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MODELLING BANK LENDING IN THE EURO AREA: A NON-LINEAR APPROACH

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Abstract

This paper investigates possible non-linearities in the response of bank lending to monetary policy shocks in the euro area. The credit market is modelled over the period 1985-2005 by means of an Asymmetric Vector Error Correction Model (AVECM) involving four endogenous variables (loans to the private sector, real GDP, lending rate, and consumer price index) and one exogenous variable (money market rate). The main features of the model are the existence of two cointegrating equations representing the long-run credit demand and supply and the possibility for loading and lagged term coefficients to assume different values depending on the monetary policy regime (easing or tightening). The paper finds that the effect on credit, GDP and prices of a monetary policy tightening is larger than the effect of a monetary policy easing. This result supports the existence of an asymmetric broad credit channel in the euro area.

JEL classification: C32, C51, E44, E52.
Keywords: monetary policy transmission, credit market, credit view, asymmetries.

Contents

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1. Introduction[1]

There is a widespread consensus among economists and policy-makers on the leading indicator properties of credit regarding medium-term prospects for output and inflation.[2] The role of credit in the conduct of monetary policy is in fact emphasized by the practice of several central banks of including credit in their information set. The European Central Bank (ECB) explicitly considers credit in both pillars of its monetary policy strategy as "given the particular importance of bank loans for the financing of euro area firms, developments in such loans may have important implications for euro area-wide economic activity" (ECB, 2004). The Federal Reserve, too, assigns a special role to credit as "policymakers continue to use monetary and credit data as a source of information about the state of the economy" (Bernanke, 2006). Both central banks use the Bank Lending Survey to obtain detailed information on developments in financial conditions.

From a theoretical perspective, the role of the credit market in the transmission mechanism of monetary policy is emphasized by authors adhering to the credit view. Although the credit channel was studied by Hawtrey, Hahn, Keynes and other authors of the "Swedish School" in the 1930s, the debate about its relevance has been re-opened by the work of Bernanke and Blinder (1988). According to these two authors the credit market is characterized by imperfect substitutability between bank loans and privately-issued debt. Indeed, where some borrowers do not have access to the capital markets (not only households, but even small firms), their spending and investment decisions must rely exclusively on the availability of bank credit and self-financing: in such a case, every change in the composition of bank assets would influence both the level and the distribution of private expenditure for consumption and investment.

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[2] See, amongst others, Stock and Watson (1999), Friedman and Kuttner (1993), Kashyap, Stein and Wilcox (1993) for the US and Nicoletti-Altimari (2001) and Calza et al. (2006) for the euro area. Greenwald and Stiglitz (2003) demonstrate that lending conditions help us to understand two recent historical episodes: the East Asian financial crisis and the 1991 US recession and subsequent recovery and boom.

Within the credit view, two transmission channels have received most attention: the "bank lending channel" (BLC) and the "balance sheet channel" (BSC). The BLC claims that a monetary tightening affects bank loans because the drop in reservable deposits cannot be completely offset by issuing other forms of funding (i.e. uninsured CDs or bonds; for an opposite view see Romer and Romer, 1990) or by liquidating some assets. Kashyap and Stein (1995, 2000), Stein (1998), Kishan and Opiela (2000) and Ehrmann et al. (2003) claim that the market for bank debt is imperfect. Since non-reservable liabilities are not insured and there is an asymmetric information problem about the value of banks' assets, a "lemon's premium" is paid to investors. According to these authors, small, low-liquid and low-capitalized banks pay a higher premium because the market perceives them to be more risky. Since these banks are more exposed to asymmetric information problems, they are less able to shield their credit relationships in the event of a monetary tightening, and they should cut their supplied loans by a larger amount. Moreover, they have less capacity to issue bonds and CDs and could therefore try to contain the drain of deposits by raising their rates further.

Loan supply shifts could also originate from a "balance sheet channel", working through the relative prices of the guarantees provided to banks (Mishkin, 1995; Oliner and Rodebusch, 1996; Kashyap and Stein, 1997): a monetary squeeze increases debt service costs which can prompt sales of real assets, reducing their value and causing a loss of creditworthiness and a reduction of lending. In this situation there is a greater incentive for banks to finance less risky projects and to start a "flight to quality" (Lang and Nakamura, 1995). The "financial accelerator hypothesis" (Bernanke and Gertler, 1989; Bernanke, Gertler and Gilchrist, 1996) reinforces this mechanism, claiming that a monetary policy tightening, by reducing the net worth of borrowers, increases the premium on external finance required by lenders, thus reducing borrowers' ability to invest. These mechanisms are amplified if loan demand also responds to changes in monetary policy and output asymmetrically, due to a differential effect on investment decisions and self-financing (Friedman and Kuttner, 1993). In this case a "broad credit channel" is identified because both supply and demand schedules move asymmetrically in response to a monetary change.

A natural implication of the credit view is that the pass-through of monetary policy shocks to output and inflation may be asymmetric. From a theoretical perspective, there are various ways of rationalizing the non-linear behaviour of credit markets in the case of monetary policy changes. The most obvious one is the outright assumption that the loan supply curve has some form of rigidity. The first example is the model of Stiglitz and Weiss (1981) in which an adverse selection problem leads to a backward bending supply of credit and a consequent credit rationing on the upside. Blinder (1987) builds a model in which monetary policy shocks have different effects when the economy is in a credit rationing regime with respect to other more accommodative regimes. McCallum (1991) finds evidence that the credit-rationing mechanism exists and that it helps to explain the fact that in the US, during the 1980s, the output effect of money shocks was about twice as large in monetary policy tightening than in easing.

Asymmetric behaviour may also be detected even if no rationing à la Stiglitz and Weiss is detected and loan supply always matches loan demand. For example, considering the BLC mechanism, we may think that, due to capital regulation, it is impossible for a bank to further increase the supply of new loans in the case of a monetary easing. This is because it is necessary to maintain a certain proportion between bank capital and lending. This rigidity does not apply in the case of a monetary tightening, and a reduction in economic activity is usually associated with a drop in loan demand. In this case the reduction of supplied credit frees up capital requirements and makes it possible to cover any losses. De Long and Summers (1988) interpret the asymmetric mechanism in a different way, claiming that "banks can either remain healthy or they can fail. If banks fail there are negative macroeconomic ramifications but there are no corresponding possibilities on the positive side".

Non-linear dynamics are also detected in the "balance sheet channel" and the "financial accelerator theory". For example, Bernanke, Gertler and Gilchrist (1996) stress that changes in credit market conditions amplify and propagate the effects of initial real or monetary shocks thus explaining the small shocks/large cycles puzzle. The intrinsically non-linear nature of the financial accelerator theory is also strengthened by moral hazard and adverse selection problems that amplify the effect of a monetary policy shock via credit more in a recession than during a boom.

In this paper we examine empirically whether credit in the euro area reacts non-linearly to monetary policy shocks. This topic is particularly critical for the euro area economy in virtue of the importance of bank financing. At the end of 2005 the total amount of bank lending to euro area households and firms amounted to 114 per cent of GDP, compared with 58 per cent in the US. Even if empirical findings support the existence of a "credit channel" in the transmission mechanism of monetary policy in the euro area (see Angeloni et al., 2003, for a survey) all the studies have been performed using linear regressions or linear autoregressions (VAR) that may not detect non-linearities in the credit market as depicted in the credit view literature. Therefore, the main novelty of this paper lies in the test for asymmetric adjustment of bank loans, real GDP and prices in the event of opposite monetary policy impulses (tightening or easing). The econometric framework used is the Asymmetric Vector Error Correction Model (AVECM) as in Lim (2001). This is based on a reformulation of the multivariate error correction model proposed by Johansen (1988; 1995), which allows for asymmetric behaviour both in the long and in the short run. In particular, the model captures the interplay of long-run relationships (a loan demand and a loan supply), embedded in the cointegration vectors, with their short-run adjustments captured by the part in first difference.

The paper is organized as follows. Section 2 reviews the empirical literature on the modelling of credit to the private sector in the euro area. Section 3 gives a descriptive analysis of the data and identifies possible breaks in the estimation period. After an examination of the characteristics of the VAR model in Section 4, Section 5 discusses the long-run relationship between bank lending, GDP, consumer prices and interest rates using Johansen's methodology. Section 6 presents the Asymmetric Vector Error Correction Model used to test for the presence of asymmetric behaviour depending on whether policy rates are increasing or decreasing. Model specification tests are reported in Section 7, while Section 8 contains the results of a simulation using the estimated AVECM. The last section summarizes the main conclusions.

2. Modelling credit to the private sector

Notwithstanding the great practical importance of bank lending in economic activity, only recently has economic literature started to investigate the characteristics of the credit market. Although the first empirical works on bank lending date back to the early 1930s

(Tinbergen, 1937), for the next 50 years, research was devoted mainly to the study of demand for money, as credit was considered only the mirror image of monetary aggregates (Fase, 1995).

The "credit view" critique to the money-credit equivalence, as well as the growing difficulty of controlling money supply, have re-awakened interest in the relationship between credit and money and in the role of bank credit as an intermediate monetary target (ECB, 2006).

Since the early 1990s, modelling credit to the private sector has been the subject of a fast growing strand of empirical literature. Empirical works for the euro area countries analyse credit to households, credit to firms or credit to the private sector as a whole. Table 1 summarizes the most recent empirical works for the euro area.

There exist a disagreement in this literature concerning the role of the supply side of the credit market. The majority of work focuses on the demand side of the credit market under the assumption that the supply effects are limited (in line with the money view). According to the credit view, however, monetary policy affects the real economy by shifting the supply schedule of credit, and the overall effects of the BLC and BSC are considered to work in addition to the traditional interest rate channel. Several studies have attempted to disentangle the different channels by focusing on cross-sectional differences between banks.[3] This literature, however, does not analyse the macroeconomic impact of the BLC on loans but claims that the existence of such a channel is proved by the different response of lending supply among banks. From a macro perspective, few studies have tried to gain insight into the identification issue by modelling separately credit demand and credit supply equilibrium within a conventional Vector Error Correction Model (Huelsewig, 2003 and Kakes, 2000). Such a framework is very interesting as it sheds light on the role of the credit market in a macroeconomic set-up.

[3] This strategy relies on the hypothesis that certain bank-specific characteristics (for example, size, liquidity and capitalization) influence loan supply movements, while banks' loan demand is independent of these features. For a review of the literature on the distributional effects of the BLC see, amongst others, Altunbas et al. (2002), Ehrmann et al. (2003) and Gambacorta (2005).

As already mentioned in the previous section, the BLC and the BSC work with non-linear mechanisms. A very recent strand of literature analyses the role of credit as a non-linear propagator of shocks (Balke, 2000 for the US, Atanasova, 2003 for the UK, Calza and Sousa, 2006 for the euro area). These authors generally employ a VAR model including output, inflation, credit, and a policy rate. The focus is on the impact of monetary policy shocks on output and inflation, allowing VAR coefficients to vary depending on the credit market regime (high lending rate or low lending rate regimes). The credit market is therefore the transition variable and the main conclusion of the literature is that the size of the impact of a temporary policy shock on output and inflation differs according to the credit regime.

In this paper we examine the non-linear nature of the credit market from a different perspective. According to the credit view, in fact, credit is likely to react directly in a non-linear way to different types of policy shocks (easing or tightening). We therefore analyse, by means of an Asymmetric Vector Error Correction Model, the reaction of credit, output and inflation to positive or negative policy shocks, assuming the monetary policy rate as the transition variable. In other words, we allow credit not only to capture the asymmetric propagation of monetary policy but also to react directly to policy shocks in a non-linear way.

3. Data description

This study is based on quarterly data for the euro area over the period 1985:1 to 2005:4. The interaction between the credit market and economic activity is analysed by means of the following variables: credit to the private sector (c), real GDP (y), the consumer price index (p), the average lending rate (l), and the monetary policy interest rate (i).

Given the lack of historical data on euro area MFI holdings of private sector securities, we restrict the analysis of credit to data on bank loans to the private sector,[4] which account for over 90 per cent of total credit. We use seasonally adjusted aggregate data for the EU-12

[4] Loans to euro area residents excluding general government and MFIs. They include: loans to non-financial corporations, households, insurance corporations, pension funds and other financial intermediaries.

countries provided by the ECB from 1996; for previous years we have reconstructed backward the series by aggregating national data.

The real GDP series is the one compiled by Eurostat for the EU-12 countries for the period 1990:4 to 2005:4. For the period 1985:1 to 1990:3 the series has been reconstructed backwards by aggregating national data. A graphical analysis of the behaviour of annual percentage changes in GDP and credit is reported in Figure 1. It shows a high correlation between the series, suggesting the possibility that they are cointegrated.

Better economic conditions usually increase the number of projects becoming profitable in terms of expected net present value and hence increase the demand for credit (Kashyap, Stein and Wilcox, 1993). This calls for the presence of a long-run relationship between credit and GDP. However, as stressed by Friedman and Kuttner (1993), the impact of business cycles on consumption and investment may also be countercyclical due to a self-financing effect that reduces the proportion of bank debt.

The seasonally adjusted consumer price index is calculated by the OECD. Figure 2 shows that the spike in nominal credit growth in the late 1980s may be due, at least in part, to the high inflation rate. Nominal lending is probably positively correlated with the price index, and the hypothesis of homogeneity between the two variables will be formally tested in the econometric section.

The composite lending rate is obtained weighting bank lending rates on different types of loans (e.g. loans to enterprises of different maturity, consumer credit, and loans for house purchase). The weights are given by the relative importance of the corresponding loan category and derived from data on the stock of MFI loans to non-financial firms and households. The ECB data cover only the period 2003-2005; for the previous years we use the composite lending rate reconstructed by Calza et al. (2006) using an aggregation of statistics on national interest rates available on the BIS database and that of the IMF, weighted according to the relative importance of each country. From 1994 the monetary policy interest rate is given by the 3-month euribor rate provided by the ECB. Prior to that time it is reconstructed by aggregating national data. The behaviour of the composite lending rate and of the monetary policy indicator clearly shows the two series to be cointegrated (Figure 3). However, there is a break in the difference between the two series l-i (the mark-up) that typically captures both credit risk and structural characteristics of the lending market (Figure 4). In other words, the mark-up tends to increase if, other things being equal, borrowers become more risky or if conditions on the credit market alter. Examples may be changes in credit supply towards forms of credit that are less guaranteed or more short-term.

The increase in the mark-up occurred from the fourth quarter of 1992 to the first quarter of 1995. During this period - characterized by the EMS crisis, a drop in real GDP and stock market capitalization - the quality of bank lending decreased sharply. A large number of firms defaulted and the delinquency rate for consumer credit peaked. All these elements point to a change in the risk component in the mark-up towards a new equilibrium level.

In order to control for possible changes in the mark-up due to the maturity composition of bank credit, we analyse only short-term loans. The first panel of Figure 5 plots the difference between the interest rate on short-term credit and the money market rate for the four main euro area countries and for the area as a whole. Two facts are worth mentioning. First, the increase in the mark-up in the period 1992-95 is still valid, supporting the idea that the increase in the mark-up for the composite lending rate is not influenced by changes in the composition of bank credit towards shorter maturities. Second, the increase in the mark-up was more pronounced in France and Germany, where the drop in the quality of credit and in bank profitability was particularly large. The second part of Figure 5 shows, on the other hand, that the mark-down, the difference between the monetary policy indicator and the interest rate on deposits, declined substantially in all the major euro area countries. This indicates that conditions applied to depositors have improved, probably due to greater competition in the deposit market. The third part of Figure 5 traces the evolution of the spread between the interest rate on short-term lending and that on deposits (the sum of the mark-up and the mark-down), which is usually used as a rough proxy for competition in the credit market. There is a downward trend in all the countries considered from the early 1990s on, pointing to an overall increase in competition on the credit market.

The Augmented Dickey Fuller (*ADF*) tests provided in Table 2 clearly show that all the series are I(1) without drift.

4. The VAR model

We start with a five-variable VAR system in which all variables are treated as endogenous. The starting point of the multivariate analysis is therefore:

$$\begin{aligned} z_t &= \mu + \sum_{k=1}^{p} \Phi_t z_{t-k} + \varepsilon_t \qquad t = 1,\ldots,T \\ \varepsilon_t &\sim \mathrm{VWN}(0,\Sigma) \end{aligned} \tag{1}$$

where z_t=[c, y, l, p, i] and ε_t is a vector of white noise residuals. The deterministic part of the model includes a constant.

In choosing the lag length of the *VAR* (p) several different criteria are used. The classical *LR* tests (with a small sample correction suggested by Sims, 1980) and the information criteria (Akaike and Hannan-Quinn) provide evidence in favour of a model with three lags (see Table 3). The analysis of the system shows serially uncorrelated residuals. However, normality of the VAR is not achieved: the residual plot indicates that the non-normality could be attributable to an outlier in the equation for credit.

The introduction of a point dummy for the second quarter of 1990 that takes into account developments in German bank loans after unification, favours an improvement in the stochastic properties of the model, which reach a normal residual distribution (Table 4).

5. Cointegration properties of the variables

Cointegration can be analysed by re-expressing equation (1) as a reduced-form error correction model:

$$\begin{aligned} \Delta z_t &= \Pi(\mu, z_{t-1}) + \sum_{k=1}^{p-1} \Gamma_t \Delta z_{t-k} + \eta\, dum90_t + \varepsilon_t \qquad t = 1,\ldots,T \\ \Pi &= \alpha\beta' \end{aligned} \tag{2}$$

where dum90 represents the point dummy. The constant is included in the cointegration space.

This framework can be used to apply Johansen's trace test to verify the order of integration of the matrix Π. In fact, the rank of Π determines the number of cointegrating vectors (r) such that α is an $n \times r$ matrix of loading coefficients and β is an $n \times r$ matrix of cointegrating vectors.

The results are reported in the first part of Table 5. The asymptotic critical values of the Johansen's trace test have been calculated according to Johansen and Nielsen (1993) in order to deal with the presence of dummy variables. Johansen's cointegration rank statistics show the presence of two cointegrating relationships in the model. The existence of two cointegrating vectors allows us to test for the presence of a long-run relationship for credit demand and credit supply.

As suggested by Pesaran and Smith (1998), we check whether all the variables included in the model can be considered genuinely endogenous: the use of a Vector Autoregressive Distributed Lag with exogenous variables offers a more parsimonious framework than a simple VAR when all variables are jointly considered endogenous. The tests reported in Table 6 show that, according to economic theory, only the monetary policy rate can be considered weakly exogenous (p-value of 11 per cent). We therefore modify the model in the following way:

$$\begin{aligned} &\Delta x_t = \Pi(\mu, x_{t-1}, i_{t-1}) + \sum_{k=1}^{p-1} \Gamma_t \Delta x_{t-k} + \sum_{k=0}^{p-1} \Phi_t \Delta i_{t-k} + \eta \; dum90_t + \varepsilon_t \qquad t = 1,\dots,T \\ &\Pi = \alpha\beta' \end{aligned} \tag{3}$$

where x_t=[c, y, l, p]. This allows us to save degrees of freedom and to simplify the structure of the model.

Starting from model (3), we impose the existence of two cointegrating vectors (r=2), interpreting them as a credit demand and a credit supply.

Loan demand should be a positive function of real GDP and prices and a negative function of the composite lending rate. In other words, we suppose the existence of a log-linear long run relationship of the type $c=\beta_{1,1}\, y+\beta_{1,2}\, l+\beta_{1,3}\, p$, in which the hypothesis of homogeneity between loans and prices may be tested for $\beta_{1,3}$=1.

As for loan supply, economic theory on oligopolistic (and perfect) competition suggests that in the long run the lending rate should be related to the monetary policy rate that represents the cost of banks' refinancing. For example, Freixas and Rochet (1997) show that in a model of imperfect competition among N banks each one sets its lending rate as the sum of the exogenous money market rate and a constant mark-up. The supply schedule is of the form $l=i+\mu$ where $\mu = \gamma_c + l'(c^*)\frac{c^*}{N}$ is constant. The mark-up μ is influenced by risk and constant marginal cost of intermediation on lending γ_c and by the elasticity of the loan demand function evaluated at the optimum (c^* is the amount of credit at the equilibrium). It is worth noting that in the case of perfect competition ($N\rightarrow\infty$) the last part of μ goes to zero and the mark-up is only influenced by marginal costs and the risk component.

As discussed in the previous section, the mark-up is not constant in our sample period. Figure 4 shows that μ is stationary in 1985-1992 and in 1995-2005 but it exhibits a trend in the period 1993-1994. In order to make the mark-up interpretable we therefore allow the constant in the cointegrating space to assume different values over the two sub-periods 1985:1-1992:3 and 1995:1-2005:4. Moreover, we replace the constant with a time trend for the period that goes from the fourth quarter of 1992 to the last quarter to 1994 in order to approximate the catching up process towards the new equilibrium.

The normalized cointegrating relationships are presented in the second part of Table 5. The set of overidentified restrictions, including the test for price homogeneity in the loan demand equation ($\beta_{1,3}$=1), is accepted with a p-value of 7 per cent.

As for the estimated coefficients, the long-run elasticity between lending and GDP, $\beta_{1,1}$, is equal to 1.3, which is consistent with Calza et al. (2006) who obtain a long-run elasticity of 1.5 using a similar set up. Income elasticity above one is likely to reflect the omission of some variables from the model such as wealth or house purchases that are not captured by GDP transactions. The semi-elasticity of bank loans with respect to the composite lending rate β_2 is negative (-4.3), in line with the findings of Calza et al. As for the second cointegrating vector, the mark-up μ is equal to 1.6 per cent over the period 1985:1-1992:3 and 2.6 per cent during the period 1995:1-2005:4.

6. The Asymmetric Vector Error Correction Model (AVECM)

The model analysed so far is symmetric. However, as discussed in the introduction, credit is likely to react in a non-linear way to positive and negative policy shocks via the BLC or the BSC. This implies asymmetric adjustment of loans in both magnitude and speed, and therefore the multivariate framework described by (3) should be extended to allow for asymmetric behaviour in the loading coefficients (α) and in the lagged responses of variables in delta (Γ).

Following Saikkonen (1992), Lim (2001), Calza and Zaghini (2006) and Gambacorta and Iannotti (2007), who use a similar framework, we assume that the intercepts and the elasticities of the long-run relationships do not vary across different monetary policy regimes. This means that in the long run the equilibrium in the credit market is unique.

Preliminarily we test whether it is worthwhile to move from the symmetric model to the more general asymmetric model (Teräsvirta, Tjøstheim and Granger, 1994). This test is particularly useful because, if no significant gain is detected using the more general model, it is possible to stop further investigation. The test gives the result $\chi^2(105.28, 52)=0.00$, which confirms the need for an asymmetric approach to the problem.

The VECM system (3) with two cointegrating vectors can be reformulated as:

$$
\begin{aligned}
\Delta c_t = {} & (\alpha_{c,1} + \alpha_{c,1}^* d_t)[c_{t-1} - p_{t-1} + \beta_{1,1} y_{t-1} + \beta_{1,2} l_{t-1} + \mu_1] + \\
& + (\alpha_{c,2} + \alpha_{c,2}^* d_t)[l_{t-1} - i_{t-1} + \mu_{2,1} c_1 + \mu_{2,2} c_2 + \mu_{2,3} c_3] + \\
& + \sum_{k=1}^{p-1} (\delta_{c,k} + \delta_{c,k}^* d_t)\Delta c_{t-k} + \sum_{i=1}^{p-1} (\varphi_{c,k} + \varphi_{c,k}^* d_t)\Delta y_{t-k} + \sum_{k=1}^{p-1} (\psi_{c,k} + \psi_{c,k}^* d_t)\Delta l_{t-k} + \\
& + \sum_{k=1}^{p-1} (\xi_{c,k} + \xi_{c,k}^* d_t)\Delta p_{t-k} + \sum_{k=0}^{p-1} (\vartheta_{c,k} + \vartheta_{c,k}^* d_t)\Delta i_{t-k} + \lambda_c dum90 + \varepsilon_t^c
\end{aligned}
\tag{4}
$$

$$\Delta y_t = (\alpha_{y,1} + \alpha^*_{y,1} d_t)[c_{t-1} - p_{t-1} + \beta_{1,1} y_{t-1} + \beta_{1,2} l_{t-1} + \mu_1] +$$
$$+ (\alpha_{y,2} + \alpha^*_{y,2} d_t)[l_{t-1} - i_{t-1} + \mu_{2,1} c_1 + \mu_{2,2} c_2 + \mu_{2,3} c_3] +$$
$$+ \sum_{k=1}^{p-1} (\delta_{y,k} + \delta^*_{y,k} d_t)\Delta c_{t-k} + \sum_{i=1}^{p-1} (\varphi_{y,k} + \varphi^*_{y,k} d_t)\Delta y_{t-k} + \sum_{k=1}^{p-1} (\psi_{y,k} + \psi^*_{y,k} d_t)\Delta l_{t-k} + \quad (5)$$
$$+ \sum_{k=1}^{p-1} (\xi_{y,k} + \xi^*_{y,k} d_t)\Delta p_{t-k} + \sum_{k=0}^{p-1} (\vartheta_{y,k} + \vartheta^*_{y,k} d_t)\Delta i_{t-k} + \lambda_y dum90 + \varepsilon^y_t$$

$$\Delta l_t = (\alpha_{l,1} + \alpha^*_{l,1} d_t)[c_{t-1} - p_{t-1} + \beta_{1,1} y_{t-1} + \beta_{1,2} l_{t-1} + \mu_1] +$$
$$+ (\alpha_{l,2} + \alpha^*_{l,2} d_t)[l_{t-1} - i_{t-1} + \mu_{2,1} c_1 + \mu_{2,2} c_2 + \mu_{2,3} c_3] +$$
$$+ \sum_{k=1}^{p-1} (\delta_{l,k} + \delta^*_{l,k} d_t)\Delta c_{t-k} + \sum_{i=1}^{p-1} (\varphi_{l,k} + \varphi^*_{l,k} d_t)\Delta y_{t-k} + \sum_{k=1}^{p-1} (\psi_{l,k} + \psi^*_{l,k} d_t)\Delta l_{t-k} + \quad (6)$$
$$+ \sum_{k=1}^{p-1} (\xi_{l,k} + \xi^*_{l,k} d_t)\Delta p_{t-k} + \sum_{k=0}^{p-1} (\vartheta_{l,k} + \vartheta^*_{l,k} d_t)\Delta i_{t-k} + \lambda_l dum90 + \varepsilon^l_t$$

$$\Delta p_t = (\alpha_{p,1} + \alpha^*_{p,1} d_t)[c_{t-1} - p_{t-1} + \beta_{1,1} y_{t-1} + \beta_{1,2} l_{t-1} + \mu_1] +$$
$$+ (\alpha_{p,2} + \alpha^*_{p,2} d_t)[l_{t-1} - i_{t-1} + \mu_{2,1} c_1 + \mu_{2,2} c_2 + \mu_{2,3} c_3] +$$
$$+ \sum_{k=1}^{p-1} (\delta_{p,k} + \delta^*_{p,k} d_t)\Delta c_{t-k} + \sum_{i=1}^{p-1} (\varphi_{p,k} + \varphi^*_{p,k} d_t)\Delta y_{t-k} + \sum_{k=1}^{p-1} (\psi_{p,k} + \psi^*_{p,k} d_t)\Delta l_{t-k} + \quad (7)$$
$$+ \sum_{k=1}^{p-1} (\xi_{p,k} + \xi^*_{p,k} d_t)\Delta p_{t-k} + \sum_{k=0}^{p-1} (\vartheta_{p,k} + \vartheta^*_{p,k} d_t)\Delta i_{t-k} + \lambda_p dum90 + \varepsilon^p_t$$

In this AVECM the two cointegrating vectors are normalized on c and l respectively. The constant term in the first long-run relationship (loan demand) is μ_1, and in the second cointegrating vector (loan supply) the mark-up μ_2, is divided into three parts ($\mu_{2,1}$, $\mu_{2,2}$ and $\mu_{2,3}$) in order to capture the structural changes discussed in the previous sections (the dummy variables c_1 and c_3 take the value 1 in the periods 1985:1-1992:3 and 1995:1-2005:4 and zero elsewhere; c_2 is a time trend only for the period 1992:4-1994:4 and is fixed at zero elsewhere).

Parameters that refer to asymmetric behaviour are those with the superscript "*". These are interacted with the dummy variable d, which captures the differential effects of increases and decreases in the monetary policy indicator. There are two possible stances of monetary policy: monetary easing (a negative change in the rate) and monetary tightening (a positive change in the rate). Therefore d is defined according to the following scheme:

$$d = \begin{cases} 1 & \text{if } \Delta i_{\mathrm{M}} < 0 \\ 0 & \text{if } \Delta i_{\mathrm{M}} > 0 \end{cases}$$

In a few cases no quarterly changes are detected in the monetary indicator (Δi_{M}=0). In these quarters a monetary easing (tightening) is considered, d=1(d=0), if the 3-month euribor rate decreases (increases), leading to easier (more difficult) access to interbank liquidity.

7. Testing asymmetry and the reduced-form model

According to Lim (2001) tests for asymmetry have been carried out considering the null hypothesis of zero restrictions on the dummy variables in the equations (4)-(7). Table 7 summarizes the results.

The test for asymmetry in the loading coefficients (see part A of Table 7) supports the hypothesis of a different adjustment to disequilibrium gaps only in the case of the lending supply curve relationship in the price equation ($\alpha^{*}_{p,2} \neq 0$). The economic interpretation of this asymmetry is that, if an exogenous shock on supplied lending makes the interest rate on loans different from the long run equilibrium, the readjustment process of this cointegrating vector via prices takes place only in the case of a monetary tightening. On the contrary, in the case of a "loose" monetary policy the loading coefficient is close to zero and there is no readjustment at all ($\alpha_{p,2} + \alpha^{*}_{p,2} d_t \cong 0$). This behaviour calls for the existence of a "balance sheet channel" that is transmitted from asset prices to consumer prices due to "moral hazard and "adverse selection" problems. In other words credit-supply disequilibria contribute to lower prices during a monetary policy tightening while there are no (upside) effects on prices from the credit-supply side during an easing regime.

It is worth mentioning that the model can be further simplified because the first cointegrating vector does not enter the lending equation and the second cointegrating vector does not directly affect the credit equation. The hypothesis $\alpha_{l,1}$= $\alpha_{l,1}{}^{*}$=0 implies that, given banking costs and risk premia, banks' price adjustments are driven by monetary conditions.

The hypothesis $\alpha_{c,2} = \alpha_{c,2}^{*} = 0$ implies that the quantity of credit in the long run is demand driven. [5]

The test for asymmetry in the lagged terms (see part B of Table 7) gives information about the dynamic path of adjustment in the short run. The main result is that asymmetries in the lagged terms can not be set aside as they help to explain a large part of the overall asymmetry in the model. This role of asymmetries in the lagged terms is in line with the findings of Calza and Zaghini (2006), who use a similar framework to estimate the demand for M1 in the euro area. The results show that credit reacts asymmetrically to short-term changes in real GDP. In the case of a monetary "easing" leading to an increase in real GDP there is, other things being equal, a reduction in bank lending due to an increase in self-financing. This is consistent with Melitz and Pardue (1973) and Friedman and Kuttner (1993) who stress that temporary increases in income are typically associated with a self-financing effect that reduces the proportion of bank debt. There is also an asymmetry in the autoregressive part of the equation for *GDP*, which tends to smooth the effects of cumulative changes in real GDP in the case of a monetary easing.

No significant asymmetries are detected in the equation for the lending rate, calling for the absence of particular frictions on banks' price-setting behaviour. The lack of asymmetric effects is expected in the long run because of the mark-up equation that establishes a unique long run relationship between the monetary market indicator and the interest rate on lending (Freixas and Rochet, 1997; Lim, 2001). Nevertheless, in the short run, if a pure bank lending channel via loan supply is at work we should identify a greater reaction not only of quantities but also of banks' prices in the case of a monetary tightening. However, coefficients $\vartheta^{*}_{p,k}$ turned out to be positive but low and not statistically significant.

There are three possible explanations for the absence of such asymmetric effects on the interest rate on loans. First, as detected in some econometric works for Italy (Gambacorta, 2005; Gambacorta and Iannotti, 2007), asymmetric monetary policy effects on lending rates vanish after some months so that the quarterly frequency of our data is not sufficient to capture this mechanism. Second, banks may tighten non-price elements of borrowing such as

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[5] The likelihood ratio test for $\alpha_{c,2} = \alpha_{l,1} = \alpha_{c,2}^{*} = \alpha_{l,1}^{*} = 0$ is given by $\chi^2(4)=4.07$ with a p-value of 40 per cent.

real and personal guarantees, the loan-to-value ratio or other additional charges and commissions. Third, an asymmetric movement in lending demand may wash out the effect via loan supply. For example, if the monetary tightening causes a severe reduction in viable investment projects or a sharp reduction in firms' self-financing (as discussed regarding the presence of coefficient φ^*_2 in equation 4) these effects may produce a downward shift of demanded lending that counterbalances the effect on prices caused by the reduction in supplied lending, exacerbating the overall effects on quantity.

Table 8 presents the results for the reduced four-equation system, including the significant asymmetric short-term effects.

8. A simulation: adjustment to positive and negative shocks

In order to evaluate the effect of an exogenous monetary policy shock, a simulation exercise is performed to generate time paths for the endogenous variables. Figure 6 presents the adjustment paths of lending, real GDP, composite lending rate and consumer prices to positive and negative changes in the money market rate. In particular, the policy experiment consists in increasing (decreasing) the money market rate by 25 basis points, starting from a base where the four equation system is in equilibrium. To make simulations more graphically comparable, the effects for easy monetary policy have been multiplied by -1. The main results are the following.

In line with the credit view, the final effect of monetary policy on credit, real GDP and, particularly, prices[6] is larger in tight regimes than during easing. In particular, the effect on prices is consistent with the existence of a broad credit channel that works via a reduction of (asset) prices: a monetary squeeze increases debt service costs which can prompt sales of real assets, reducing their value and causing a loss of creditworthiness and a drop in lending. This result is in line with the "pushing on the string" view of monetary policy (see De Long and Summers, 1988; Karras, 1996), which explains the asymmetric effects of money on output and prices by arguing that negative money-supply shocks affect aggregate demand

[6] The larger non-linear effect found for prices with respect to real GDP is in line with the results in Calza and Sousa (2006) who use a different approach to analyse credit regimes.

more than do positive shocks. It is worth mentioning that our result adds to this strand of literature by stressing the fact that the asymmetric movement of aggregate demand depends on a different adjustment of the credit market to negative and positive monetary policy shocks.

This result can also be explained easily using a simple graphical representation of Bernanke and Blinder's model. Using the *CC* line to indicate the contemporaneous equilibrium on the goods and credit markets and *LM* for the equilibrium in the money market, the economic system can be represented using a simple *CC-LM*, *AD-AS* scheme (see Figure 7). For example, an unexpected restrictive monetary policy not only moves the *LM* curve to LM^{T}, but also produces a shift of the *CC* towards CC^{T}, since money contraction works through the broad credit channel as well, reducing the loans available to the economy. In the case of a monetary easing that moves the *LM* curve to LM^{E}, if the *CC* shift is not very pronounced, the E^{E} equilibrium is found to have a lower impact than in the case of a tightening, both on income ($|y^{E}-y^{*}|<|y^{*}-y^{T}|$) and on prices ($|p^{E}-p^{*}|<|p^{*}-p^{T}|$).

9. Robustness checks

The robustness of the results has been checked in several ways. The first test was to analyse the effects of a temporary 25 basis point change in money market rates on bank lending, real GDP, the composite lending rate and consumer prices. Part B of Table 9 reports the effects of this policy experiment after 2, 5 and 30 years, while part A presents, for the sake of comparison, the results obtained in the case of a permanent change (discussed in Section 8). As expected, "the pushing on a string" result still holds in the adjustment towards the new equilibrium: the effect of monetary policy on credit, real GDP and prices is still greater under tight monetary policy regimes than easy ones.

Second, we have analysed the implications of endogenous adjustment of the monetary policy indicator (Table 9, part C). The assumption, made in Figure 6, of an exogenous and permanent change in the money market rate is obviously not realistic. We have therefore relaxed this hypothesis by allowing the money market rate to react to output and inflation according to a simple Taylor rule.[7] When a reaction function for the policy-maker is accounted for, the asymmetry in the response of credit (both real and nominal) and prices to policy shocks is smaller than in the case without an interest rate reaction function, but still present. The rationale for this is that the movements in the monetary policy rate only partially offset the asymmetric behaviour in the transmission mechanism. In other words, even when the policy-maker is free to react to macroeconomic fluctuations, the response of output and prices to a policy shock is still larger in a tightening than in an easing regime.

10. Conclusions

The evidence presented in this paper supports the hypothesis that tight monetary policy has a larger effect on bank lending, real output and prices than easy monetary policy.

From the point of view of theory, this result suggests the existence of a "broad credit channel" in the euro area: a rise in short-term interest rates makes loan supply shifts more pronounced because moral hazard and adverse selection problems increase the need for a bank to reduce credit risk and rebalance loan portfolios via a "flight to quality" effect; moreover, loan demand may also respond asymmetrically to changes in monetary policy due to a differential effect on investment decisions and self-financing. These mechanisms are in line with the "pushing on the string" view of monetary policy, which claims the existence of asymmetric aggregate demand movements depending on the sign of the monetary impulse.

With regard to policy, the "pushing on a string" result reinforces the case for a conservative central bank that only cares about inflation (Rogoff, 1989). The lexicographical order in the ECB statute in favour of inflation is preferable because any attempt of the monetary authority to increase output has a limited effect. It is worth mentioning that this result is derived in a more general framework than the Keynesian liquidity trap.

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[7] The Taylor rule takes the form $i_t=r+\pi^*+\beta(\pi_t-\pi^*)+\gamma(y_t-y^*)$, where r denotes the real interest rate (by assumption constant), $\pi^*=\Delta p^*$ the central bank's inflation objective and y_t-y^* is the output gap, i.e. the percentage deviation of actual output from potential output. According to Taylor (1993) and Alesina et al. (2001) we set the coefficients $r=2$, $\pi^*=1.5$, $\beta=1.5$ and $\gamma=0.5$. The annual increase of potential output is set equal to 2.25 per cent. The values of β and γ chosen to calibrate the Taylor rule are consistent with many of the empirical rules for Germany and Europe estimated using pre-EMU data.

Further research could be directed towards three additional issues. First, the analytical framework of the model could be used to analyse possible non-linearities in the response of bank lending to monetary policy shocks in single European countries, checking whether the degree of asymmetry varies among them. Second, a comparison could be carried out also with respect to the US. As stressed by Angeloni et al. (2003) the adjustment of euro area output in the wake of a monetary policy change appears to be primarily driven by investment changes. The evidence for the US is that monetary policy seems to have relatively stronger effect on consumption than on investment. This difference may be due to a stronger dependence of euro area firms on bank lending, while households in US are relatively more indebted. Third, the results of this paper could be replicated using different definitions of monetary policy stance. As pointed out in Section 6 and in line with Jacobs and Kakes (2000), we define the two possible stances of monetary policy according to the sign of the quarterly change in the short-term interest rate. Anyway, different approaches may be adopted to assess the degree of tightness and looseness of the monetary policy as, for instance, the interest rate gap or the developments of broad monetary condition indicators (Freedman, 1995).

Tables and figures

Table 1

EMPIRICAL LITERATURE ON THE CREDIT MARKET IN THE EURO AREA (1)

Paper	Country	Method	Cointegrating equation(s)	Main conclusions
A. Credit to households				
Casolaro and Gambacorta (2005)	Italy (1984-2003)	Loans for house purchases and other loans are analysed separately. A SURE model (4 lags) is employed to estimate the two equations simultaneously.	$c^{n,hh}=y^{n}-0.04\ ph+0.09\ x+0.08\ l^{r,hh}$ $c^{n,ho}=C-0.02\ l^{r,ho}$	One cointegrating relationship is detected in each equation. The equations are interpreted as the reduced form resulting from the equilibrium between demand and supply. The underlying hypothesis is that **credit market is both demand and supply determined. The two schedules, however, are not disentangled in the paper**.
de Bandt, et al. (2006)	9 euro area countries (1991-2005)	A credit demand equation is estimated using a Pooled Mean Group estimator. According to this method credit demand of different countries shares a common equilibrium but is allowed for different short-run dynamics.	$c^{r,h}= 1.6\ H^{n}-0.1\ l^{n}+0.6\ ph^{r}$	Estimating the credit equation independently across countries often leads to the rejection of cointegration. Taking advantage of the panel dimension, however, a stable long-run relationship is found and can be constrained to be homogeneous in the long run for 7 European countries (including the 5 largest countries). **The credit market is assumed to be demand determined.**
B. Credit to firms				
Focarelli and Rossi (1998)	Italy (1984-1996)	Starting from a 5-variable VECM (1 lag), the model is then reduced to one credit equation (as all the variables, except credit, are found to be weakly exogenous). Credit is taken in delta.	$\Delta(c^{n,e})=0.11\ (I^{n,e}-E)$ (1) $I^{n,e}=0.46\ E$ (2) $l^{n,e}=igov^{n}$ (3)	Three cointegrating relationships are found: (1) is interpreted as the credit demand; (2) is the relationship between investment expenditure and firms' borrowing requirement; (3) in the long run the lending rate equals the risk free government bond yield. The underlying hypothesis is that the **credit market is both demand and supply determined**. The credit supply schedule is flat; banks are price-makers that behave as in (3).
Kakes (2000)	The Netherlands (1983-1996)	Long-term and short-term loans to corporate sector are analysed using two VECM models (4 lags). All variables are treated as endogenous.	<u>Short term loans</u> $c^{r,e}=1.8\ y^{r}-0.6\ l^{n,e}$ (1) $c^{r,e}=1.7\ y^{r}+0.1\ (l^{n,e}-i^{n})$ (2) <u>Long term loans</u> $c^{r,ps}=2.5\ y^{r}-0.2\ l^{n,e}$ (3)	Two cointegrating relationships are found in the short term loan model (credit demand (1) and supply (2)). In the model for long term loans only one cointegrating vector is found (3) and is interpreted as the credit demand equilibrium.
Casolaro et al. (2006)	Italy (1988-2003)	Starting from a 4-variable VECM (4 lags), the model is then reduced to two equations as k and ($l^{n,e}-i^{n,e}$) are found to be weakly exogenous.	$c^{n,e}=1.4+k^{n}-0.2\ (l^{n,e}-i^{n,e})+2.2\ (I^{n,e}/E)$	One cointegrating relationship is detected. It represents the equilibrium between demand and supply. **The two schedules, however, are not disentangled.**

Table 1 (continued)

Paper	Country	Method	Cointegrating equation(s)	Main conclusions
C. Credit to private sector				
Kakes (2000)	The Netherlands (1983-1996)	A 4-variable VECM (4 lags) is used. All variables are endogenous.	$c^{r,ps}$=2.2y^r-0.1 $l^{n,ps}$ *(1)* $c^{r,ps}$=1.9y^r +0.03 ($l^{n,ps}$-i^n) *(2)*	Two cointegrating relationships are found and are interpreted as the credit demand (1) and the credit supply equilibrium (2). Shifts in the credit supply schedule do not have a direct significant impact on credit (the loadings of the cointegrating vector are not significant in the credit equation). **Supply effects are significant through their impact on the lending rate.**
Hofmann (2001)	8 euro area countries (1980-1998)	A 4-variable VECM is estimated for different countries. All variables are endogenous. The lags vary depending on the country under analysis.	$c^{r,ps}$=β_1 y^r+β_2 $l^{r,ps}$+β_3 ph^{re} (values of the β vector vary across countries)	Without the inclusion of p^{re} within the set of the endogenous variables the model fails to detect cointegrating relationships. The inclusion of p^{re} allows the identification of one long-run relationship in all countries except Germany. The cointegrating vector is interpreted as the credit demand equilibrium. **The credit market is demand determined.**
Huelsewig (2003)	Germany (1975-1998)	A 5-variable VECM (4 lags) is used. *PY* and eq^r are found to be weakly exogenous.	$c^{n,ps}$ =0.9 *PY*- 0.2 $l^{n,ps}$ *(1)* $c^{r,ps}$ =0.1 ($l^{n,ps}$-i^n)+0.8 eq^r *(2)*	Two cointegrating relationships are found and are interpreted as the credit demand and the credit supply equilibrium. Credit reacts only slowly in the direction of the long-run credit demand and supply equation (the loadings of the two cointegrating vectors are not significant in the credit equation). **Supply effects are significant through their impact on lending rate**
Calza et al. (2006)	Euro area (1980-2001)	4-variables VECM (4 lags). The variables *y* and *l* are found to be weakly exogenous.	$c^{n,ps}$-p =1.6 y^r-5.0 l^n +5.9 π	One cointegrating relationship is detected and it is interpreted as the credit demand equilibrium. **The credit market is demand driven.**

Explanatory note: (1) All papers use quarterly data. Superscripts have the following meaning: **n** refers to nominal variables and **r** to real variables. As for sectors, **e** indicates enterprises, **h** households (**hh** for housing finance **ho** for other purposes), **ps** private sector. As for variables, according to the definition in Section 2, **c** refers to loans, **y** to GDP, ***l*** to the lending rate, **p** to the consumer price index and **i** to the short-term interest rate. As for other symbols, **ph** is the house price index, **x** is the equity price index, **C** is consumption expenditure, **H** is housing investment, **I** is investment expenditure and **E** is earnings before interest, taxes, depreciation and amortization, **igov** is the interest rate on government bonds up to one year, **π** is the inflation rate, **PY** is the private share of real GDP, **eq** is the banks equity position and **k** is firms' capital stock. As a general rule, all variables are in logs with the exclusion of interest rates and ratios.

Table 2

AUGMENTED DICKEY-FULLER TESTS

Three models are compared: Model C which includes a trend and a constant, Model B, which includes a constant and Model A, which has no deterministic components. Starting from the more general model the progressive tests establish what is the most appropriate deterministic component (Model C → Model B → Model A). The lagged differences in the models are included to obtain white noise residuals. The length of the lag (p*) used in the model for each series is chosen by comparing three different information criteria (Schwarz, Hannan-Quinn and Final Prediction Error), taking into consideration the necessary condition that the errors should be white noise. Further information on the test is provided by Said and Dickey (1984) and Dolado and Jenkinson (1987).

Series	p*	Model C $\Delta y_t = \mu + \gamma t + \rho y_{t-1} + \sum_{j=1}^{p^*-1} \rho_j \Delta y_{t-1} + \varepsilon_t$			Model B $\Delta y_t = \mu + \rho y_{t-1} + \sum_{j=1}^{p^*-1} \rho_j \Delta y_{t-1} + \varepsilon_t$			Model A $\Delta y_t = \rho y_{t-1} + \sum_{j=1}^{p^*-1} \rho_j \Delta y_{t-1} + \varepsilon_t$
		ρ=0 τt	γ=0 τ α t	ρ=t=0 Φ3	ρ=0 τμ	μ=0 ταμ	ρ=μ=0 Φ1	ρ=0 τ
c	2	-3.19	3.22	5.10	-0.39	0.68	2.44	2.08
y	4	-3.07	3.09	5.76	-1.75	1.83	4.68	2.30
l	1	-2.20	1.99	2.45	-0.91	0.53	1.23	-1.46
p	4	-1.85	1.90	2.60	-1.73	1.81	2.17	0.98
i	1	-2.08	1.73	2.17	-1.13	0.49	1.31	-1.52
Critical	5%	-3.45	3.11	6.49	-2.89	2.54	4.71	-1.95
values	1%	-4.04	3.78	8.73	-3.51	3.22	6.7	-2.61

Table 3

LAG ORDER DETERMINATION

Information criteria: AK=Akaike, SC=Schwarz and HQ=Hannan-Quinn. The Likelihood Ratio (LR) is computed taking into account the small sample correction suggested by Sims (1980). GODF=Godfrey portmanteau test for autocorrelation of order 4. The symbol * indicates the lag order selected by the criterion.

lag (h)	LR: L[h] vs L[h-1]	df	p-value	LR: L[4] vs L[h]	df	p-value	AK	HQ	SC	GODF p-value
1	n.a.	25	n.a.	138.0	75	0.00	-57.23	-56.94	-56.54*	0.00
2	74.8	25	0.00	73.8	50	0.02	-57.67	-57.09	-56.24	0.04
3	50.1	25	0.00*	27.5	25	0.33*	-57.81*	-56.94*	-55.63	0.20*
4	27.5	25	0.33	n.a.	0	n.a.	-57.64	-56.47	-54.72	0.47

Table 4

JARQUE-BERA NORMALITY TESTS

Equation	Skewness	p-value	Kurtosis	p-value	Skewness & Kurtosis	p-value
c	0.59	0.44	4.08	0.04	4.66	0.10
y	0.05	0.82	0.07	0.79	0.12	0.94
l	2.21	0.14	0.01	0.94	2.21	0.33
p	0.39	0.53	5.03	0.03	5.42	0.07
i	0.66	0.42	0.39	0.53	1.05	0.59
system	*3.89*	*0.57*	*9.69*	*0.09*	*13.57*	*0.19*

(1) Normality is accepted when the p-value is larger than 5 per cent.

Table 5

COINTEGRATION ANALYSIS

Test for the cointegration rank of the models. ** denotes rejection at the 1 per cent significance level; * denotes rejection at the 5 per cent significance level. Johansen λ-trace tests take into account the adjustment for degrees of freedom proposed by Reimers (1992) for small samples. In order to make the test consistent with the presence of a point dummy in the model, asymptotic critical values, reported below, are calculated with the approach suggested by Johansen and Nielsen (1993). The asymptotic estimates of the critical values involve 100,000 simulations with 800 steps in the approximation to Brownian motion.

	H_0: r=0	H_0: $r\leq 1$	H_0: $r\leq 2$	H_0: $r\leq 3$	H_0: $r\leq 4$
Trace Statistic	122.55**	64.01**	32.28	9.44	3.66
5% critical val.	*75.1*	*52.6*	*33.8*	*19.1*	*7.3*

Constrained cointegrating vectors

(standard errors in brackets)

$$c = \underset{(0.14)}{1.310}\, y - \underset{(0.56)}{4.327}\, l + p + \underset{(1.133)}{5.396}$$

$$l = i + \underset{(0.01)}{0.016}\, c_1 + \underset{(0.00)}{0.005}\, c_2 + \underset{(0.00)}{0.026}\, c_3$$

Loading coefficients

(standard errors in brackets)

$$\alpha = \begin{bmatrix} \underset{(0.02)}{-0.05} & \underset{(0.14)}{0.03} \\ \underset{(0.05)}{-0.06} & \underset{(0.22)}{-0.18} \\ \underset{(0.01)}{-0.01} & \underset{(0.06)}{-0.22} \\ \underset{(0.04)}{0.04} & \underset{(0.09)}{0.10} \end{bmatrix}$$

Table 6

WEAK EXOGENEITY(1)

H0: weak exogeneity of	LR test	P-value
c	17.75	0.00
y	9.20	0.01
l	7.46	0.02
p	22.96	0.00
i	4.43	0.11

(1) Weak exogeneity is accepted when the p-value is larger than 5 per cent.

TESTS FOR ASYMMETRY

The symbols ***, ** and * represent significance at the 1, 5 and 10 per cent level of the non-linear coefficient. The asymmetries are rejected when the p-value is larger than 0.05.

	1985:01-2005:04	
	LR statistic	P-value
A. Testing asymmetry in the loading coefficients		
$\alpha^*_{c,1} = \alpha^*_{c,2} = 0$	*0.65*	*0.72*
$\alpha^*_{y,1} = \alpha^*_{y,2} = 0$	*2.77*	*0.25*
$\alpha^*_{l,1} = \alpha^*_{l,2} = 0$	*1.55*	*0.46*
$\alpha^*_{p,1} = \alpha^*_{p,2} = 0$	*14.10*	*0.00* ***
B. Testing asymmetry in the short-term terms		
$\delta^*_{c,1}=\delta^*_{c,2}=0$	*4.15*	*0.13*
$\varphi^*_{c,1}=\varphi^*_{c,2}=0$	*6.50*	*0.04***
$\psi^*_{c,1}=\psi^*_{c,2}=0$	*0.29*	*0.86*
$\xi^*_{c,1}=\xi^*_{c,2}=0$	*0.84*	*0.66*
$\theta^*_{c,0}=\theta^*_{c,1}=\theta^*_{c,2}=0$	*2.95*	*0.40*
$\delta^*_{y,1}=\delta^*_{y,2}=0$	*3.17*	*0.20*
$\varphi^*_{y,1}=\varphi^*_{y,2}=0$	*7.66*	*0.02 ***
$\psi^*_{y,1}=\psi^*_{y,2}=0$	*3.85*	*0.15*
$\xi^*_{y,1}=\xi^*_{y,2}=0$	*0.09*	*0.96*
$\theta^*_{y,0}=\theta^*_{y,1}=\theta^*_{y,2}=0$	*1.98*	*0.58*
$\delta^*_{l,1}=\delta^*_{l,2}=0$	*4.33*	*0.12*
$\varphi^*_{l,1}=\varphi^*_{l,2}=0$	*3.67*	*0.16*
$\psi^*_{l,1}=\psi^*_{l,2}=0$	*0.21*	*0.90*
$\xi^*_{l,1}=\xi^*_{l,2}=0$	*0.67*	*0.72*
$\theta^*_{l,0}=\theta^*_{l,1}=\theta^*_{l,2}=0$	*5.23*	*0.16*
$\delta^*_{p,1}=\delta^*_{p,2}=0$	*1.61*	*0.45*
$\varphi^*_{p,1}=\varphi^*_{p,2}=0$	*9.11*	*0.01****
$\psi^*_{p,1}=\psi^*_{p,2}=0$	*13.88*	*0.00****
$\xi^*_{p,1}=\xi^*_{p,2}=0$	*6.22*	*0.04 ***
$\theta^*_{p,0}=\theta^*_{p,1}=\theta^*_{p,2}=0$	*4.14*	*0.25*

COEFFICIENTS OF THE MODEL IN REDUCED FORM

The reduction from the general model represented by equations (4)-(7) to this reduced-form model has been carried out according to Lim, 2001. Asymmetric coefficients, as from Table 7, have been removed from the reduced model when statistically not significant (10% level). Standard errors in brackets. The symbols ***, ** and * represent significance at the 1, 5 and 10 per cent level. Coefficients and standard errors for the dummies are not reported.

Coefficients \ Equations	c	y	l	p
α_1	-0.046 *(0.01)****	-0.051 *(0.01)* ***		0.021 *(0.00)* ***
α_2		-0.120 *(0.13)*	-0.196 *(0.06)* ***	0.262 *(0.09)****
α^*_2				-0.263 *(0.10)* **
μ_1	4.342 *(0.68)* ***	4.342 *(0.68)* ***	4.342 *(0.68)* ***	4.342 *(0.68)* ***
$\mu_{2,1}$	-0.015 *(0.00)* ***	-0.015 *(0.00)* ***	-0.015 *(0.00)* ***	-0.015 *(0.00)* ***
$\mu_{2,2}$	-0.005 *(0.00)* ***	-0.005 *(0.00)* ***	-0.005 *(0.00)****	-0.005 *(0.00)* ***
$\mu_{2,3}$	-0.027 *(0.00)* ***	-0.027 *(0.00)* ***	-0.027 *(0.00)* ***	-0.027 *(0.00)* ***
$\beta_{1,1}$	-1.179 *(0.09)* ***	-1.179 *(0.09)* ***	-1.179 *(0.09)* ***	-1.179 *(0.09)* ***
$\beta_{1,2}$	5.461 *(0.52)* ***	5.461 *(0.52)* ***	5.461 *(0.52)* ***	5.461 *(0.52)* ***
δ_1	0.417 *(0.11)* ***			0.190 *(0.03)* ***
δ_2	0.035 *(0.12)* ***			
φ_1	0.088 *(0.08)*			
φ_2	-0.043 *(0.11)*	-0.395 *(0.14)* ***		
φ^*_2	-0.266 *(0.12)* **	0.446 *(0.15)* ***		
ψ_1		0.177 *(0.31)*	0.123 *(0.10)*	0.049 *(0.12)*
ψ_2			-0.077 *(0.09)*	
ξ_1	0.224 *(0.16)*	0.660 *(0.17)* ***		
ξ_2	0.647 *(0.15)* ***	0.640 *(0.18)* ***		0.367 *(0.13)* ***
θ_0		0.394 *(0.12)* ***	0.474 *(0.04)* ***	
θ_1		-0.036 *(0.14)*	0.033 *(0.06)*	-0.056 *(0.08)*

Table 9

RESPONSE OF THE ENDOGENOUS VARIABLE TO CHANGES IN THE MONETARY POLICY INDICATOR

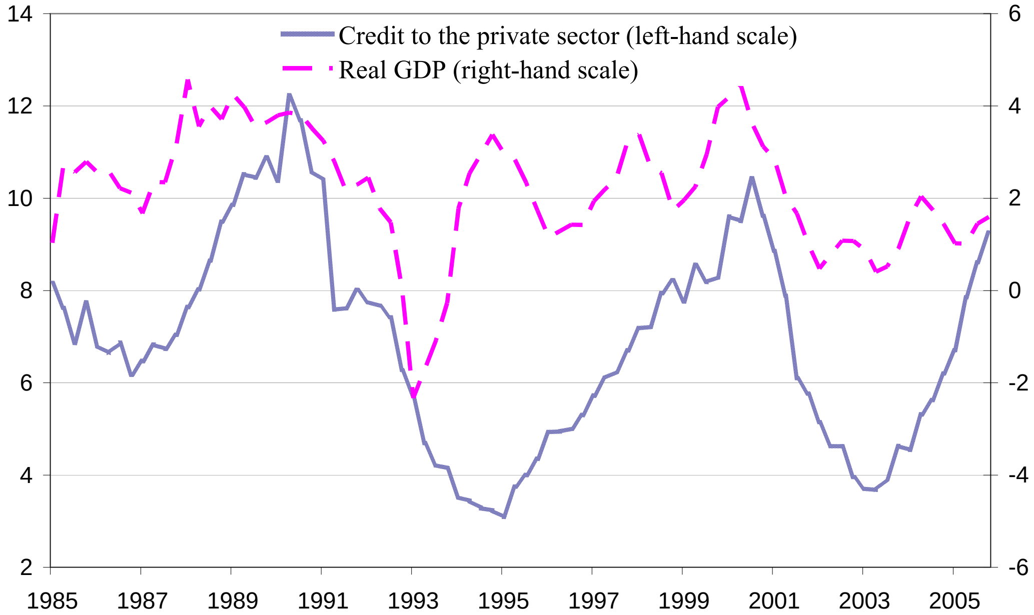
(Percentage values and basis points)

In this table we carry out three simulation exercises. Panel A summarizes the responses of the endogenous variables to a 25pb permanent change in the exogenous money market interest rate. Panel B shows how the same variables react to a 25pb temporary (one year) change in the money market interest rate. Lastly Panel C shows the reaction of the endogenous variables after a temporary 25bp change in the exogenous money market rate when a Taylor rule is accounted for.

		25bp increase			25bp decrease		
	Series	2 years	5 years	30 years	2 years	5 years	30 years
A. Permanent change	*c*	*-0.98*	*-3.80*	*-5.87*	*0.59*	*1.76*	*3.94*
	y	*-0.28*	*-0.97*	*-1.57*	*0.07*	*0.53*	*1.53*
	l	*0.23*	*0.25*	*0.25*	*-0.23*	*-0.25*	*-0.25*
	p	*-0.18*	*-0.89*	*-2.83*	*-0.04*	*0.09*	*0.77*
B. Temporary change	*c*	*-0.69*	*-0.97*	*-0.01*	*0.36*	*0.38*	*0.00*
	y	*-0.20*	*-0.24*	*0.00*	*0.11*	*0.16*	*0.00*
	l	*0.03*	*0.00*	*0.00*	*-0.03*	*0.00*	*0.00*
	p	*-0.10*	*-0.30*	*0.03*	*0.01*	*0.06*	*0.00*
C. Taylor rule	*c*	*-0.58*	*-0.44*	*-0.04*	*0.39*	*0.24*	*0.02*
	y	*-0.11*	*-0.10*	*-0.01*	*0.18*	*0.11*	*0.01*
	l	*-0.05*	*0.01*	*0.00*	*0.06*	*0.00*	*0.00*
	p	*-0.07*	*-0.18*	*-0.03*	*0.01*	*0.06*	*0.01*
	i	*-0.05*	*0.02*	*0.00*	*0.13*	*0.00*	*0.00*

Figure 1

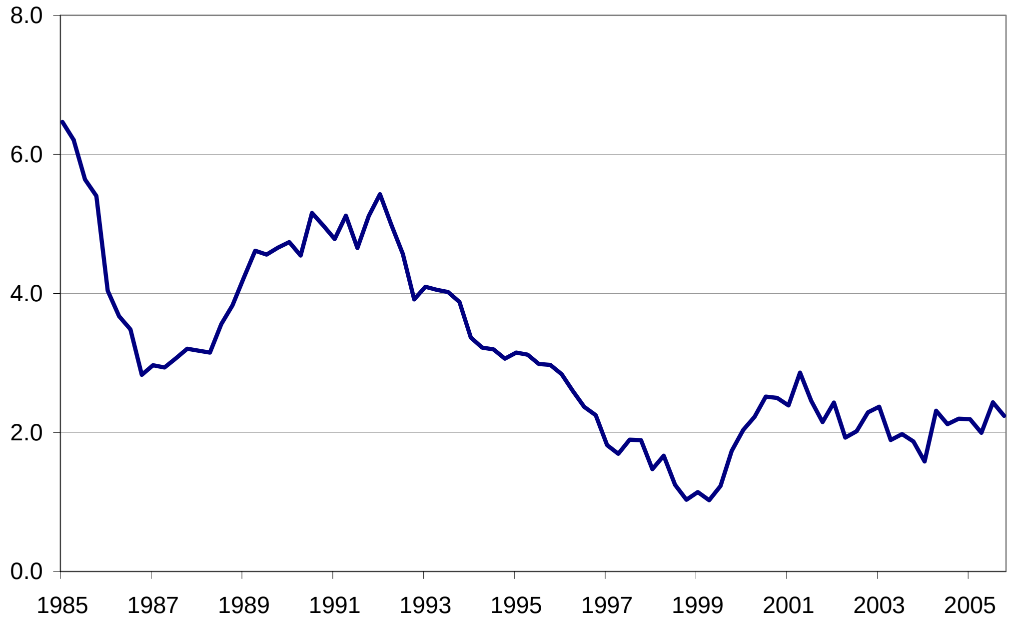
Credit and the business cycle
(quarterly data, annual percentage changes)



Source: ECB, Eurostat and national statistics.

Figure 2

Consumer price index
(quarterly data, annual percentage changes)

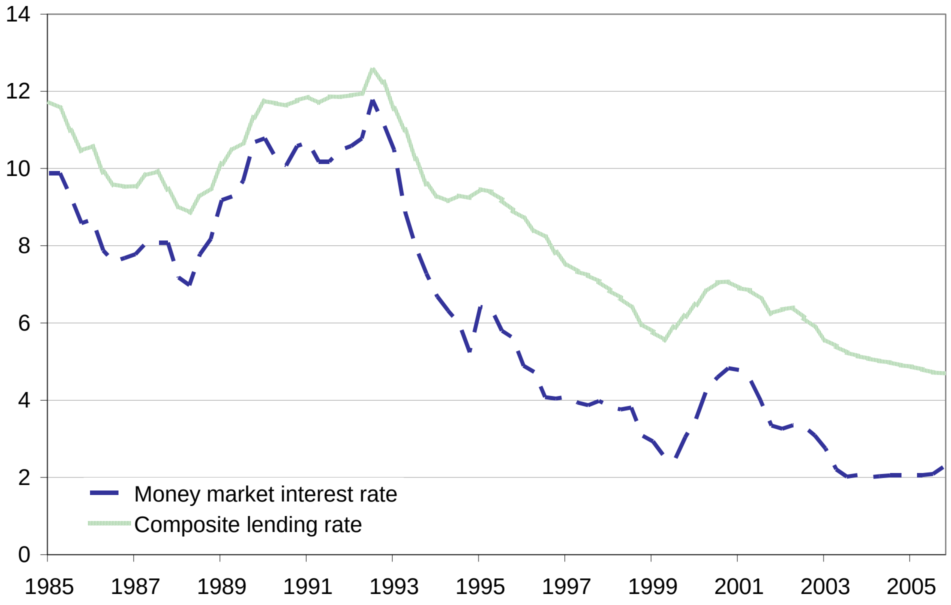


Souce: OECD.

Figure 3

Interest rates

(quarterly data, percentage values)

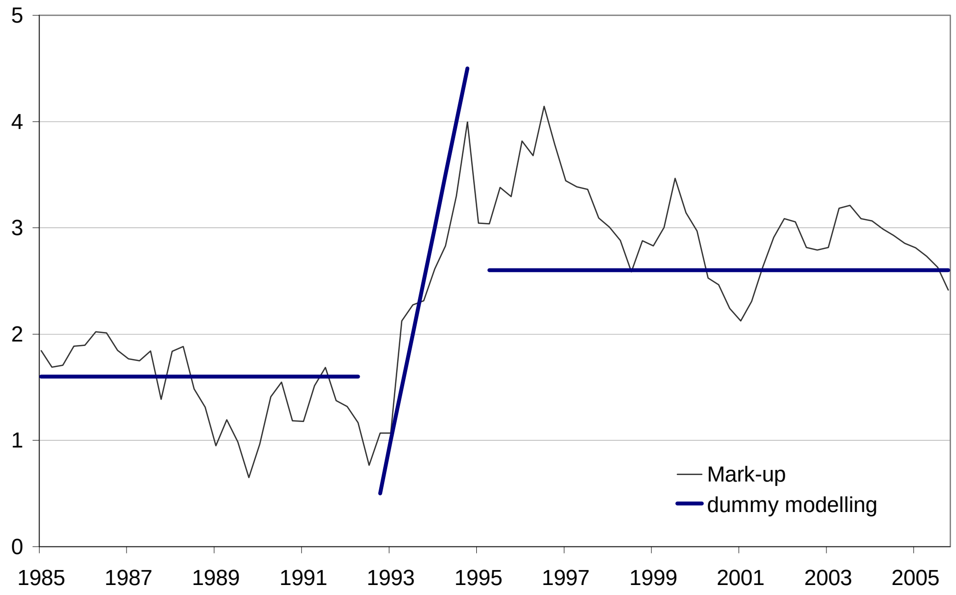


Source: ECB and Calza (2006).

Figure 4

Structural break in the mark-up

(quarterly data)

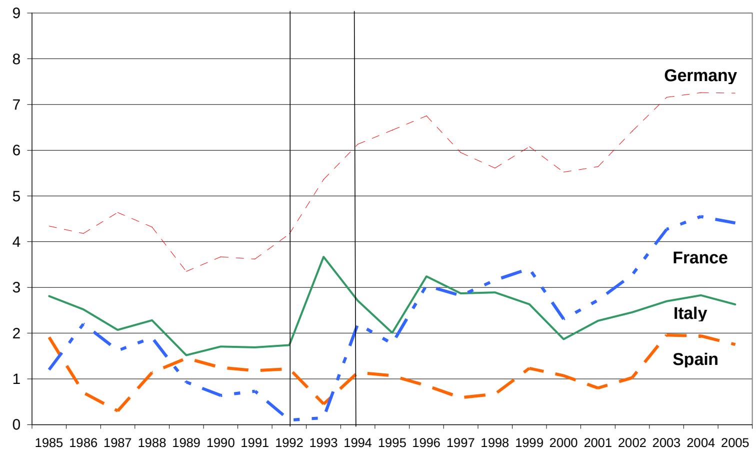


Source: ECB, Calza (2006) and authors' calculations.

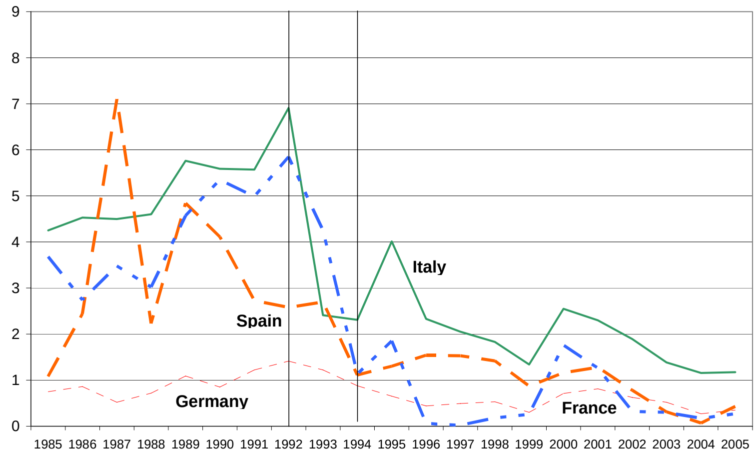
Figure 5

Spread behaviour in the four major euro area countries

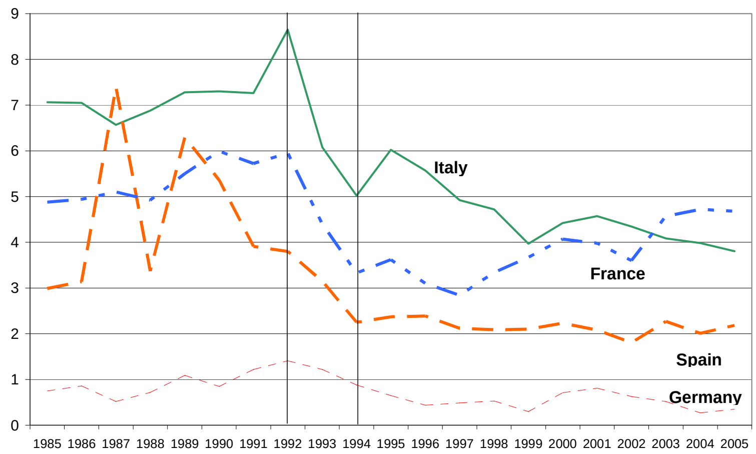
a. Mark-up: short lending rate – money market rate



b. Mark-down: money market rate – deposit rate



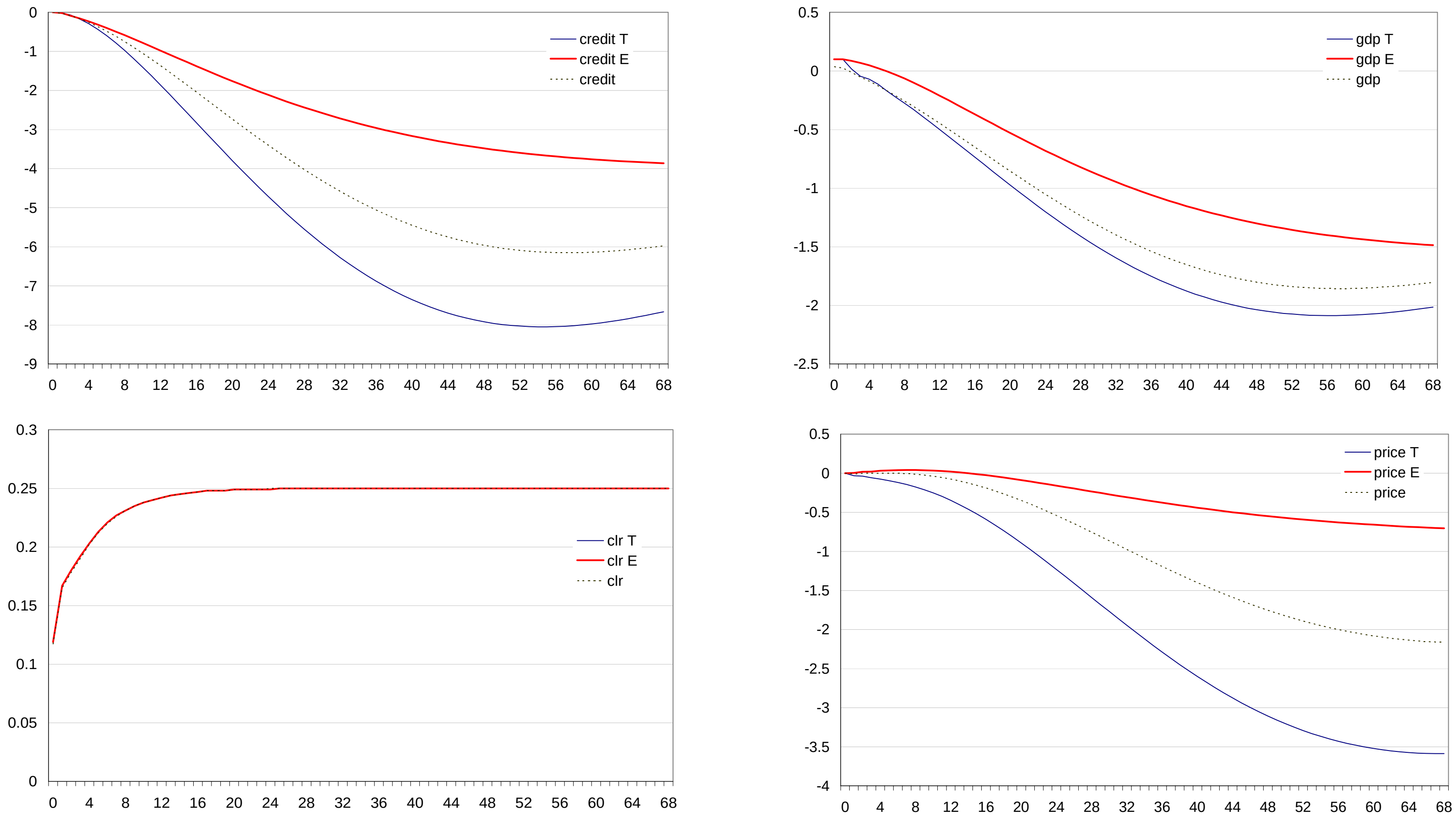
c. Spread: short-term lending rate – deposit rate (**a**+**b**)



Source: IFS and ECB. Annual data and percentage values. Data are not harmonized and therefore we may infer qualitative indications on the pattern of the interest rates but we cannot make any comparison of the levels.

Figure 6

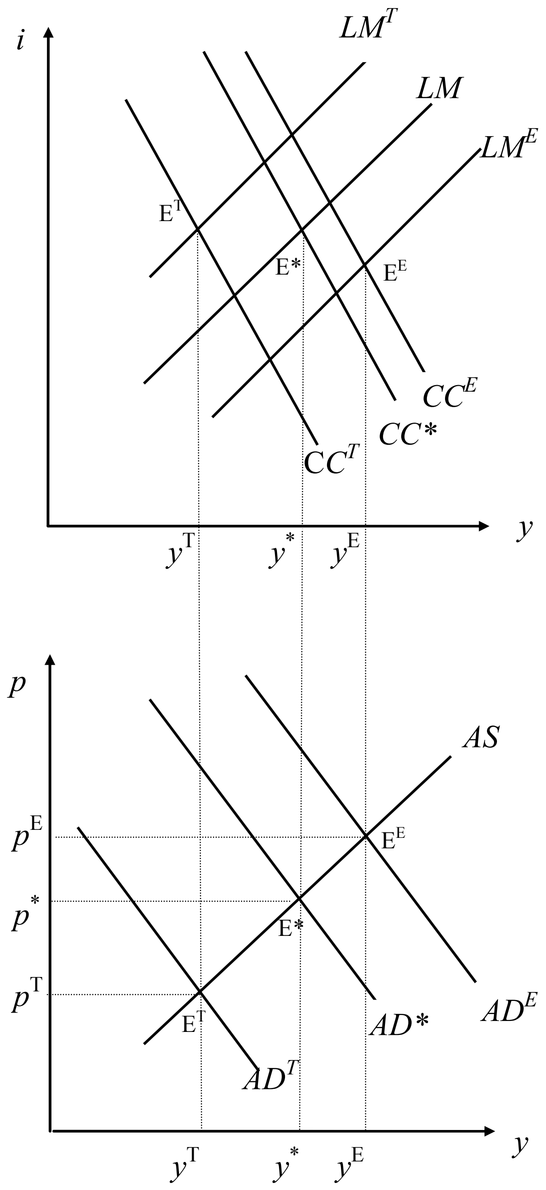
Adjustment paths to positive and negative changes in the monetary policy indicator
(percentage values)



Note: The experiment consists in evaluating the effect after 70 quarters of a 25basis point permanent change in the monetary policy indicator. The symbol T represents a monetary tightening, the symbol E a monetary easing. To make simulations more comparable the effects for easing monetary policy are multiplied by -1.

Figure 7

"Pushing on a string effect" inside Bernanke and Blinder's model



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