | 0,028 (0,60) | -0,056 (-1,62) | 0,245 (8,74) | | 0,084 (2,58) | 0,052 (1,74) | | | -0,111 (-2,03) | 0,515 | 0,181 | 2,139 | | |
| Δi_{CLLav} | 0,425 (5,39) | -0,174 (-7,23) | 0,173 (7,72) | 0,138 (0,58) | 0,064 (1,59) | -0,09 (-3,17) | 0,276 (12,01) | 0,085 (3,02) | 0,089 (2,99) | 0,118 (4,18) | | | -0,180 (-3,32) | -0,113 (-2,20) | 0,626 | 0,147 | 2,076 | |
| Δi_{CLLmax} | 0,729 (4,49) | -0,204 (-5,82) | 0,204 (6,42) | 0,271 (0,49) | 0,085 (1,36) | -0,132 (-3,48) | 0,290 (7,31) | 0,147 (2,84) | 0,090 (1,80) | 0,179 (3,82) | | | -0,313 (-5,55) | -0,161 (-2,79) | -0,101 (-1,86) | 0,445 | 0,252 | 2,057 |

$D_t = 0$, for 1975/02 – 1990/12 and $D_t = 1$, for 1991/1 – 1997/10

Insignificant coefficients of lagged changes have been excluded from estimation

Table 5a: Testing for cointegration over the period of 02/1975 until 12/1989

| | Error-correcting term | | | $\Delta i_{IM1(t-j)}$ | | $\Delta i_{CL^*(t-j)}$ | | R ² c | ser | DW |
|---------------------|-----------------------|--------------------|------------------|-----------------------|-----------------|------------------------|-------------------|------------------|-------|-------|
| | δ_0 | δ_1 | δ_2 | β_{10} | β_{11} | β_{21} | β_{22} | | | |
| Δi_{CLSmin} | 0,719 (8,81) | -0,229 (-11,26) | 0,211 (11,70) | 0,234 (8,71) | | | -0,181 (-3,06) | 0,599 | 0,170 | 2,161 |
| Δi_{CLSav} | 0,739 (8,86) | -0,174 (-11,70) | 0,163 (12,76) | 0,243 (9,54) | | | | 0,629 | 0,162 | 1,993 |
| Δi_{CLSmax} | 0,871 (7,06) | -0,160 (-8,94) | 0,148 (9,82) | 0,239 (7,18) | | | | 0,495 | 0,212 | 1,993 |
| Δi_{CLLmin} | 0,389 (6,19) | -0,193 (-10,80) | 0,183 (11,56) | 0,245 (8,20) | | | | 0,571 | 0,191 | 2,011 |
| Δi_{CLLav} | 0,518 (7,65) | -0,193 (-11,39) | 0,187 (12,16) | 0,279 (10,23) | | | | 0,624 | 0,175 | 1,985 |
| Δi_{CLLmax} | 0,829 (5,50) | -0,219 (-7,17) | 0,211 (7,77) | 0,314 (6,96) | 0,106 (1,97) | -0,264 (-4,16) | | 0,467 | 0,281 | 2,049 |

Insignificant coefficients of lagged changes have been excluded from estimation

Table 5b: Testing for cointegration over the period of 01/1991 until 10/1997

| | Error-correcting term | | | $\Delta i_{IM1(t-j)}$ | | $\Delta i_{CL^*(t-j)}$ | | R ^{2c} | ser | DW |
|---------------------|-----------------------|-------------------|-----------------|-----------------------|-----------------|------------------------|-------------------|-----------------|-------|-------|
| | δ_0 | δ_1 | δ_2 | β_{10} | β_{11} | β_{21} | β_{22} | | | |
| Δi_{CLSmin} | 0,994 (5,02) | -0,212 (-6,04) | 0,159 (6,57) | | | -0,184 (-2,03) | | 0,339 | 0,159 | 2,123 |
| Δi_{CLSav} | 0,409 (1,46) | -0,064 (-1,83) | 0,053 (2,57) | 0,193 (2,25) | 0,229 (2,52) | | | 0,334 | 0,124 | 1,954 |
| Δi_{CLSmax} | 1,259 (3,15) | -0,134 (-3,45) | 0,081 (4,13) | | 0,172 (1,74) | | -0,204 (-2,16) | 0,290 | 0,134 | 1,897 |
| Δi_{CLLmin} | 0,585 (2,94) | -0,171 (-3,59) | 0,133 3,97 | 0,385 3,26 | | | -0,198 -2,10 | 0,355 | 0,168 | 2,320 |
| Δi_{CLLlav} | 0,575 (2,59) | -0,108 (-2,91) | 0,078 (3,36) | 0,209 (2,88) | 0,214 (2,71) | | | 0,438 | 0,106 | 2,017 |
| Δi_{CLLmax} | 2,143 (4,70) | -0,243 (-4,98) | 0,122 (5,19) | | | | | 0,240 | 0,208 | 2,237 |

Insignificant coefficients of lagged changes have been excluded from estimation

Table 7: Allowing for asymmetric short term adjustment in the ECMs

| | Error-correcting term | | | $\Delta i_{IM1(t-j)}^+$ | | | | $\Delta \bar{i}_{IM1(t-j)}^-$ | | | | $\Delta i_{CL}^{*(t-j)}$ | | R ² c | ser | DW |
|---------------------|------------------------------|--------------------|------------------|-------------------------|-----------------|-----------------|-----------------|-------------------------------|-----------------|----------------|----------------|--------------------------|-------------------|------------------|-------|-------|
| | δ_0 | δ_1 | δ_2 | β_{10}^+ | β_{11}^+ | β_{12}^+ | β_{13}^+ | β_{10}^- | β_{11}^- | β_{12}^- | β_{13}^- | β_{21} | β_{22} | | | |
| | 1975/02 until 1997/10 | | | | | | | | | | | | | | | |
| Δi_{CLLmin} | 0,257 (3,96) | -0,116 (-6,14) | 0,104 (6,57) | 0,262 (6,46) | | 0,183 (4,23) | 0,072 (1,80) | 0,189 (3,45) | 0,183 (3,03) | | | | | 0,507 | 0,183 | 2,095 |
| | 1975/02 until 1989/12 | | | | | | | | | | | | | | | |
| Δi_{CLSmin} | 0,719 (8,78) | -0,229 (-11,22) | 0,211 (11,54) | 0,235 (6,01) | | | | 0,233 (3,94) | | | | | -0,181 (-3,02) | 0,596 | 0,171 | 2,161 |
| Δi_{CLSav} | 0,740 (8,92) | -0,175 (-11,79) | 0,161 (12,58) | 0,285 (7,69) | | | | 0,169 (3,12) | | | | | | 0,632 | 0,162 | 1,946 |
| Δi_{CLSmax} | 0,880 (6,61) | -0,166 (-8,04) | 0,150 (8,03) | 0,311 (6,45) | | | 0,086 (1,75) | 0,114 (1,59) | | | | | -0,128 (-2,05) | 0,511 | 0,206 | 1,938 |
| Δi_{CLLav} | 0,520 (7,85) | -0,195 (-11,72) | 0,184 (12,14) | 0,357 (9,12) | | | | 0,140 (2,44) | | | | | | 0,638 | 0,171 | 1,928 |
| Δi_{CLLmax} | 0,952 (6,90) | -0,246 (-8,96) | 0,230 (9,21) | 0,357 (5,51) | | | | 0,188 (1,97) | | | | | -0,212 (-3,52) | 0,463 | 0,283 | 2,064 |
| | 1991/01 until 1997/10 | | | | | | | | | | | | | | | |
| Δi_{CLSmin} | 0,735 (3,04) | -0,162 (-3,62) | 0,126 (4,06) | | 0,596 (2,04) | | | 0,281 (1,99) | | | | | -0,187 (-1,97) | 0,365 | 0,154 | 2,090 |
| Δi_{CLSav} | 0,399 (1,595) | -0,064 (-2,06) | 0,051 (2,79) | | 0,796 (3,65) | | | 0,365 (3,50) | | | | | | 0,400 | 0,118 | 1,769 |
| Δi_{CLSmax} | 1,068 (2,73) | -0,116 (-3,06) | 0,071 (3,73) | | 0,705 (2,95) | | | 0,204 (1,77) | | | | | -0,202 (-2,22) | 0,339 | 0,129 | 1,765 |
| Δi_{CLLav} | 0,546 (2,87) | -0,104 (-3,30) | 0,074 (3,74) | | 0,802 (4,47) | | | 0,388 (4,50) | | | | | | 0,528 | 0,097 | 1,854 |
| Δi_{CLLmax} | 1,836 (3,81) | -0,209 (-4,03) | 0,102 (4,00) | | 0,795 (2,21) | | | | | | | | | 0,234 | 0,204 | 2,252 |

Insignificant coefficients of lagged changes have been excluded from estimation