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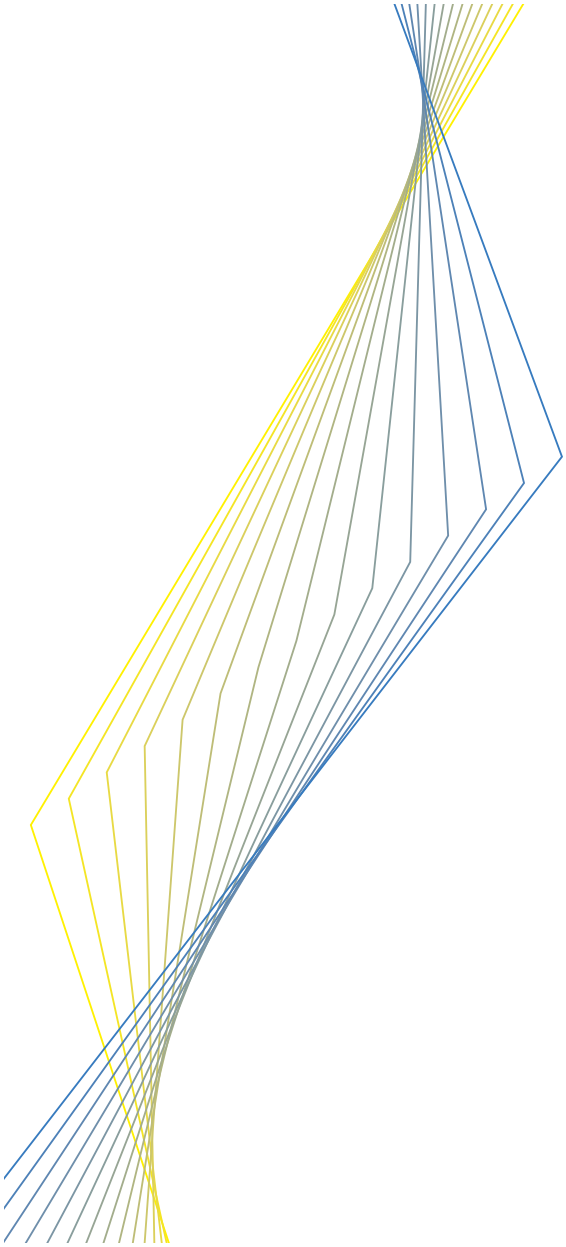

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* *European Central Bank, Kaiserstrasse 29, D-60311, Frankfurt am Main, GERMANY. Telephone: +49 69 1344 6477; fax: +49 69 1344 6514; e-mail address: gabe.de_bondt@ecb.int.* *Comments by Hans-Joachim Klöckers, John Fell, Manfred Kremer and an anonymous referee, and editorial assistance by Sarah Grout are appreciated.* *All views expressed are those of the author alone and do not necessarily reflect those of the ECB or the Eurosystem.*

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Address	**Kaiserstrasse 29**
	D-60311 Frankfurt am Main
	Germany
Postal address	**Postfach 16 03 19**
	D-60066 Frankfurt am Main
	Germany
Telephone	**+49 69 1344 0**
Internet	**http://www.ecb.int**
Fax	**+49 69 1344 6000**
Telex	**411 144 ecb d**

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Contents

Abstract

This paper presents an error-correction model of the interest rate pass-through process based on a marginal cost pricing framework including switching and asymmetric information costs. Estimation results for the euro area suggest that the proportion of the pass-through of changes in market interest rates to bank deposit and lending rates within one month is at its highest around 50%. The interest rate pass-through is higher in the long term and notably for bank lending rates close to 100%. Moreover, a cointegration relation exists between retail bank and comparable market interest rates. Robustness checks, consisting of impulse responses based on VAR models and results for a sub-sample starting in January 1999, show qualitatively similar findings. However, the sub-sample results are supportive of a quicker pass-through process since the introduction of the euro.

Keywords: retail bank interest rates; market interest rates; euro area

JEL classification: E43; G21

Non-technical summary

This paper examines the retail bank interest rate pass-through process in the euro area. This is an important issue to address because a quicker and fuller pass-through of official and market interest rates to retail bank interest rates strengthens monetary policy transmission. The main contribution of this study is that for the first time both bank deposit and lending interest rates at the level of the euro area are analysed using more than one empirical method. Moreover, the marginal cost prices of retail bank instruments are more accurately captured than in previous studies by examining bank and market interest rates that have a comparable maturity, avoiding distortions resulting from maturity mismatches.

On the basis of a survey of interest rate pass-through studies for individual euro area countries and of a theoretical marginal cost pricing framework with switching and asymmetric information costs, a so-called error-correction model for the retail bank interest rate pass-through process is formulated. The key ingredient of this empirical framework is the distinction between the short-term adjustment of the retail bank interest rate to changes in the market interest rate and the possibility of a long-term equilibrium relationship between the retail bank and market interest rate.

Notwithstanding the fact that the empirical findings presented in this study have to be interpreted with more than usual caution because the sample period is short and the interest rate cycles covered are limited, two main conclusions emerge from the empirical analysis.

First, the immediate pass-through of market interest rates to retail bank interest rates is found to be incomplete, in line with previous cross-country studies. The proportion of a given market interest rate change that is passed through within one month is found, at its highest, to be around 50%. In the long term the pass-through is higher and notably for bank lending rates close to 100%. The most sticky retail bank interest rates in the euro area are the interest rates on overnight deposits and deposits redeemable at notice of up to three months with a long-term pass-through of at most 40%. Furthermore, long-term equilibrium relationships exist between retail bank and market interest rates. Robustness checks, which consist of impulse responses based on vector autoregressive models and results for a sub-sample starting in January 1999, confirm these findings.

The second conclusion is that the empirical results suggest a quicker retail interest rate pass-through process since the introduction of the euro. The mean adjustment speed of all considered retail bank interest rates to fully adjust to market interest rate changes has become quicker since January 1999. Furthermore, a quicker immediate pass-through after the start of Stage Three of EMU is found for time deposits and mortgages. These findings could be an indication of an increase in the prevailing competitive forces, i.e. the degree of competition faced by banks and the interest rate elasticity of the demand for retail bank products, and/or a decrease in switching and asymmetric information costs in the different segments of the retail bank market in the euro area since January 1999.

1. Introduction

The retail bank interest rate pass-through process is an important link in the process of monetary policy transmission. Central banks exert a dominant influence on money market conditions and thereby steer money market interest rates. Changes in money market interest rates in turn affect long-term market interest rates and retail bank interest rates, albeit to varying degrees. Bank decisions regarding the yields paid on their assets and liabilities have an impact on the expenditure and investment behaviour of deposit holders and borrowers and thus real economic activity. In other words, a quicker and fuller pass-through of official and market interest rates to retail bank interest rates strengthens monetary policy transmission. Furthermore, prices set by banks influence bank profitability and consequently the soundness of the banking system and financial stability, which in turn may affect economic growth.

This paper aims to provide new insights into the determination of retail bank interest rates in the euro area. The main contribution of this study is that for the first time both bank deposit rates and lending rates at the level of the euro area are analysed using more than one empirical method. In addition, the marginal cost prices of retail bank instruments are more accurately captured than in previous studies by examining retail bank and market interest rates that have a comparable maturity, avoiding distortions resulting from maturity mismatches.

The main empirical findings are as follows. Retail bank interest rates in the euro area are sticky in the short term; the pass-through of market interest rates to retail bank interest rates within one month is found to be at its highest around 50%. In the long term, the pass-through tends to be higher and notably for bank lending rates close to 100%. Moreover, cointegration relationships exist between retail bank and market interest rates. These findings are confirmed by robustness checks, consisting of examining impulse responses based on vector autoregressive (VAR) models and a sub-sample starting with Stage Three of EMU. Finally, fairly supportive evidence is found of a significantly quicker pass-through process since the introduction of the euro. This is likely due to an increase in the degree of competition and the interest rate elasticity of the demand for retail bank products and/or a decrease in switching and asymmetric information costs in the different segments of the retail bank market in the euro area since January 1999.

The paper proceeds as follows. Section 2 briefly reviews interest rate pass-through studies for individual euro area countries. Section 3 presents a theoretical model of the retail bank interest rate pass-through process. The main model characteristics are marginal cost pricing and the existence of switching and asymmetric information costs. Section 4 describes the euro area data on retail bank interest rates analysed in this paper and presents a correlation analysis to detect the most comparable market interest rates for the bank interest rates considered. Section 5 discusses the empirical results based on the error-correction model that takes into account both short-term dynamics as well as the possibility of a cointegration relation between the retail bank interest rate and the comparable market interest rate. Section 6 follows with a robustness analysis by examining impulse responses based on VAR models (Section 6.1) and sub-sample results for the period since January 1999 (Section 6.2). Section 7 summarises with concluding remarks. Appendices A and B provide detailed regression results and impulse responses based on the estimated error-correction and VAR models, respectively.

2. Interest rate pass-through studies for individual euro area countries

While there is voluminous literature on monetary policy transmission, the retail bank interest rate pass-through process has been, at least for several years, surprisingly underexplored. Table 1 summarises the main findings of interest rate pass-through studies performed for individual euro area countries. All studies show cross-country differences in the interest rate pass-through, but no clear pattern of cross-country differences emerge from Table 1. Nevertheless it seems to be the case that short-term bank lending rates to enterprises in Belgium, Spain and the Netherlands adjust less sluggishly after three months compared with the other euro area countries.

Studies from the mid-1990s broadly show that changes in official and/or money market rates are not fully reflected in short-term bank lending rates to enterprises after three months, but that the pass-through is higher in the long term (BIS, 1994, Cottarelli and Kourelis, 1994, and Borio and Fritz 1995). Recent cross-country studies by Kleimeier and Sander (2000), Donnay and Degryse (2001), and Toolsema et al. (2001) confirm this finding. Hofmann (2000) and Mojon (2000) also find short-term sluggishness in short-term bank lending rates to enterprises, but assume a priori a complete long-term pass-through.

As regards long-term bank lending rates to enterprises and households, all studies, except BIS (1994), typically show that the pass-through tends to be less complete than for short-term bank lending rates to enterprises. This finding may be driven by the fact that the marginal cost prices are approximated by money market interest rates which may not be the most appropriate marginal funding costs for long-term loans.

One study examines the adjustment of deposit rates to changes in the money market interest rate in individual euro area countries (Mojon, 2000). The main finding is an incomplete short-term pass-through for deposit rates, notably for savings deposits, and that deregulation has significantly affected the interest rate pass-through process for deposits, but not for loans.

{Table 1}

Several studies also examine the issue of an asymmetric interest rate pass-through process. The response of bank rates to changes in official rates and/or money market rates seems to depend in some cases on whether market interest rates are rising or falling (Borio and Fritz, 1995, and Mojon, 2000) or whether bank interest rates are below or above equilibrium levels as determined by cointegration relations (Hofmann, 2000, and Kleimeier and Sander, 2000).[1]

Industrial organisation based literature examines the pricing behaviour of banks using bank data. The focus of this strand of the literature is typically on the link between bank interest rate margins and the

[1] See Scholnick (1996) for an analysis of an asymmetric interest rate pass-through process in Malaysia and Singapore.

market structure of the banking system (Hannan and Berger, 1991, Neumark and Sharpe, 1992, Angbazo, 1997, Hannan, 1997, Wong, 1997, and Corvoisier and Gropp, 2001). The main lesson of these banking structure studies is that the pricing behaviour of banks may depend on the degree of competition and contestability in the different segments of the retail bank market. For instance, Corvoisier and Gropp (2001) conclude that for demand deposits and loans increasing bank concentration in individual euro area countries during the years 1993–1999 may have resulted in less competitive pricing by banks, whereas for savings and time deposits the opposite seem to be the case.

3. Retail bank interest rate pass-through model

Marginal cost pricing model with switching and asymmetric information costs

In the textbook world of perfect competition with complete information, prices equal marginal costs and the derivative of prices with respect to marginal costs equals one. This derivative typically becomes less than one when the perfect competition and information assumption are relaxed. Applying this idea to the price setting of banks results in the following *marginal cost pricing model* equation (Rousseas, 1985).[2]

$$(1) \quad br = \gamma_0 + \gamma_1 \, mr$$

where br is the price set by banks, that is the bank interest rate, γ_0 is a constant markup and mr is the marginal cost price approximated by a comparable market interest rate. The underlying idea is that market interest rates are the most appropriate marginal cost prices, because of their accurate reflection of the marginal funding costs faced by banks.

The coefficient γ_1 depends on the *demand elasticity* of deposits and loans with respect to the retail bank interest rate. If the demand for deposits and loans is not fully elastic, parameter γ_1 is expected to be less than one. Deposit demand is expected to be relatively elastic with respect to the bank deposit rate when close substitutes for deposits exist, for instance, money market funds. The loan demand elasticity depends, among other factors, on whether borrowers have access to alternative sources of finance.

Parameter γ_1 will also be less than one if banks have some degree of *market power*. Retail bank interest rates in less competitive or oligopolistic segments of the retail bank market adjust incompletely and only with a delay, while bank interest rates set in a fully competitive environment respond quickly and completely (Laudadio, 1987). A wide range of factors influences market power. For instance, entry into the banking sector is restricted by regulatory agencies, creating one of the preconditions for a degree of monopoly power and administrated pricing (Niggle, 1987). Market power and an inelastic demand for

[2] Another approach to model the interest rate pass-through, not followed in this paper, is along the lines of the Klein (1971) - Monti (1971) model or Tobin (1982) model and extensions of these models (Dermine, 1986). These studies particularly focus on the impact of capital requirements on bank pricing policy.

retail bank products may also result from the existence of switching costs and asymmetric information costs.

Switching costs may arise when bank customers consider switching from one bank to another, for example when a household intend to transfer its savings deposits from bank A to bank B. Switching cost, such as costs of acquiring information and search and administrative costs, are potentially important in markets where significant information or transaction costs exist. They are also expected to be high in markets with long-term relationships and repeated transactions (Sharpe, 1997). However, even in the presence of small switching costs, the theory predicts that the smaller the proportion of customers that are "new" to the market, the less competitive prices will be. Klemperer (1987) shows that generally the existence of switching costs results in market segmentation and reduces the demand elasticity. Even with non-co-operative behaviour, switching costs result in a retail bank interest rate adjustment of less than one to a change in the market interest rate (Lowe and Rohling, 1992).

As regards the setting of lending rates by banks, *asymmetric information costs* introduce problems of adverse selection and moral hazard (Stiglitz and Weiss, 1981). If banks increase their lending rates they may attract riskier borrowers (adverse selection) or the increase of lending rates will give adverse incentives for borrowers to choose riskier projects (moral hazard). In other words, banks expected receipts may actually fall when they increase their lending rates even if funding costs increase, if the probability of default rises sufficiently. Consequently, banks will set lending rates below the market clearing rates and ration the amount of credit supply accordingly. In this case of credit rationing, bank lending rates exhibit upward stickiness.

However, this result of lending rate stickiness does not necessarily hold up if credit is not rationed. Consider a world in which there are two broad classes of borrowers to which banks can lend. For the first class of loans, such as fully secured lending, the probability of default is zero, while for the second class of borrowers, the probability of default is positive and increasing in the lending interest rate through adverse selection and moral hazard. Assume that banks can distinguish between the two borrowers types, but not between customers within each class and that banks are risk neutral. Given perfect competition, banks must earn the same expected return on both classes of loans, as formulated in equation (2).

$$(2) \quad br_1 = [1 - P(br_2)]br_2 = \gamma_0 + mr$$

where br_1 is the rate charged by banks on the riskless loan, $P(\cdot)$ is the probability of default on the second class of loan and br_2 is the bank lending rate on these loans.

For the first type of loans $\partial br_1/\partial mr = 1$; that is, changes in the marginal cost of funds get transmitted one for one into changes in the lending rate on the riskless loans. However, when banks are lending to the second borrower type, $\partial br_2/\partial mr > 1$, since $\partial P/\partial br_2 > 0$. For these loans banks must increase their lending rate by an amount greater than the increase in the market interest rate to compensate for the decrease in the probability of repayment. At some interest rate banks will not be able to increase the interest rate sufficiently to compensate for this risk and all lending will be made to the first type of borrower, also

known as the flight to quality phenomenon. However, until this happens, the interest rate should not be sticky on the risky loans. In fact, the reverse is true; the rate on these loans should be very sensitive to changes in the market interest rate. In other words, a more than one-to-one adjustment of bank lending rates to changes in market interest rates, as shown in some cases in Table 1, suggests that bank credit was on average not rationed and consisted of relatively risky loans during the period under review.

Adjustment of retail bank interest rates to market interest rates within error-correction framework

In the presence of fixed adjustment costs retail bank interest rates will adjust to changes in market interest rates only if those adjustment costs are lower than the costs of maintaining a nonequilibrium bank rate (Hannan and Berger, 1991). Consequently, it is important that a time dimension is explicitly considered in the adjustment process of retail bank interest rates to changes in market interest rates. The degree of market power and asymmetric information costs likely have long-term effects, while switching costs are expected to play particularly a role in the short-term adjustment process of bank rates to changes in market interest rates. Demand curves are likely to be more inelastic in the short than in the long term. The greater the elasticity of demand for deposits and loans, the higher the cost of keeping retail bank interest rates out of equilibrium.

Against this background, an appropriate way to specify the adjustment of retail bank interest rates to changes in market interest rates is within an error-correction framework. The main advantage of this empirical approach is that it takes into account both the short-term dynamics as well as the possibility of a cointegration or long-term equilibrium relationship between the bank and market interest rate (Scholnick, 1991, and Winker, 1999). The error-correction model equation to be estimated reads as follows.

$$(3) \quad \Delta br_t = \alpha_1 + \alpha_2 \Delta mr_t - \beta_1 (br_{t-1} - \beta_2 mr_{t-1}) + \varepsilon_t$$

The coefficient α_2 reflects the immediate or short-term pass-through, β_2 the final or long-term pass-through and $(1-\alpha_2)/\beta_1$ equals the mean adjustment lag at which market interest rates are fully passed through to retail bank interest rates (Hendry, 1995). The existence of cointegration between retail bank interest rates and market interest rates can be directly tested by examining the significance of the coefficient of the error-correction term, β_1, using the critical values as proposed by Kremers et al. (1992) and Boswijk (1994).

4. Data

4.1 Retail bank interest rate data

The euro area retail bank interest rates on the deposits and loans considered are average monthly data published by the ECB, including synthetic euro area data before 1 January 1999. From 1 January 2001 onwards, euro area retail interest rate data include Greece. The sample period starts in January 1996 and

ends in May 2001. Of the retail bank interest rates considered almost 100% reflect new business, although the exact definition of new business may differ across countries.[3] Differences in country weights across instruments are large, but fairly stable over time. For instance, the interest rate on deposits redeemable at notice of over three months for the euro area is actually only based on German data.

Charts 1a and 1b plot the average monthly interest rates charged by MFIs in the euro area on the deposits and loans considered, respectively.[4] Chart 1a illustrates that the level of bank deposit rates depends on maturity: typically the lower the maturity of the deposits the lower the deposit rate. The interest rate on overnight deposits is also low compared to other bank deposit rates, partially due to the fact that in France and Ireland this deposit rate is administrated to be zero. Turning to Chart 1b, the maturity of the instruments also plays prima facie a role in determining the level of bank lending rates: the lower the maturity the higher the level of the bank lending rate. This is noteworthy since the yield curve is generally positively sloped. However, the differences in the level of bank lending rates can be explained by differences in secured and unsecured lending practices. Short-term borrowing by enterprises, such as overdrafts, is unsecured, while long-term lending to enterprises is mostly secured on corporate assets. Mortgages are collateralised, while this is typically not the case for consumer credit. Another explanation is that the information and monitoring costs of banks are higher for short-term loans, because borrowers with severe information asymmetries will tend to borrow more heavily at short maturities.[5]

{Chart 1a and 1b}

Charts 2a and 2b provide insight into the relative importance of the different retail bank interest rates by plotting the percentage shares of the deposit and loan categories in terms of the total amount outstanding of Monetary Financial Institutions (MFI) deposits and loans. At the end of 2000, the most important deposits in terms of size were overnight deposits (demand deposits), closely followed by deposits redeemable at notice of up to three months (savings deposits) and deposits with an agreed maturity of over two years (time deposits). Deposits redeemable at notice over three months are very small compared to the other deposit categories considered. As regards loans, loans to households for house purchase and loans to enterprises over one year were the most important in terms of amounts outstanding (each around 30% of total loans). Loans to households for consumer lending and loans to enterprises up to one year were of almost equal importance and amounted to around 18% of total loans at the end of 2000.

[3] The exceptions are the interest rate on overnight deposits, deposits redeemable at notice of up to three months notice and on loans to enterprises up to one year. For the two deposit rates the distinction between amounts outstanding and new business is rather artificial because of the short-term nature of these deposits. As regards the lending rate, it is only for one country that the lending rate does not reflect close to 100% new business.

[4] See ECB (2001) for charts of the spread between retail bank interest rates and comparable market interest rates.

[5] See Section 1.6 on debt maturity theories in De Bondt (2000).

{Chart 2a and 2b}

4.2 Correlation analysis between retail bank interest rates and market interest rates

This section presents a correlation analysis between retail bank rates and market interest rates. The aim is to detect which market interest rates are most closely related to the bank interest rate analysed. The idea is to capture adequately the marginal cost price. A distinction is made between the correlations of the variables in levels and in first differences (the change in the interest rate). The market interest rates analysed, with Reuters as data source, are the overnight market interest rate, money market rates at 1, 3, 6 and 12 months maturities and government bond yields at 2, 3, 5 and 10 years maturities. Correlations are computed both across maturities and for different lags of the market interest rates. Table 2 presents the results of the correlation analysis for the sample starting in January 1996 as well as two sub-samples: 1996.01–1998.12 and 1999.01–2001.05 (EMU sample).

Looking at the total sample results (see column 2–4 in Table 2), the correlation coefficients in level terms broadly vary between 0.89 and 0.98 implying that bank and market rates move closely together. The lag with the highest correlation varies between 1 and 8 months, suggesting that retail bank rates do not collectively react by the same speed to market interest rate changes. In first differences, the correlation coefficients are lower with a range of 0.52 and 0.77. For all bank interest rates the same or a lower "optimal" lag applies than for the levels.

{Table 2}

As regards the two sub-samples, the same qualitative picture emerges. However, two striking differences emerge when comparing the two sub-samples. First, the correlation coefficients for the sample starting in January 1999 are higher than for the years 1996–1998. Secondly, the lags with the highest correlation are typically lower for the EMU sample than for the three-year sample starting in January 1996. These findings suggest that the co-movement between retail bank rates and market interest rates has become closer since the introduction of the euro, suggesting a quicker interest rate pass-through process since the start of Stage Three of EMU. Section 6.2 addresses this issue in more detail.

The last column of Table 2 shows the comparable market rates selected for the empirical analyses of Section 5 and 6. Generally, it is fairly clear what the most relevant market interest rate is; at least three of the six cases in Table 1 indicate the same comparable market interest rate. For the interest rate on deposits redeemable at notice of over three months the results for the EMU sample determine the selected market interest rate because this deposit rate is a 100% German interest rate and euro area money market interest rates are considered. For the mortgage interest rate the five-year government bond yield is chosen as the most comparable market interest rate, because European Mortgage Federation country level data indicate that the most common mortgage rate in euro area countries is an initial fixed period rate of at least five

years. Moreover, around 95% of all MFI loans to households for house purchase have an original maturity of over five years.

5. Empirical analysis

Error-correction framework: immediate and final pass-through and speed of adjustment

Table A.1 in Appendix A provides the detailed estimation results of the error-correction models. As regards a statistical assessment of the regression results, the multiple correlation coefficients adjusted for degrees of freedom indicate that the model equations explain around 30% of the variation in the bank rate on overnight deposits and deposits redeemable at notice of up to three months and between 54% and 83% for the other retail bank interest rates. The standard errors of the regressions vary between 4 basis points for the interest rate on overnight deposits and deposits redeemable at notice of up to three months and 6 to 8 basis points for the other retail bank interest rates. In most, but not in all cases, the residuals are statistically well behaved. Some irregularities might arise because of an omitted variables problem due to the fact that factors other than the market interest rate might play a role in the determination of retail bank interest rates and because of measurement errors in the interest rate series.[6]

Along the line of the three components of the interest rate pass-through process, three conclusions emerge from an economic assessment of the estimation results as summarised in Table 3.

First, the immediate pass-through of market interest rates to retail bank interest rates is found to be incomplete, in line with previous country studies. The proportion of a given market interest rate change that is passed through within one month is found to be typically around 30% during the sample period. The highest immediate pass-through is found to be 54% in the case of the interest rate on lending to enterprises over one year. This may be explained by a relatively elastic loan demand, since firms have access to alternative sources of funds, such as trade credit (Kohler, Britton and Yates, 2000) and the corporate bond market.

The second conclusion is that the final pass-through of market interest rates to retail bank interest rates is typically complete or even well above 100%, as in the case of loans to enterprises of up to one year. This overshooting may, among other factors, be explained by asymmetric information costs without credit rationing, as described in Section 3. If banks increase their lending rates exactly one-for-one with market interest rates they will attract a more risky class of borrowers. Consequently, banks have to increase the lending rate premium charged. The final pass-through is clearly incomplete for the interest rates on overnight deposits and deposits redeemable at notice of up to three months. Explanations for this finding

[6] Besides measurement errors in retail bank interest rates measurement errors arise because in some cases end-of-month government bond yield data are used while the retail bank interest rates are monthly average data. Government bond yields in the euro area, except for the 10-year maturity, are only available as end-of-period data up to December 1998.

might be that these segments of the retail bank market are not fully competitive or that the switching costs of demand and savings deposits are relatively high.

Thirdly, the average speed for retail bank interest rates to fully adjust to market interest rate changes is typically between 3 and 10 months. Exceptions to this finding are the slow speed of adjustment between 1 and 2 years for the interest rate on overnight deposits and deposits redeemable at notice of over three months. The latter finding is biased because this deposit rate is actually a German interest rate, while an euro area market interest rate is considered. This also explains why for this deposit rate no cointegration relation with the market interest rate is found. In all other cases a long-term equilibrium relationship exists between the retail bank interest rate and the comparable market interest rate. Regarding lending rates, the speed of adjustment of around 9 months as found for the interest rates on lending to enterprises with a maturity up to one year and on consumer lending is much slower than for the other lending rates which show a mean adjustment speed of around 3 months. This difference might be explained by the fact that the asymmetric information costs are higher for unsecured lending than for secured lending.

In sum, the pass-through process clearly differs across retail bank interest rates in the euro area. The most notable sluggish retail bank rates are the interest rate on overnight deposits and deposits redeemable at notice of up to three months. Furthermore, retail bank interest rates adjust to changes in market interest rates with a delay and incompletely in the short term. At the same time, long-term equilibrium relationships exist between retail bank interest rates and market interest rates, and most bank interest rates fully adjust to changes in market interest rates in the long term.

{Table 2}

6. Robustness analysis

This section presents two robustness checks: i) the interest rate pass-through process based on another empirical framework, namely impulse responses based on bivariate VAR models and ii) applying both empirical methods using a sample starting in January 1999 (EMU sample) instead of January 1996 (pre-EMU sample).

6.1 Impulse response analysis

VAR framework: adjustment of retail bank interest rates to market interest rate shocks

The main advantage of a VAR framework is that it lets the data "speak for itself". The appropriate specification of a VAR model with integrated, i.e. I(1) variables, and possibly cointegrated variables is a debated issue in the literature. Broadly speaking, three different ways to specify a VAR model can be distinguished: a VAR model specified in levels, a specification in first differences, or a Vector Error Correction Model (VECM) form. This paper applies a VAR model in levels, because the main advantage

of a level VAR specification is that it maximises the long-term information in the data set and delivers super-consistent coefficient estimates. In contrast, imposing inappropriate cointegration relations can lead to biased estimates and hence may bias the impulse responses derived from the reduced form VARs. This possible bias may be even more relevant as interest rates are only near-integrated variables, that is variables that usually contain a root close to, but less than one.

A uniform lag order is applied for all interest rate pairs to allow differences in the pass-through process across instruments to be compared. Moreover, overparameterisation is considered to be a larger problem than underestimation of the lag order given the short sample. The lag order is therefore set at two months, as low as possible given the wide range of optimal lag orders derived from the Akaike, Hannan-Quin and Schwartz criteria and the residual properties. This leads to the following uniform VAR model specification.

$$(4) \quad Y_t = c + \sum_{i=1}^{2} A_i Y_{t-i} + \varepsilon_t$$

With:

$$Y_t = \begin{bmatrix} market\ rate \\ bank\ rate \end{bmatrix}_t \quad \varepsilon_t = \begin{bmatrix} \varepsilon^{mr} \\ \varepsilon^{br} \end{bmatrix}_t \quad c = \begin{bmatrix} c^{mr} \\ c^{br} \end{bmatrix}_t \quad A_i = \begin{bmatrix} a_i^{mr} & b_i^{mr} \\ a_i^{br} & b_i^{br} \end{bmatrix}$$

In computing the impulse response functions the missing identification of the contemporaneous relationships between each pair of interest rates is solved by using the traditional Cholesky decomposition of the residual variance-covariance matrix (Hamilton, 1994). This decomposition boils down to a recursive assumption where zero-restrictions are imposed on the simultaneous correlation among residuals. As a result, the ordering of the variables is crucial. The intuition of this decomposition is that a shock on the last ordered variable in the system does not contemporaneously affect the previous one. For the interest rate pass-through analysis, the Cholesky decomposition method matches well with economic intuition. With the order of equation (4) a shock in the retail bank interest rate will have no contemporaneous effect on the market interest rate, while shocks in market rates may have an immediate impact on retail bank interest rates.

Pass-through process within VAR framework

The interest rate pass-through process according to the impulse responses plotted in Charts B.1a and B.1b in Appendix B is summarised in Charts 3a and 3b. These charts plot how a temporary shock to the market interest rate is passed through to bank deposit and lending rates, respectively. Three main conclusions emerge from Charts 3a and 3b.

The first conclusion is that shocks in the market interest rates are not immediately reflected in retail bank interest rates. In other words, bank interest rates are sticky in the short term. The immediate response of deposit rates to a one percentage point shock to the market interest rate varies between around 3 basis

points for overnight deposits and deposits redeemable at notice of up to three months and 33 basis points for deposits with an agreed maturity of over two years. The immediate pass-through of a one percentage point shock in the market interest rate to a bank lending rate varies between 13 basis points for consumer lending and 52 basis points for loans to enterprises of over one year.

Secondly, the pass-through of a market interest rate shock is higher in the longer term. After 12 months the pass-through for deposits rates varies between 15% (overnight deposits) and 68% (time deposits) and for bank lending rates between 44% (consumer lending) and 76% (loans to enterprises up to one year and loans to households for house purchase). After 36 months the pass-through is far from complete for the overnight deposits and deposits redeemable at notice of up to three months, but almost fully complete (around 90%) for time deposits and loans. The exception is loans to enterprises up to one year that shows, in line with the error-correction model outcome, a pass-through of around 145%. This overshooting of the bank lending rate suggests a move towards riskier borrowers during the period under review.

The third conclusion, closely related to the other two conclusions, is that the interest rate pass-through process clearly differs across instruments. The interest rates on overnight deposits and deposits redeemable at notice of up to three months are sticky compared to other bank deposit rates. This can be explained to some extent by the fact that these euro area deposit rates are administered in some euro area countries. Moreover, these instruments are often targeted at the general public, which uses them for convenience reasons (inelastic demand). The interest rate on consumer lending is sticky compared to the other bank lending rates, suggesting relatively weak competition, an inelastic demand and/or high switching and asymmetric information costs in the consumer credit market. Another likely explanation of the stickiness in the interest rate on consumer lending is a relatively high degree of credit rationing in this segment of the credit market during the period under review.

In sum, the overall findings based on the VAR framework are fairly similar to the results based on the error-correction framework.

{Chart 3a and 3b}

6.2 EMU sub-sample results

As earlier mentioned in Section 4, correlation coefficients between bank and market interest rates at different time lags show that the co-movement between both interest rates has become closer since the introduction of the euro, suggesting a quicker pass-through process since the introduction of the euro. This section examines the hypothesis of a quicker retail interest rate pass-through since the start of Stage Three of EMU in more detail by applying the two empirical methods to a sub-sample starting in January 1999.

Pass-through process since the introduction of the euro within error-correction framework

Table A.2 in Appendix A provides detailed estimation results for the error-correction model based on the EMU sample. As regards a statistical assessment of the regression results based on the EMU sample compared with the sample including pre-EMU data, the explanatory power of the EMU sample is clearly higher than for the pre-EMU sample. The multiple correlation coefficients adjusted for degrees of freedom are substantially higher and the standard errors of regression lower, notably for deposit interest rates.

Table 4 summarises the pass-through process since the introduction of the euro and compares the results based on the EMU sample with the estimated pre-EMU coefficients. The table confirms the main findings based on the pre-EMU sample: sticky retail bank interest rates in the short term, a close to complete pass-through in the long term, a cointegration relation between bank and market interest rates and striking differences in the pass-through process across retail bank instruments.

Comparing the findings based on the EMU sample with the results from the pre-EMU sample, three observations emerge.

The first observation is that Chow breakpoint tests, analysing a structural break for the error-correction model at January 1999, indicate a significant change in the pass-through process since 1 January 1999 in all cases with the exception of the interest rate on consumer lending. The impact of the introduction of the euro is, for all retail bank interest rates, reflected in a quicker speed of adjustment, which in most cases is statistically significant. The mean adjustment lag since January 1999 is typically 1 month for deposit interest rates and 3 months for bank lending rates. Exceptions are the interest rate on deposits redeemable at notice of up to three months and on consumer lending with an adjustment speed of 4 and 6 months, respectively. An explanation for the quicker adjustment speed of deposit interest rates compared with lending rates is that credit risk considerations due to asymmetric information costs play no role in the determination of bank deposit rates.

Secondly, the proportion of a given market interest rate change that is immediately passed through to the interest rate on mortgages and on deposits with a maturity of over two years has significantly increased since the start of Stage Three of EMU by around 20 and 10 percentage points, respectively. This suggests a rise in the prevailing competitive forces (market power and demand elasticity) and/or a fall in switching and asymmetric information costs in these segments of the retail bank market.

A third difference between both sets of findings is that for the period since 1 January 1999 the final pass-through to interest rates on loans to enterprises up to one year is no longer more than 100%. At the same time, for the interest rate on consumer lending an incomplete long-term pass-through is found for the period since the introduction of the euro, suggesting a certain degree of credit rationing in this segment of the credit market. More generally, for all retail bank interest rates, except the mortgage interest rate, the final pass-through found for the EMU sample is lower than for the pre-EMU sample. In several cases this effect is statistically significant. This suggests, in contrast to the other findings presented, a less competitive pricing by banks since the introduction of the euro. This is in line with the finding of

Corvoisier and Gropp (2001) that increasing concentration may have resulted in less competitive pricing for loans and demand deposits during the years 1993–1999. Moreover, broadly speaking the final pass-through for deposits is lower than for lending rates. This may be explained by a lower elasticity of the demand for deposits with respect to the market interest rate than for loans as shown by money and loan demand studies for the euro area. For money demand in the euro area Calza, Gerdesmeier and Levy (2001) find a semi-elasticity with respect to the opportunity cost of M3 between 0.6 and 0.9. As regards the demand of firms and households for loans in the euro area, Calza, Gartner and Sousa (2001) find a semi-elasticity with respect to the short-term interest rate of 0.4 to 1.0 and to the long-term interest rate of 1.8 to 3.1. However, it should be kept in mind that these interest rate elasticities are based on total deposits and loans, whereas this paper examines specific components of total deposits and loans.

{Table 4}

Pass-through process since the introduction of the euro within VAR framework

Charts B.2a and B.2b in Appendix B plot impulse response functions based on estimated VAR models for the period since the introduction of the euro. Charts 4a and 4b provide an overview of the retail interest rate pass-through process since January 1999 based on a VAR approach.

Broadly speaking, the picture emerging from Charts 4a and 4b is similar to that of Charts 3a and 3b. There are, however, two striking differences between both sets of charts.

The first difference relates to the extent by which market interest rate shocks are immediately passed through to retail bank interest rates. The share of the immediate pass-through of a market interest shock to the interest rate on deposits redeemable at notice of over three months, time deposits and on loans to households for house purchase has increased since the introduction of the euro by around 15 percentage points. Looking at the pass-through during the first year, the results suggest a quicker pass-through of changes in market interest rates to these bank interest rates since January 1999.

The second observation is that only for mortgages the difference in the pass-through, if any, remains substantial in the longer term. The proportion of a shock to the five-year government bond yield passed through between 12 and 36 months to the mortgage interest rate is at least 20 percentage points higher for the period since the introduction of the euro compared with a sample starting in January 1996. The interest rate on lending to enterprises up to one year no longer overshoots, in line with the error-correction model outcomes.

In sum, the results based on the VAR and error-correction frameworks are fairly similar. The findings of both empirical methods are supportive of a quicker interest rate pass-through process since January 1999. A likely driving factor for this finding is an increase in the degree of competition in the euro area banking system after the start of Stage Three of EMU, a more elastic demand for retail bank products with respect to bank interest rates and/or declining switching and asymmetric information costs.

{Chart 4a and 4b}

7. Concluding remarks

This paper is the first study that analyses the interest rate pass-through process at the euro area level using more than one empirical method. Furthermore, the paper explicitly focuses on how changes in market interest rates with a comparable maturity, as the most appropriate marginal pricing costs, are passed through to bank deposit rates as well as bank lending rates. Notwithstanding the fact that the empirical findings presented in this paper have to be interpreted with more than usual caution because the sample period is short and the interest rate cycles covered are limited, two main conclusions emerge from the empirical results presented which are fairly robust.

The first conclusion is that the immediate pass-through of market interest rates to retail bank interest rates is incomplete, in line with previous cross-country studies. The proportion of a given market interest rate change that is passed through within one month is found, at its highest, to be around 50%. The pass-through is higher in the longer term and notably for bank lending rates close to 100%. The most sticky retail bank interest rates in the euro area are the interest rates on overnight deposits and deposits redeemable at notice of up to three months with a long-term pass-through of at most 40%.

Secondly, the empirical results suggest a quicker retail interest rate pass-through process in the euro area since the introduction of the euro. For all retail bank interest rates the mean adjustment speed has become quicker since January 1999. Furthermore, a quicker immediate pass-through since the introduction of the euro has been found for time deposits and mortgages. These findings could be an indication of an increase in the prevailing competitive forces, i.e. less market power and/or a more interest rate elastic demand for retail bank products, and/or a decrease in switching and asymmetric information costs in the euro area banking system after the start of Stage Three of EMU.

The issue of the underlying reasons for differences in the retail bank interest rate pass-through over time and across retail bank instruments, for instance the role of competitive forces, warrants in particular future research. Another topic for future research, as soon as a more extended EMU interest rate cycle becomes available, is the possibility of an asymmetric interest rate pass-through process in the euro area.

Appendix A Estimation results error-correction model

{Table A.1}

{Table A.2}

Appendix B Impulse responses of bank deposit and lending rates

{Chart B.1a}

{Chart B.1b}

{Chart B.2a}

{Chart B.2b}

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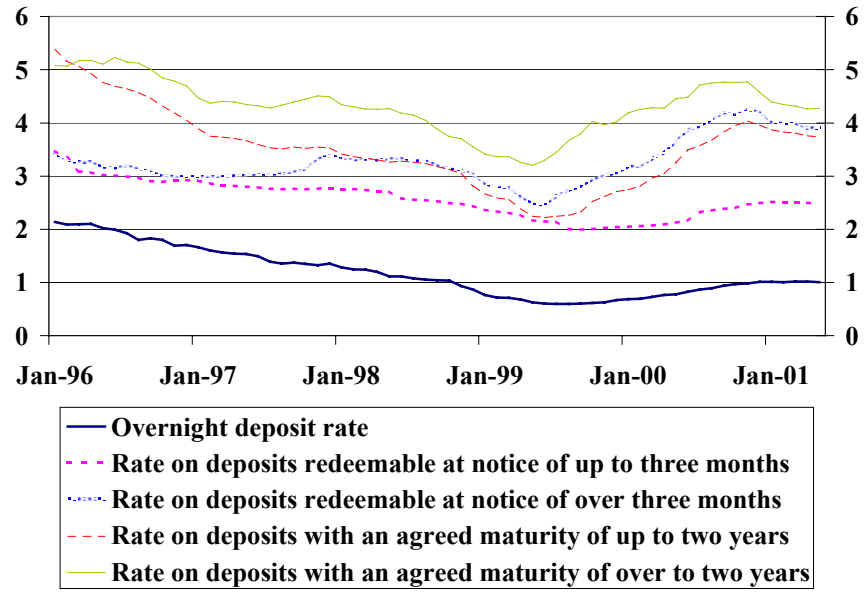
Chart 1a Bank deposit rates

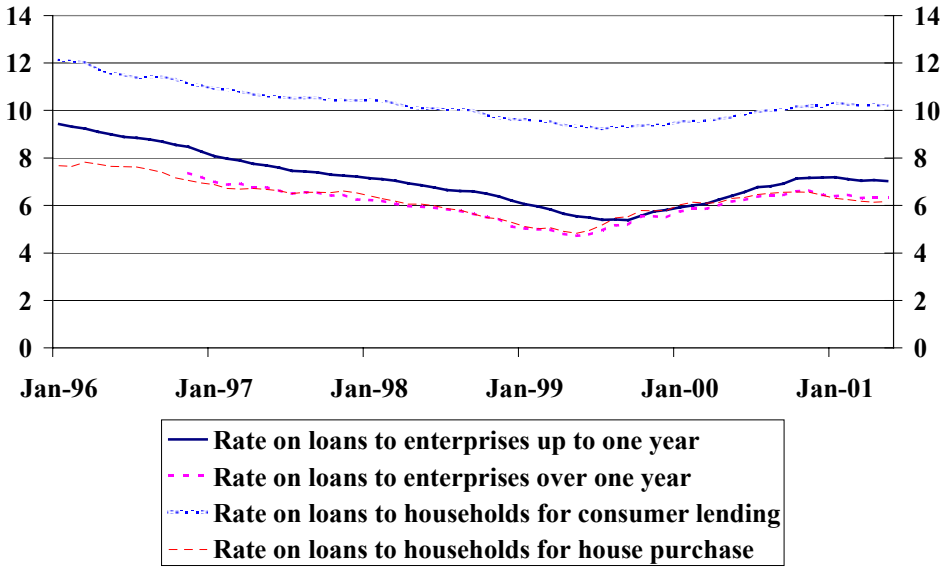
(percentages per annum; monthly averages)



Source: ECB.

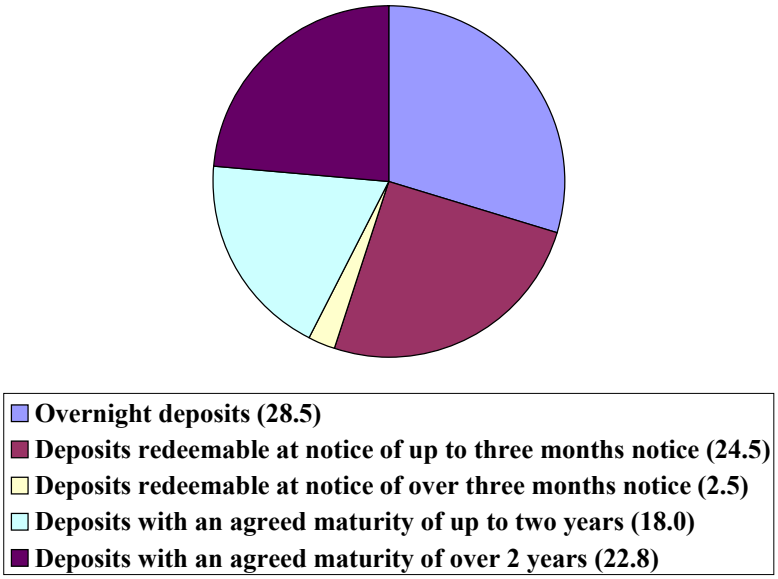
Chart 1b Bank lending rates

(percentages per annum; monthly averages)



Source:ECB.

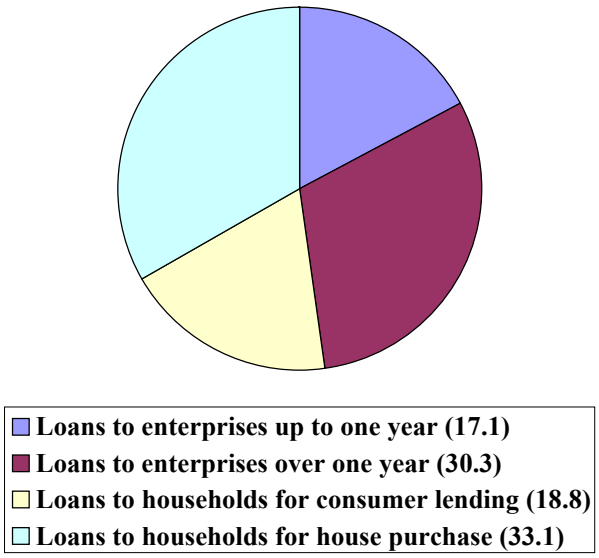
Chart 2a Percentage shares in total MFI deposits, end-2000[1)]



Source: ECB

[1)] Repurchase agreements are not considered (3.7% of total deposits).

Chart 2b Percentage shares in total MFI loans, end-2000[1)]

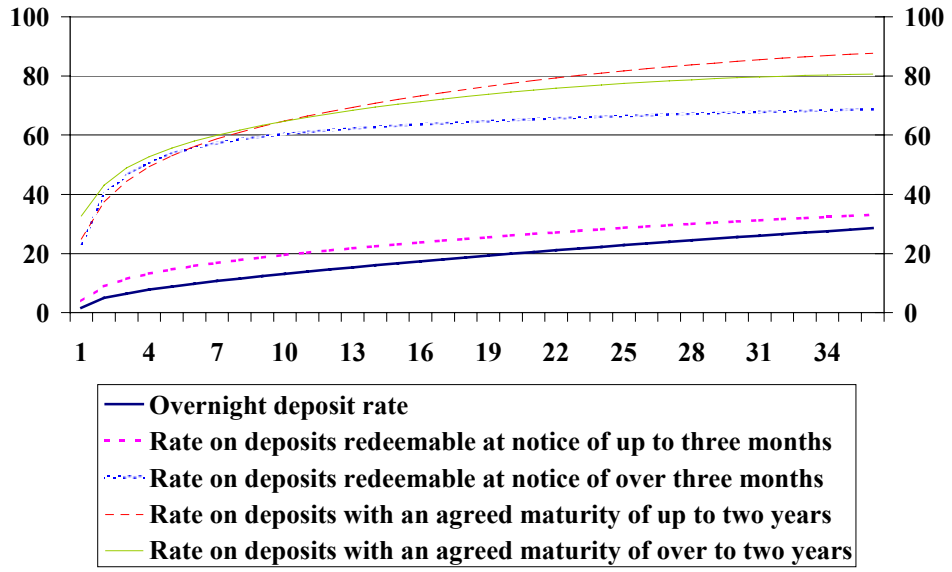


Source: ECB.

[1)] Loans to non-profit institutions serving households are not considered (0.7% of total loans); consumer credit (8.4% of total loans) and other lending to households (10.4% of total loans) are aggregated.

Chart 3a Overview bank deposit rate pass-through based on VAR framework

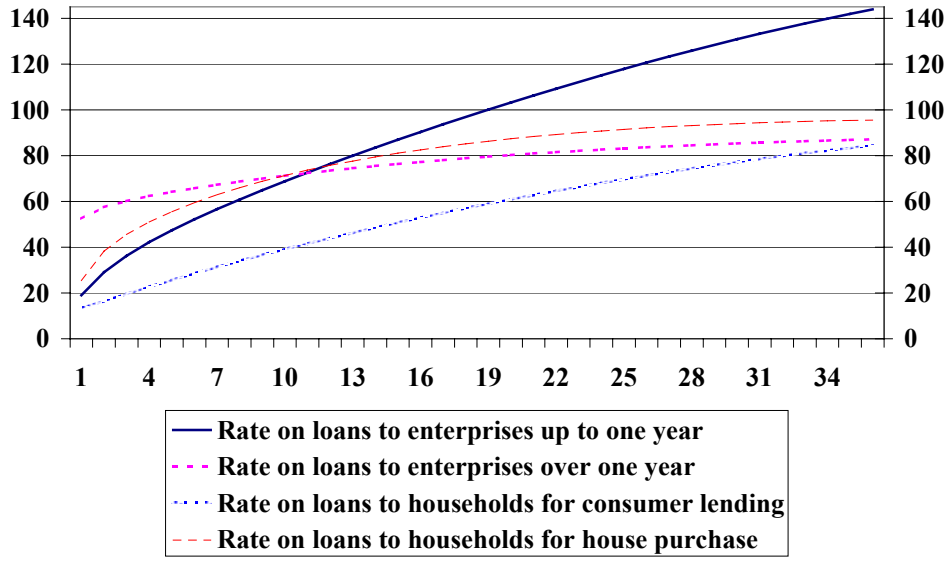
(percentage shares of cumulative market interest rate shock passed through to bank deposit rate)



Sources: ECB, Reuters and author's estimations.

Chart 3b Overview bank lending rate pass-through based on VAR framework

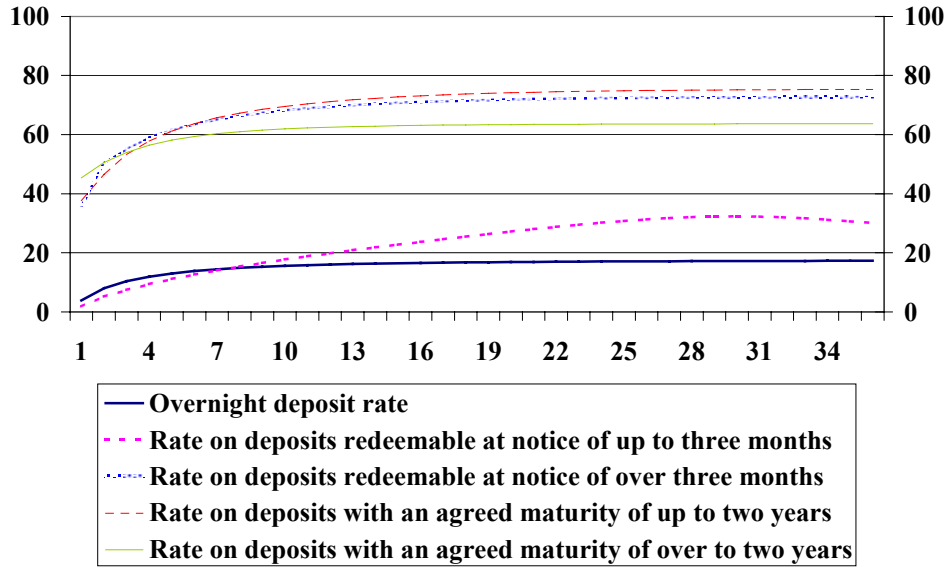
(percentage shares of cumulative market interest rate shock passed through to bank lending rate)



Sources: ECB, Reuters and author's estimations.

Chart 4a Overview bank deposit rate pass-through based on VAR framework since 1 January 1999

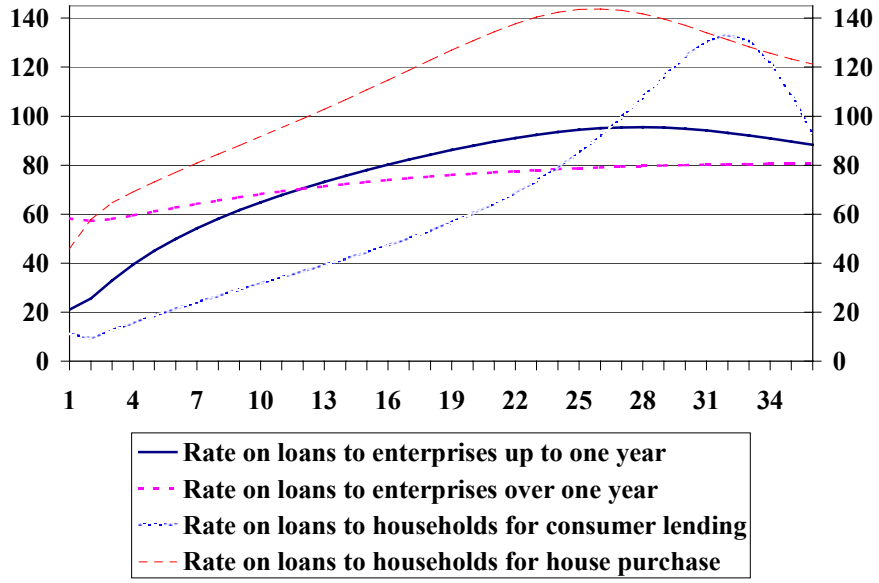
(percentage shares of cumulative market interest rate shock passed through to bank deposit rate)



Sources: ECB, Reuters and author's estimations.

Chart 4b Overview bank lending rate pass-through based on VAR framework since 1 January 1999

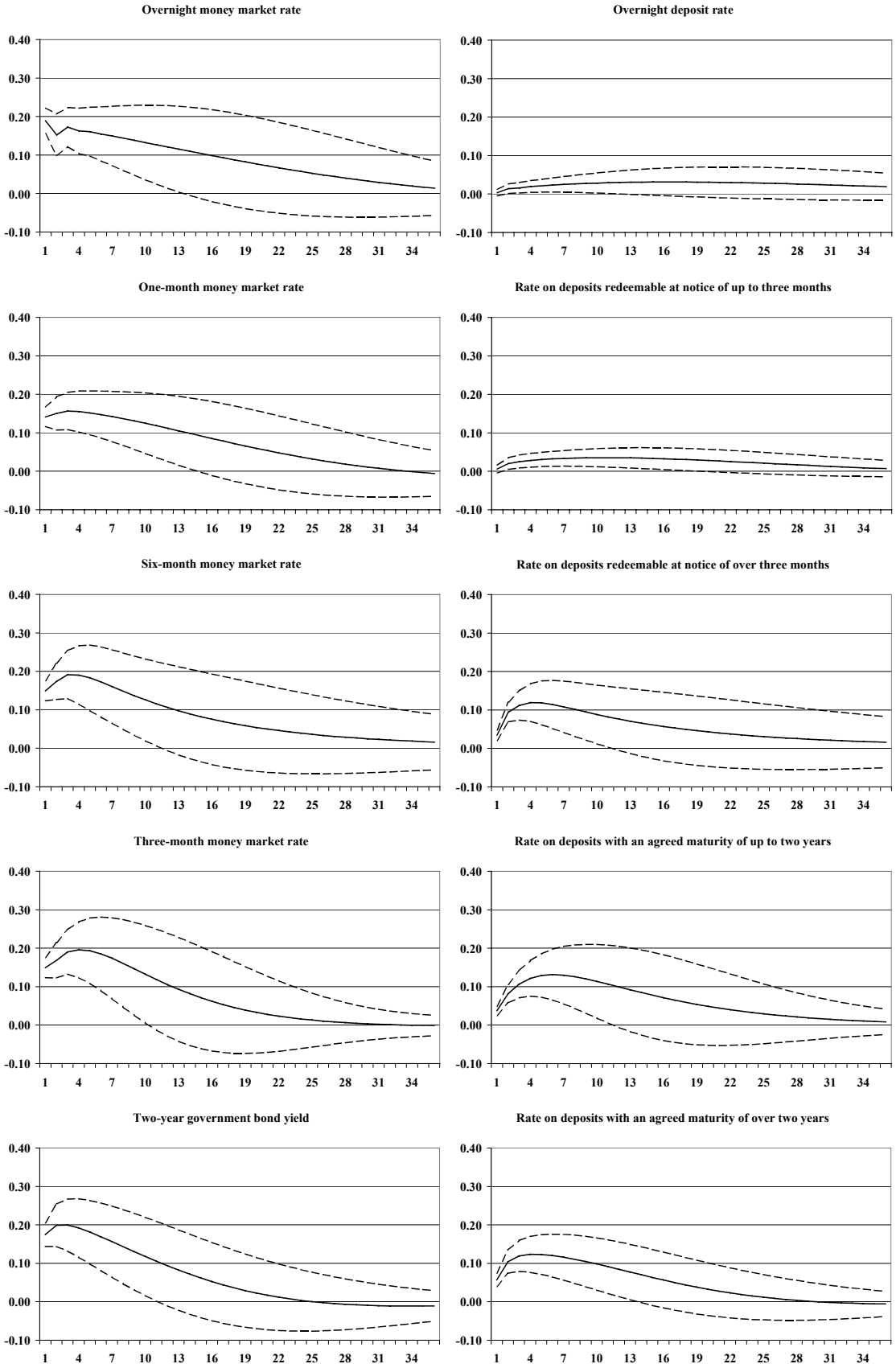
(percentage shares of cumulative market interest rate shock passed through to bank lending rate)



Sources: ECB, Reuters and author's estimations.

Chart B.1a Impulse response of bank deposit rate to a one standard-deviation innovation to market interest rate

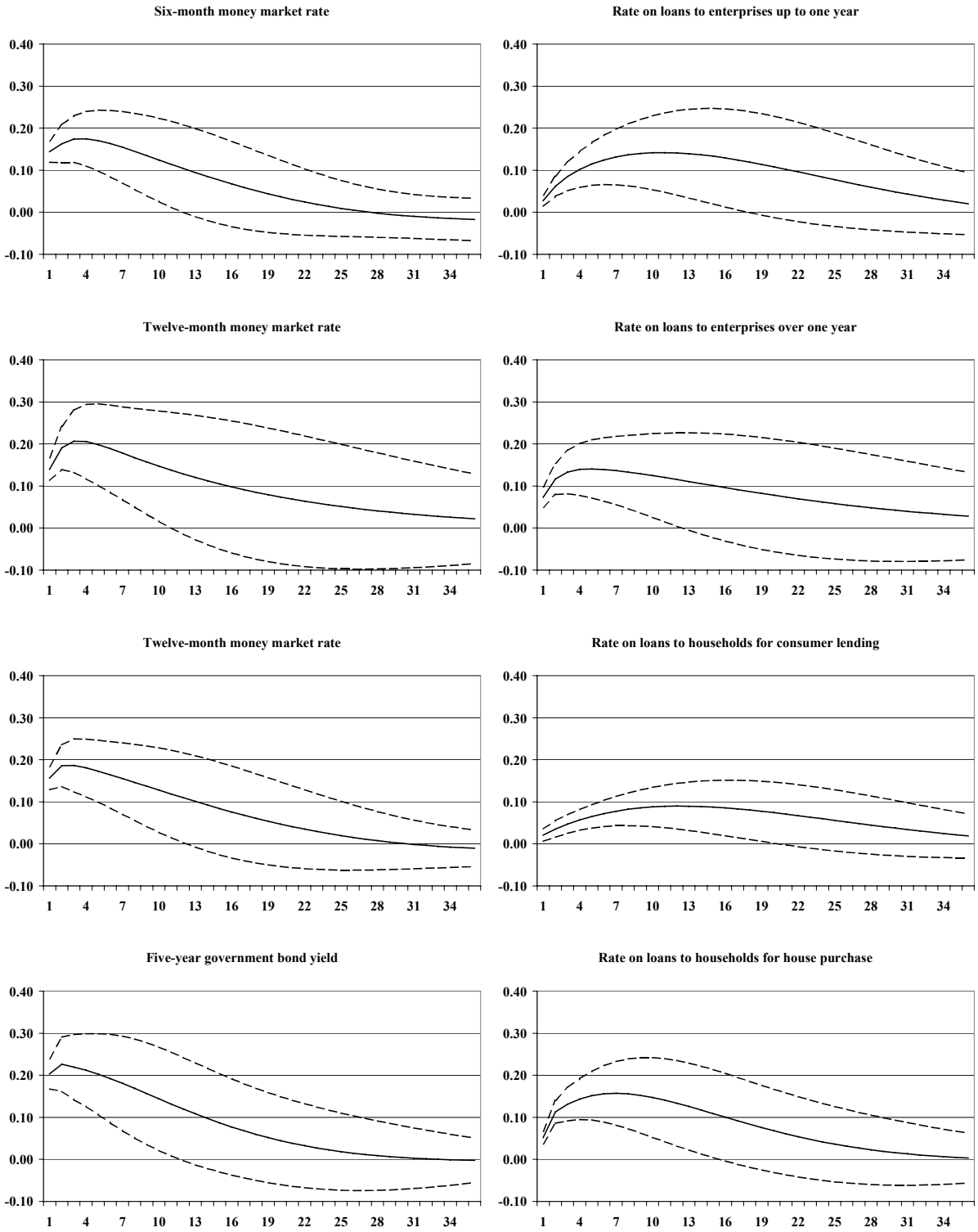
(dotted lines denote 95% confidence interval based on analytical standard errors)



Sources: ECB, Reuters and author's estimations.

Chart B.1b Impulse response of bank lending rate to a one standard-deviation innovation to market interest rate

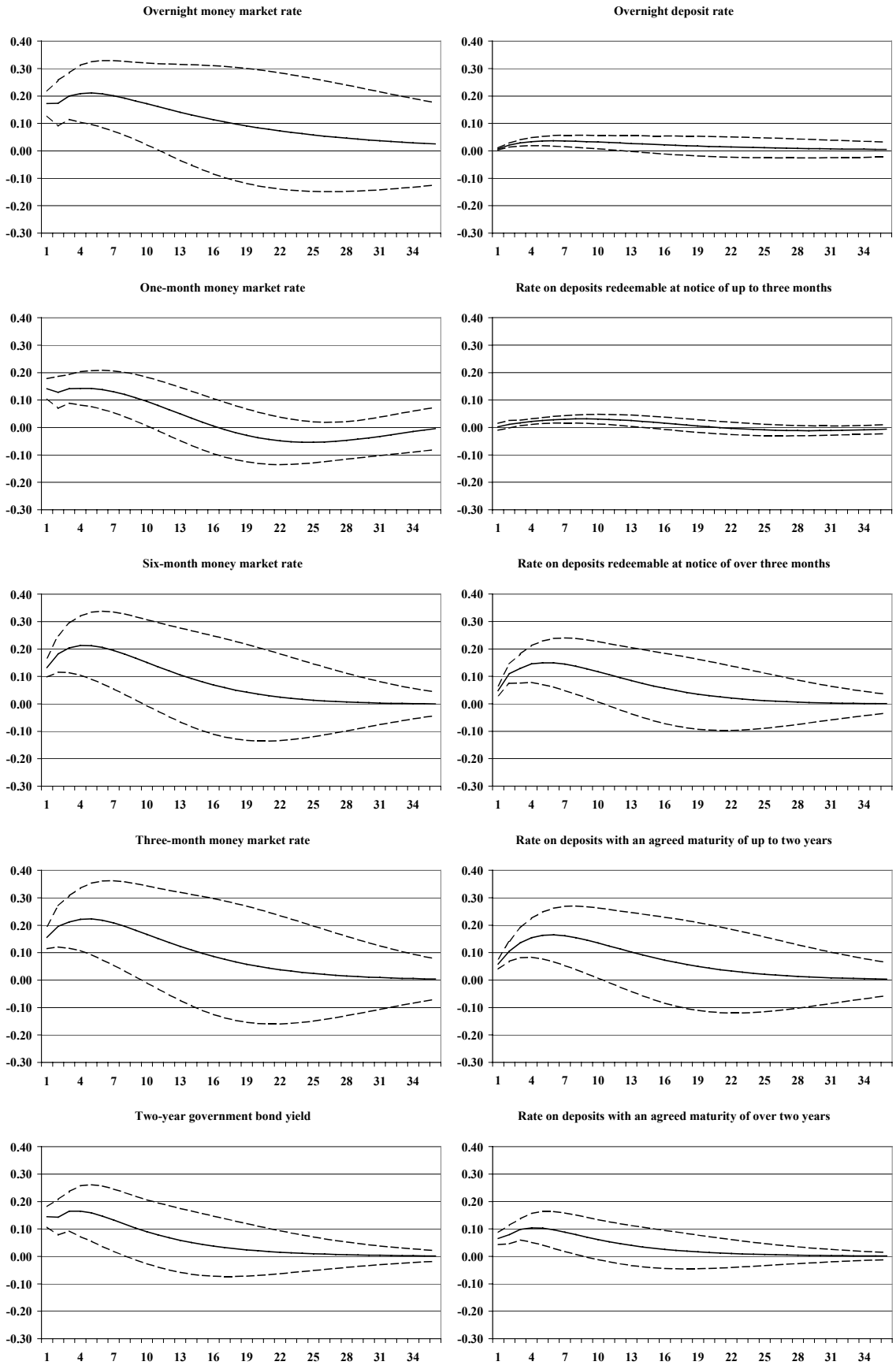
(dotted lines denote 95% confidence interval based on analytical standard errors)



Sources: ECB, Reuters and author's estimations.

Chart B.2a Impulse response of bank deposit rate to a one standard-deviation innovation to market interest rate since the introduction of the euro

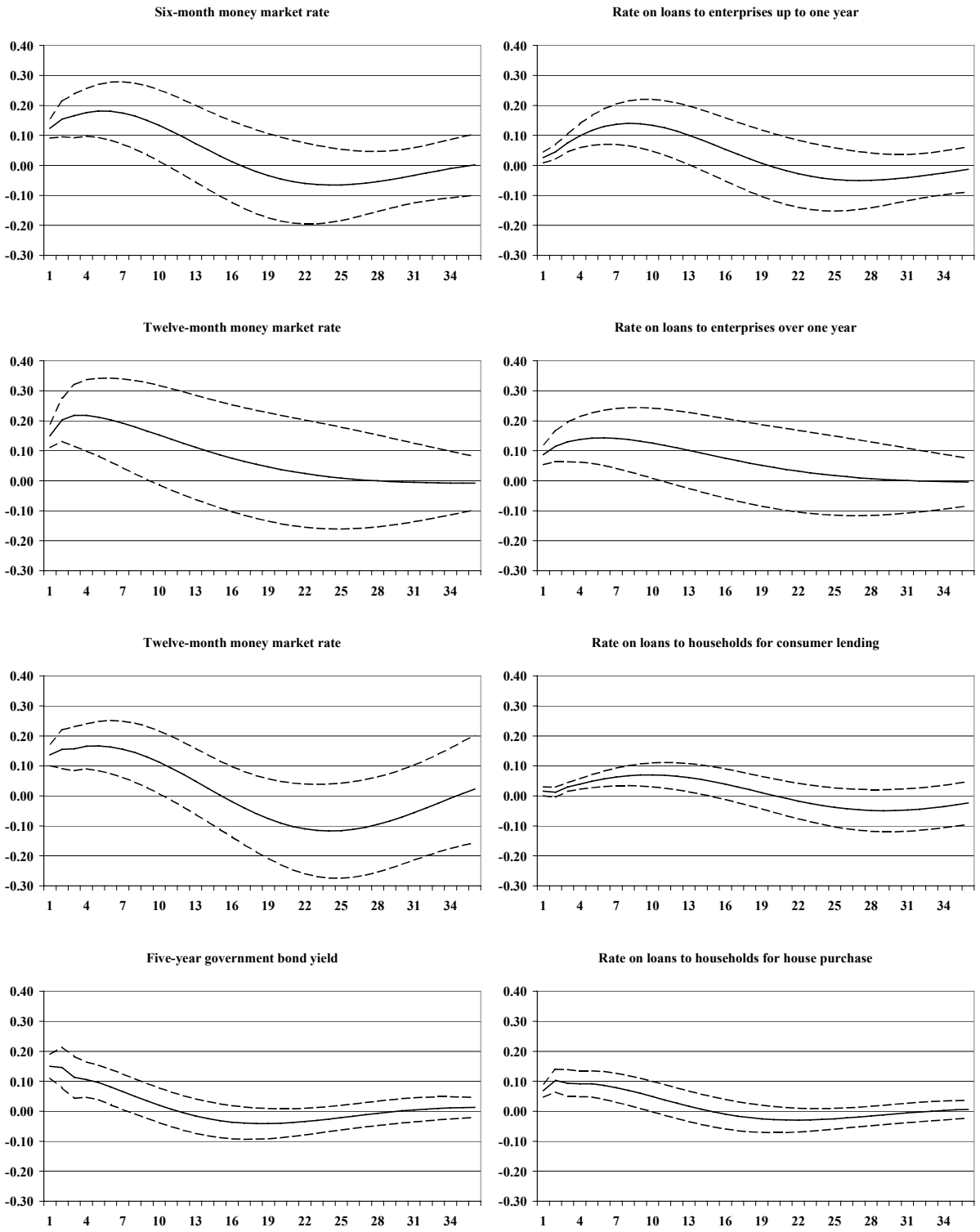
(dotted lines denote 95% confidence interval based on analytical standard errors)



Sources: ECB, Reuters and author's estimations.

Chart B.2b Impulse response of bank lending rate to a one standard-deviation innovation to market interest rate since the introduction of the euro

(dotted lines denote 95% confidence interval based on analytical standard errors)



Source: ECB, Reuters and author's estimations.

Table 1 Overview interest rate pass-through studies individual euro area countries[1)]

(Adjustment of retail bank rates to 100 basis points change in money market interest rates in basis points)

Study		AT	BE	DE	ES	FI	FR	GR	IE	IT	LU	NL	PT	Euro area
Short-term loans to firms														
BIS (1994)	ST	-	85	18	78		15			10		58		28
	LT	68	112	106	110		-			61		107		89
Cottarelli and	ST		67	87	78	23		61	107	60		82	95	75
Kourelis (1994)	LT		87	100	94	28		82	107	83		82	95	90
Borio and Fritz	ST		95	36	100		53			72		95		65
(1995)	LT		93	98	105		59			107		103		95
Hofmann (2000)	ST		44	63	48		43			43		110		54
	LT		100	100	100		100			100		100		100
Kleimeier and	ST													-
Sander (2000)	LT		110	97	107	195	72	117	101	114	59	91	112	100
Mojon (2000)	ST		100	36	55		71			62		112		61
	LT		100	100	100		100			100		100		100
Donnay and	ST	15	85	66	102		43	36	20	60		53	11	58
Degryse (2001)	LT	18	92	72	100		75	42	18	86		87	14	74
Toolsema et al.	ST		76	72	103		53			61		84		70
(2001)	LT		102	90	114		62			62		97		80
Long-term loans to firms														
Mojon (2000)	ST		61		18		42							37
	LT		100		100		100							100
Donnay and	ST		21		69	87	23	25	17	78				54
Degryse (2001)	LT		10		40	93	50	64	16	99				67
Mortgages														
BIS (1994)	ST		-	48	-		-			26		21		41
	LT		82	89	27		90			88		88		82
Hofmann (2000)	ST		14	27	6		16			23		16		21
	LT		100	100	100		100			100		100		100
Mojon (2000)	ST		5	45	-11		41					33		35
	LT		100	100	100		100					100		100
Donnay and	ST	26	19	20	40	39			16	63		34	7	27
Degryse (2001)	LT	32	48	44	14	61			-6	103		27	35	41
Savings deposits														
Mojon (2000)	ST		27	9	13							6		11
	LT		100	100	100							100		100
Time deposits														
Mojon (2000)	ST		94	82	15					63		83		65
	LT		100	100	100					100		100		100

Sources: BIS (1994), Table 5, 1984–1993; Cottarelli and Kourelis (1994), Table 1, model 2; Borio and Fritz (1995), Table 8, 1990–1994; Hofmann (2000), Table 3, 1979–2000; Kleimeier and Sander (2000), Table 5, 1994–1998; Mojon (2000), Table 2a, 1992–1998; Donnay and Degryse (2001), Table 3, 1992–2000; Toolsema et al. (2001), Table 3, 1980–2000.

[1)] ST = short-term pass-through, that is adjustment after 3 months; LT = long-term pass-through; euro area figures are based on available country results using January 2001 country weighting structures as applied for euro area retail bank interest rates.

Table 2 Correlation analysis between bank and market interest rate

Bank rate	Market rate	Corre-lation	Lag in months	Market rate	Corre-lation	Lag in months	Market rate	Corre-lation	Lag in months	Market rate chosen
	1996.01–2001.05[1)]			*1996.01–1998.12*[1)]			*1999.01–2001.05*			
Level										
Deposit rate										
Overnight	Overnight	0.89	8	Overnight	0.92	8	Overnight	0.99	1	Overnight
Up to 3 months notice	1 month	0.89	7	1 month	0.94	1	1 month	0.96	4	1 month
Over 3 months notice[2)]	1 year	0.79	1	1 year	0.30	1	6 months	0.99	1	6 months
Maturity up to 2 years	2 years	0.96	5	3 months	0.96	1	3 months	0.99	1	3 months
Maturity over 2 years	3 years	0.97	1	5 years	0.98	1	2 years	0.99	0	2 years
Lending rate										
Up to 1 year to firms	6 months	0.90	7	6 months	0.91	0	3 months	0.99	2	6 months
Over 1 year to firms	5 years	0.94	4	10 years	0.98	3	1 year	0.98	0	1 year
Consumer lending	10 years	0.98	7	10 years	0.98	4	2 years	0.98	4	1 year
House purchase	5 years	0.97	2	10 years	0.99	0	2 years	0.99	0	5 years
First difference										
Deposit rate										
Overnight	1 month	0.54	1	1 month	0.22	2	1 month	0.79	1	Overnight
Up to 3 months notice	1 month	0.53	2	1 month	0.57	2	1 month	0.54	1	1 month
Over 3 months notice[2)]	1 year	0.77	1	1 year	0.78	1	6 months	0.79	0	6 months
Maturity up to 2 years	6 months	0.73	1	3 months	0.67	1	3 months	0.80	0	3 months
Maturity over 2 years	2 years	0.70	0	10 years	0.64	0	2 years	0.89	0	2 years
Lending rate										
Up to 1 year to firms	3 months	0.60	1	3 months	0.38	1	6 months	0.70	2	6 months
Over 1 year to firms	1 year	0.70	0	10 years	0.46	0	1 year	0.81	0	1 year
Consumer lending	1 year	0.52	3	1 year	0.36	3	1 year	0.57	2	1 year
House purchase	10 years	0.71	0	5 years	0.72	1	2 years	0.86	0	5 years

Sources: ECB, Reuters and author's calculations.

[1)] *Data for the interest rate on loans to enterprises with a maturity of over one year is available since November 1996.*

[2)] *Result for the sample starting in January 1996 is biased downward, since the interest rate on deposits redeemable at notice of over three months is a 100% German interest rate and the money market rates considered are euro area money market rates.*

Table 3 Overview retail interest rate pass-through process within error-correction framework[1)]

Retail bank rate	Immediate pass-through	Final pass-through	Adjustment speed in months	Complete pass-through	Cointegration relation
H_0	$\alpha_2 = 0$	$\beta_2 = 0$	$(1-\alpha_2)/\beta_1 = 0$	$\beta_2 = 1$	$\beta_1 = 0$
Deposit rate					
Overnight	0.02	0.41**	15.3**	No**	Yes**
Up to 3 months notice	0.05	0.35**	8.7**	No**	Yes**
Over 3 months notice	0.35**	0.87**	23.8	Yes**	No**
Maturity up to 2 years	0.32**	0.98**	4.8**	Yes**	Yes**
Maturity over 2 years	0.35**	0.76**	3.0**	No**	Yes**
Lending rate					
Up to 1 year to firms	0.24**	1.53**	8.7**	No**	Yes**
Over 1 year to firms	0.54**	0.92**	3.9**	Yes**	Yes**
Consumer lending	0.13**	0.93**	10.2**	Yes**	Yes**
House purchase	0.26**	0.94**	2.8**	Yes**	Yes**

Sources: ECB, Reuters and author's estimations

*[1)] Sample period 1996.01–2001.05, except for lending to enterprises over one year (1997.01–2001.05) ** and * denote significance of the F-statistic at the 1% and 5% level, respectively.*

Table 4 Overview pass-through process since January 1999 within error-correction framework[1)]

Retail bank rate	Pass-through EMU sample					Chow test	Pass-through coefficient pre-EMU sample = EMU value[2)]		
	Immediate	Final	Speed	Complete	Cointe-gration	LR	Immediate	Final	Speed
H_0	$\alpha_2 = 0$	$\beta_2 = 0$	$(1-\alpha_2/\beta_1) = 0$	$\beta_2 = 1$	$\beta_1 = 0$	Break 1999.01	α_2	β_2	$(1-\alpha_2)/\beta_1$
Deposit rate									
Overnight	0.04**	0.18**	1.6**	No**	Yes**	24.6**	1.27	6.12*	19.1**
Up to 3 months notice	0.01	0.26**	4.1**	No**	Yes**	15.4**	1.23	1.61	7.93**
Over 3 months notice	0.35**	0.72**	0.8**	No**	Yes**	53.0**	0.01	0.04	0.55
Maturity up to 2 years	0.38**	0.76**	1.1**	No**	Yes**	53.2**	1.73	9.06**	34.1**
Maturity over 2 years	0.47**	0.65**	1.0**	No**	Yes**	28.1**	6.60*	4.28*	10.8**
Lending rate									
Up to 1 year to firms	0.19*	0.88**	2.8**	Yes*	Yes**	38.7**	1.49	24.0**	37.0**
Over 1 year to firms	0.55**	0.80**	2.5	Yes*	No**	9.5*	0.02	0.68	2.22
Consumer lending	0.08	0.61**	6.3**	No**	Yes**	3.8	1.63	5.13*	7.86**
House purchase	0.46**	1.04**	2.6**	Yes**	Yes**	18.7**	36.1**	8.54**	0.58

Sources: ECB, Reuters and author's estimations

*[1)] ** and * denote significance of the F-statistic at the 1% and 5% level, respectively, unless stated otherwise; LR denotes log likelihood ratio statistic. [2)] F-statistic.*

Table A.1 Estimation results error-correction model[1)]

Retail bank rate	α_1	α_2	β_1	β_2	R^2 adj.	S.E.	Q(4)	Q(12)
Deposit rate								
Overnight	-0.044	0.002	0.064**	0.411**	0.27	0.036	14.7**	25.9*
	(0.025)	(0.021)	(0.013)	(0.095)				
Up to 3 months notice	0.112*	0.052	0.109**	0.354**	0.36	0.044	5.1	7.6
	(0.044)	(0.038)	(0.022)	(0.074)				
Over 3 months notice	0.002	0.348**	0.027	0.873	0.33	0.078	7.3	11.7
	(0.075)	(0.060)	(0.035)	(0.727)				
Maturity up to 2 years	-0.079	0.323**	0.141**	0.978**	0.71	0.056	16.1**	23.0*
	(0.043)	(0.043)	(0.019)	(0.074)				
Maturity over 2 years	0.214*	0.348**	0.218**	0.764**	0.62	0.066	4.9	12.2
	(0.082)	(0.046)	(0.046)	(0.057)				
Lending rate								
Up to 1 year to firms	0.041	0.245**	0.086**	1.529**	0.69	0.057	19.4**	36.6**
	(0.051)	(0.046)	(0.010)	(0.132)				
Over 1 year to firms	0.246*	0.544**	0.116**	0.922**	0.64	0.076	15.5**	34.0**
	(0.096)	(0.068)	(0.023)	(0.142)				
Consumer lending	0.521**	0.135**	0.085**	0.926**	0.55	0.059	8.9	31.1**
	(0.104)	(0.045)	(0.012)	(0.138)				
House purchase	0.426**	0.264**	0.260**	0.943**	0.76	0.055	1.2	8.0
	(0.068)	(0.033)	(0.026)	(0.033)				

Sources: ECB and author's estimations.

*[1)] Non-linear least squares estimates using the Gauss-Newton algorithm; sample period 1996.01–2001.05; ** and * denote significance at the 1% and 5% level, respectively; standard errors are reported in parentheses; Q(.) is the Ljung-Box Q-statistic.*

Table A.2 Estimation results error-correction model since the introduction of the euro[1)]

Retail bank rate	α_1	α_2	β_1	β_2	R^2 adj.	S.E.	Q(4)	Q(12)
Deposit rate								
Overnight	0.094**	0.044**	0.607**	0.176**	0.89	0.011	7.8	41.0**
	(0.013)	(0.011)	(0.047)	(0.004)				
Up to 3 months notice	0.314**	0.010	0.244**	0.260**	0.55	0.036	2.3	11.8
	(0.112)	(0.045)	(0.062)	(0.043)				
Over 3 months notice	0.467**	0.353**	0.808**	0.720**	0.89	0.039	3.4	14.4
	(0.077)	(0.054)	(0.102)	(0.011)				
Maturity up to 2 years	0.115**	0.380**	0.560**	0.756**	0.92	0.030	5.4	16.0
	(0.032)	(0.032)	(0.058)	(0.012)				
Maturity over 2 years	0.758**	0.468**	0.546**	0.645**	0.87	0.042	1.8	19.4
	(0.206)	(0.052)	(0.134)	(0.019)				
Lending rate								
Up to 1 year to firms	0.842**	0.188*	0.290**	0.880**	0.81	0.050	8.7	27.9**
	(0.174)	(0.072)	(0.045)	(0.051)				
Over 1 year to firms	0.457	0.553**	0.176	0.804**	0.66	0.072	15.2**	36.4**
	(0.311)	(0.082)	(0.107)	(0.103)				
Consumer lending	1.073*	0.077	0.146**	0.614**	0.52	0.048	11.0*	16.4
	(0.440)	(0.064)	(0.051)	(0.131)				
House purchase	0.233	0.463**	0.205**	1.041**	0.88	0.043	2.4	10.2
	(0.121)	(0.050)	(0.040)	(0.089)				

Sources: ECB and author's estimations.

*[1)] Non-linear least squares estimates using the Gauss-Newton algorithm; sample period 1999.01–2001.05; ** and * denote significance at the 1% and 5% level, respectively; standard errors are reported in parentheses; Q(.) is the Ljung-Box Q-statistic.*

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