Interest Rate Pass-Through, Monetary Policy Rules and Macroeconomic Stability *

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December 2005

Abstract

In this paper we analyze equilibrium determinacy in a sticky price model in which the pass-through from policy to retail interest rates is sluggish and potentially incomplete. In addition, we empirically characterize and compare the interest rate pass-through process in the euro area and the U.S. We find that if the pass-through is incomplete in the long run, the standard Taylor principle is insufficient to guarantee equilibrium determinacy. Our empirical analysis indicates that this result might be particularly relevant for bank-based financial systems like the euro area.

Keywords: Interest Rate Pass-Through, Interest Rate Rules, Equilibrium Determinacy, Stability

JEL codes: E32, E52, E58

*The views expressed in this paper are those of the authors and do in no way commit the Oesterreichische Nationalbank.

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1 Introduction

The stability properties associated with monetary policy rules have attracted a substantial amount of attention. In particular, monetary policy rules give rise to a determinate equilibrium if the implied response to inflation is sufficiently strong. To avoid indeterminacy, nominal interest rates have to respond sufficiently to an increase in inflation to raise the real interest rate. Hence, the nominal rate has to respond at least one-for-one to changes in the (expected) inflation rate to guarantee a stable and unique equilibrium. This result is referred to as the *Taylor principle* (Woodford, 2003). Otherwise, the equilibrium is indeterminate and fluctuations resulting from self-fulfilling revisions in expectations become possible. Intuitively, if nominal rates do not adjust sufficiently, a rise in expected inflation leads to a decrease in the real interest rate which stimulates aggregate demand. Higher aggregate demand results in an increase in inflation and consequently the initial expectation is confirmed. Several studies argue that the comparatively successful conduct of monetary policy since the early 1980s is primarily due to the implementation of an appropriate policy rule, that is, a rule that satisfies the Taylor principle (see e.g. Judd and Rudebush, 1998; Taylor, 1999; Clarida et al., 1998, 2000).[1]

However, empirically it appears that retail interest rates respond less than one-for-one to policy rates (e.g. De Bondt, 2005; Ehrmann et al., 2003). Moreover, retail rates are likely to at least partially influence aggregate demand. Thus, it seems conceivable that although monetary policy is tightened sufficiently obeying the Taylor principle, market and especially retail inter-

[1] Nevertheless, this view is not without controversy. In a series of papers, Orphanides (2005, 2003, 2002) argues that the instability observed in the 1970s was the consequence of too ambitions goals for output stabilization and too pessimistic real time estimates of the output gap.

est rates do not respond sufficiently to ensure that real rates are stabilizing. This appears to be particularly relevant for the euro area which is generally thought to be an example of a bank-based financial system (Allen and Gale, 2000). Berger and Udell (1992) point out that liquidity smoothing is typical for environments, in which close customer relationships develop over time. That is, banks with close ties to their customers may offer implicit interest rate insurance and hold interest rates relatively constant despite changes in the stance of monetary policy.

In the present paper we analyze the stability properties of a simple sticky price model in which retail interest rates adjust sluggishly to changes in policy rates and the pass-through is potentially incomplete. In particular, we introduce costly financial intermediation which gives rise to sticky retail interest rate rates. Although we model limited interest rate pass-through in a highly simplified way without providing explicit micro foundations, we still believe that this feature of the model represents an important aspect of the monetary transmission mechanism that is missing in most other models.

Several studies find that the conditions for a determinate equilibrium have to be modified under certain circumstances. Edge and Rudd (2002) and Roisland (2003) claim that the presence of taxes on capital income requires a strengthening of the Taylor principle. Galí et al. (2004) introduce rule-of-thumb consumers in a sticky-price model and show that the Taylor principle is no longer sufficient for determinacy. De Fiore and Liu (2005) find that for a small open economy the degree of openness to trade is critical for stability. However, the idea that the financial system and in particular the interest rate pass-through may impact upon the determinacy of the equilibrium has not been explored to our knowledge. Thus, the present paper contributes to the literature in this respect.

Our main result is that if the pass-through to retail interest rates is incomplete in the long run, the standard Taylor principle does no longer guarantee a determinate equilibrium. Put differently, the coefficient on inflation in the Taylor rule may have to be well above unity to be consistent with a unique and stable equilibrium.

In addition, we explore whether limited interest rate pass-through is likely to be important in a quantitative sense. We provide empirical evidence on the pass-through process for the euro area and the U.S. as examples of market-based and bank-based systems. We find that the pass-through is slower and less complete in the euro area in comparison to the U.S. Overall, we conclude that limited pass-through does not appear to be a source of instability neither in the euro area nor in the U.S.

The paper is structured as follows: Section 2 describes a simple model which will be the basis of our analysis. The link between limited pass-through and determinacy is analyzed in Section 3. Section 4 reports the results of our empirical analysis and Section 5 discusses the implications of the empirical results in terms of determinacy. Section 6 concludes the paper.

2 Model

The model we employ is a standard New Keynesian business cycle model closely related to Christiano et al. (1999) and Woodford (2003), hence the description will be brief. The model consists of firms, a financial intermediary sector and households. The only asset available in the economy is a risk-less, nominal, one-period bond that pays an interest rate of R_t. However, it is assumed that households cannot directly buy bonds, but have to deposit funds at a financial intermediary instead. The financial intermediary uses the deposits of the households and buys bonds. Moreover, we assume that financial intermediation is costly and that this cost is a function of the change in interest rates. This assumption allows us to introduce interest rate smoothing into the model in a simple, reduced form way. The financial intermediaries maximize profits, given by $R_t B_t - \Psi_t R_t^D D_t$, by the choice of bonds, B_t and deposits, D_t, which yield a gross interest rate of R_t^D. $\Psi_t > 1$ represents an intermediation cost. In particular, we assume that $\Psi_t = \psi_0 \left(\frac{R_t^D}{(R_{t-1}^D)^\nu} \right)^\psi$, where $\psi_0 > 0$ and $\psi > 0$. The parameter ψ_0 is chosen such that $\Psi_t > 1$. Since, banks do not have an incentive to hold reserves, it follows that $D_t = B_t$. Taking a log-linear approximation of the bank's necessary condition gives

$$\hat{R}_t^D = \frac{1}{1+\psi} \hat{R}_t + \frac{\psi\nu}{1+\psi} \hat{R}_{t-1}^D, \tag{1}$$

where hatted variables denote percentage deviations from the steady state. Thus, $1/(1+\psi)$ determines the immediate pass-through from the bond yield, which is assumed to be the interest rate targeted by monetary policy, and $\psi\nu/(1+\psi)$ determines the persistence of the deposit rate.

Households maximize their expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\eta}}{1+\eta} \right), \tag{2}$$

where $\sigma > 0$ and $\eta > 0$, β is a discount factor, C_t is consumption of a composite good in period t and L_t denotes labor supply in period t. The composite consumption good, C_t, is a CES aggregate of the quantities of differentiated goods, $C_t(i)$, where $i \in (0,1)$: $C_t = \left(\int_0^1 C_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$. Households enter each period with bank deposits carried over from the previous period, D_{t-1}. Furthermore, households supply L_t units of labor at a nominal wage of W_t. The representative household owns firms and the financial intermediaries and receives dividends. Hence, deposits evolve according to: $D_t = W_t L_t + R_t^D D_{t-1} - P_t C_t + \Pi_t$, where P_t denotes the aggregate price index and Π_t are dividends distributed at the end of the period. Household behavior is summarized by the usual consumption Euler equation and a labor supply equation:

$$\hat{C}_t = -\frac{1}{\sigma}(\hat{R}_t^D - E_t(\hat{\pi}_{t+1})) + E_t(\hat{C}_{t+1}), \tag{3}$$

$$\hat{W}_t - \hat{P}_t = \eta \hat{L}_t + \sigma \hat{C}_t. \tag{4}$$

The business sector of the economy consists of a continuum of monopolistically competitive firms normalized to unit mass. Each firm i hires labor, H_{it}, and produces output according to: $Y_{it} = H_{it}^{1-\alpha}$, where $\alpha \in (0,1)$. Furthermore, we assume staggered price setting and allow inflation to depend on its own history as in Galí et al. (1999) and Galí et al. (2001). That is, each period, a fraction $(1-\theta)$ of the firms is able to readjust its price. However, a fraction $(1-\omega)$ of these firms that can set prices in the current period, resets prices optimally, the remaining firms follow a backward looking rule. As shown in Galí et al. (2001), these assumptions on the pricing behavior of firms give rise to a Phillips curve of the form:

$$\hat{\pi}_t = \delta \widehat{mc}_t + \beta\theta\phi^{-1} E_t \hat{\pi}_{t+1} + \omega\phi^{-1}\hat{\pi}_{t-1}, \tag{5}$$

where $\pi_t = \log P_t - \log P_{t-1}$ is the inflation rate, $\delta = \frac{(1-\theta)(1-\theta\beta)(1-\alpha)(1-\omega)}{(1+\alpha(\epsilon-1))}\phi^{-1}$, $\phi = \theta + \omega(1-\theta(1-\beta))$ and mc_t denotes average real marginal cost.

Using the market clearing conditions $Y_t = C_t$ and $H_t = L_t$ and (4), the log-linearized model can be written as:

$$\hat{Y}_t = -\frac{1}{\sigma}(\hat{R}_t^D - E_t(\hat{\pi}_{t+1})) + E_t(\hat{Y}_{t+1}), \tag{6}$$

$$\hat{\pi}_t = \delta\gamma \hat{Y}_t + \beta\theta\phi^{-1} E_t \hat{\pi}_{t+1} + \omega\phi^{-1}\hat{\pi}_{t-1}, \tag{7}$$

$$\hat{R}_t^D = \lambda_1 \hat{R}_t + \lambda_2 \hat{R}_{t-1}^D, \tag{8}$$

where $\gamma = \frac{1+\eta}{1-\alpha} - 1 + \sigma$, $\lambda_1 = 1/(1+\psi)$ and $\lambda_2 = \psi\nu\lambda_1$. The intertemporal IS curve in (6) and the Phillips curve in (7) constitute a baseline model widely used for the evaluation of monetary policy (see e.g. Clarida et al., 1999). The dynamics of the deposit rate is determined by (8) where λ_1 captures the instantaneous pass-through from policy to deposit rates and λ_2 determines the degree of persistence. To fully describe the equilibrium dynamics of the model an interest rate rule as a description of monetary policy is added. We assume that monetary policy targets the interest rate on bonds, R_t:

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1-\rho)(\kappa_\pi \hat{\pi}_t + \kappa_y \hat{y}_t), \tag{9}$$

where ρ determines the degree of monetary policy inertia and κ_π, κ_y characterize the response of the policy rate to inflation and output.

3 Interest Rate Pass-Through and Determinacy

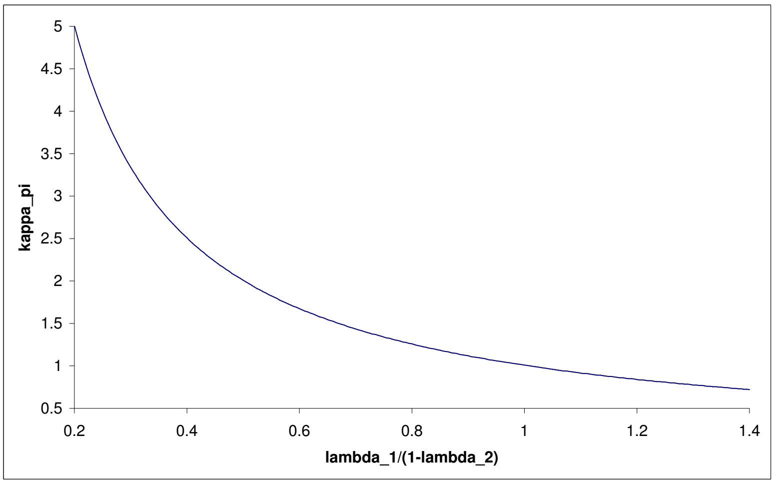
In this section we analyze how the interest rate pass-through influences the stability properties of the model. The model (6) - (9) can be conveniently written as $AE_t(u_{t+1}) = Bu_t$, where $u_t = (\hat{Y}_t, \hat{\pi}_t, \hat{R}_t, \hat{R}_t^D)'$ and A and B are coefficient matrices with entries that are functions of the structural parameters. Determinacy or stability of the rational-expectations equilibrium corresponds to the case where the number of eigenvalues of $A^{-1}B$ outside the unit circle is equal to the number of predetermined variables (Blanchard and Kahn, 1980). We simulate the model to see how the parameters λ_1 and λ_2 influence this stability condition.

The following parameter values are chosen: The time discount factor β is set to 0.99. The coefficients σ and η, which determine the intertemporal elasticity of substitution and the labor supply elasticity, are both set equal to 2. ϵ is set to 11, which corresponds to a steady-state mark-up of 11. α is set to 0.33. Furthermore, $\omega = 0.3$, which means that 30 percent of the firms follow a backward looking pricing rule. Prices are assumed to be fixed on average for 4 quarters, therefore $\theta = 0.75$. This calibration of the price-setting behavior is roughly in line with the recent empirical evidence (see Leith and Malley, 2005). According to empirical evidence reported in Gerdesmeier and Roffia (2004) for the euro area and in Clarida et al. (2000) for the U.S., we set $\rho = 0.8$.

For simplicity, consider the case where monetary policy does not react to the output gap, that is $\kappa_y = 0$. Furthermore, let $\lambda = \lambda_1/(1 - \lambda_2)$ denote the long-run effect of the policy interest rate on the deposit rate. Figure 1 displays the frontier that divides the parameter space (λ, κ_π) into regions corresponding to determinate and indeterminate equilibria. The frontier is downward sloping and convex to the origin. Points to the right of the frontier correspond to parameter combinations that are consistent with a determinate equilibrium. Points to the left lead to indeterminacy. Thus, the frontier defines the lower bound on κ_π, denoted by $\bar{\kappa}_\pi$, consistent with a determinate equilibrium. Clearly, a lower long-run pass-through requires a stronger response of monetary policy to inflation to ensure determinacy. In particular, our simulations show that for $\kappa_y = 0$, $\bar{\kappa}_\pi$ corresponds to $1/\lambda$. Thus, the Taylor principle has to be modified in this environment to $\kappa_\pi \lambda > 1$. For values of κ_π below $\bar{\kappa}_\pi = 1/\lambda$, the equilibrium is indeterminate and fluctuations resulting from self-fulfilling revisions in expectations become possible. The intuition is straightforward: For low values of λ, changes in the policy interest rate are to a large extent absorbed by the banking sector and not passed on to households. Hence, if expected inflation increases, monetary policy has to be tightened considerably to have a stabilizing effect on aggregate demand. Note that what matters is the long-run pass-through. Thus, high persistence, λ_2, compensates for a low initial pass-through, λ_1. For $\lambda = 1$ the associated value of $\bar{\kappa}_\pi$ is unity. Hence, for a complete pass-through at least in the long run, we obtain the standard Taylor principle.

So far we have restricted our analysis to the case $\kappa_y = 0$. For $\kappa_y > 0$, the frontier shifts down, since the response of interest rates to the output gap has to be taken into account. According to the Phillips curve, permanently higher inflation implies a permanently higher output gap, which will lead to higher interest rates in the long run (see Woodford, 2003). However, for empirically plausible values for κ_y the implications for $\bar{\kappa}_\pi$ are negligible.

Figure 1: Regions of Determinacy and Indeterminacy



Notes: The frontier divides the parameter space into regions corresponding to determinate and indeterminate equilibria. Points to the right of the frontier correspond to parameter combinations that are consistent with a determinate equilibrium.

Note that according to (9) the nominal interest rate adjusts to contemporaneous deviations of inflation and output from their steady state values, whereas empirical evidence indicates that monetary policy acts in a forward looking manner. In models with forward looking interest rate rules, the Taylor principle is still a necessary condition for equilibrium determinacy, although it is no longer sufficient. In particular, if the nominal interest rate is adjusted in response to expected inflation determinacy requires that κ_π is not too large (Woodford, 2003). However, the upper bound on κ_π associated with determinacy appears to be extremely large for plausible parameterizations and is satisfied by empirically estimated interest rate rules. Thus, focusing our analysis on the class of non-forward looking interest rate rules does not appear to be overly restrictive.

4 Empirical Analysis

In this section we empirically compare the interest rate pass-through across financial systems, where the euro area and the U.S. are taken as examples of a bank-based and a market-based system, respectively. As our model does not explicitly account for investment, we interpret C_t more broadly as the interest-sensitive part of GDP and not just as consumption spending. Hence, our empirical analysis is based on a wide spectrum of retail rates relevant for households and firms.

4.1 Data

As a proxy for the monetary policy rate we take the 3-month money market rate. Due to differences in the statistical systems, it is hard to find equivalent retail interest rate series for the U.S. and the euro area. For bank deposit rates we aim for interest rates with similar maturities, while regarding lending rates we take loans that cover businesses and consumers over short as well as long horizons. For the U.S. we analyze four different bank deposit rates with maturities between one month and one year. For the euro area we include five different deposit rates: sight deposits, saving deposits (redeemable at notice below and above three months) and time deposits (with agreed maturities below and above two years). Moreover, we incorporate three different bank lending rates for the U.S. in our analysis, which cover short-term loans for businesses, short-term consumer credits and mortgage loans for businesses and households. For the euro area we include four different lending rates, namely business loans (below and above one year) and short-term loans as well as mortgage loans to households. All interest rates are monthly data, with the exception of consumer credit rates in the U.S., which are reported with a quarterly frequency. The time period we consider starts in January 1995 and ends in September 2003, because no longer aggregated time series are available for the euro area.[2] There are few exceptions, where the time series starts little later than January 1995. Details on the time period covered by the data as well as the source of the data are found in Appendix A.

In addition to the individual series, we conduct our empirical analysis with a weighted average of the interest rates to obtain a summary measure for the pass-through process. The weights are chosen according to the importance of the individual lending and deposit categories in the portfolio of commercial banks. For the U.S. we take the weights from the Flow of Funds Accounts of the United States (Z.1), which are published by the Board of Governors of the Federal Reserve System.[3] The three lending rates mentioned above are taken as representative interest rates for the portfolio items 'bank loans n.e.c.', 'consumer credit' and 'mortgages', which altogether amount to 95 percent of total loans of the commercial banking sector.[4] Time and saving deposits

[2]In 2003 the ECB changed the statistical system for collecting retail interest rates and stopped producing the series mentioned above in September 2003. The new series that starts in 2003 is not compatible with the one we are using.

[3]Table L.109 gives the levels of the portfolio of U.S. Commercial Banks.

[4]In 2003 'bank loans n.e.c.' constitute 29 percent, 'consumer credit' 15 percent and

are also included in the Flow of Funds Accounts, however, unfortunately not according to their maturities. Thus, we are not able to set up a weighted average for U.S. bank deposit rates. For weighting retail rates in the euro area we can directly refer to balance sheet information from Monetary Financial Institutions (MFI), which are published in the statistical section of the ECB's Monthly Bulletin.[5]

4.2 Unit root tests

We first test for unit roots in money market and retail interest rates in our sample using the Augmented Dickey-Fuller (ADF) test (see Dickey and Fuller, 1979; Said and Dickey, 1984) and the Phillips-Perron (PP) test (see Phillips, 1987; Phillips and Perron, 1988). Ng and Perron (2001) argue that many unit root tests suffer from low power and size distortions. Thus, we also apply the four tests developed by Ng and Perron (2001) (NgP-tests) with improved size and power.[6]

Detailed test results are reported in Appendix B. In all but one case the results of the ADF-test and the PP-test suggest that the series are $I(1)$ and these results are confirmed by the four NgP-tests. The one exception is the interest rate on sight deposits in the euro area, where the PP-test argues in favor of $I(1)$, while the ADF-test and the four NgP-tests indicate that the

'mortgages' 51 percent of total loans from Commercial Banks.

[5]Table 2.4 of the ECB's Monthly Bulletin gives the amount of loans from Monetary Financial Institutions according to counterpart, type and maturity. In 2003 the shares of business loans, short-term loans to consumers and mortgage loans to consumers were 52 percent, 8 percent and 40 percent, respectively. Table 2.5 of the ECB's Monthly Bulletin gives the amount of deposits held with MFIs by counterpart and instrument. Sight deposits, saving deposits and time deposits amounted to 38 percent, 31 percent and 31 percent of total deposits held by non-financial corporations and households in the euro area, respectively.

[6]These test statistics from Ng and Perron (2001) are modified forms of the PP-test statistics (MZa, MZt), the test statistic suggested by Bhargava (1986) (MSB), and the Point Optimal statistic from Elliot et al. (1996)(MPT).

time series is $I(2)$. Hence, we follow the majority of the tests and take this series to be $I(2)$.

4.3 Co-integration tests

As money market rates and retail interest rates are $I(1)$, with the exception of the interest rate on sight deposits in the euro area, we proceed with testing for co-integration. The series for the interest rates on sight deposits in the euro area is excluded from this analysis. Again we apply a battery of tests. First, we apply the OLS-residual-based tests proposed by Engle and Granger (1987) (ADF-test) and Phillips and Ouliaris (1990) (PP-test). In addition, we use the more recent tests developed by Perron and Rodriguez (2001) (PR-test), who use GLS-detrended data and construct test statistics similar to those by Ng and Perron (2001). In particular, we apply two of the PR-tests, which are modified forms of the PP-test statistics (MZa) and the ADF-test (ADF-GLS).

For the U.S. the standard tests suggest that all retail interest rates (lending as well as deposit rates) are co-integrated, while the PR-tests reject the hypothesis of co-integration. For the euro area the standard tests do not give a uniform answer for all the series. While lending rates seem to be more likely to be co-integrated, deposit rates do not seem to have a co-integrating relationship with money market rates. However, as in the case of U.S. retail rates, the new PR-tests clearly argue against co-integration for all series. Detailed test results can be found in Appendix B.

As the tests suggested by Perron and Rodriguez (2001) are achieving important power gains through the use of GLS-detrended data, we conclude that none of the retail rates is co-integrated with the money market rate.

4.4 Long-run pass-through

Since our data series do not appear to be co-integrated we estimate the pass-through in the short and in the long run based on (8). However, the equation is generalized to an autoregressive distributed-lag (ADL) model by adding additional lags of the money market rate and the retail interest rate. To take the non-stationarity of the data into account, the equation is estimated with differenced data. We choose the number of lags according to the Akaike Information Criterion with the initial maximum number of lags set at six.

$$\Delta R_t^D = c_0 + \sum_{i=0}^{i_{max}} a_i \Delta R_{t-i} + \sum_{j=1}^{j_{max}} b_j \Delta R_{t-j}^D \tag{10}$$

While the short-run pass-through is equal to a_0, the long-run multiplier λ is calculated according to

$$\lambda = \sum_{i=0}^{i_{max}} a_i / 1 - \sum_{j=1}^{j_{max}} b_j. \tag{11}$$

Tables 1 and 2 give the results for the U.S. and the euro area, respectively. In the U.S. the pass-through of money market rates to bank deposit rates is nearly complete. For deposits with short maturities (1 and 3 months) the null-hypothesis that the long-run pass-through is equal to one is not rejected. Thus, the long-run pass-through appears to be complete for deposit rates with short-maturities, while it is slightly below unity for deposit rates with maturities of 6 months and 1 year. Changes in policy rates are passed on very quickly and sometimes in the short run even to a larger extent than in the long run.

In the euro area we observe a much smaller pass-through to deposit rates than in the U.S. The long-run pass-through ranges between 0.27 for saving deposits with maturities of less than 3 months and 0.66 for time deposits with a maturity of up to 2 years. Our estimates of the final pass-through

Table 1: Short and long-run pass-through in the U.S., 1995-2003

	short-run pass-through		long-run pass-through	
Deposit rates				
TCD, 1 month	0.76	(0.06)	1.04	(0.03)
TCD, 3 months	1.02	(0.01)	1.01	(0.01)
TCD, 6 months	1.03	(0.05)	0.92	(0.04)
US deposits, 1 year	1.08	(0.09)	0.74	(0.08)
Lending rates				
Business, short-term	0.44	(0.06)	1.04	(0.05)
Mortgage, long-term	0.71	(0.16)	0.29	(0.28)
Consumers, short-term	0.30	(0.12)	0.36	(0.08)
Weighted average	0.79	(0.15)	0.57	(0.11)

Notes: TCD abbreviates Time Certificates of Deposit. Standard errors in parenthesis. The standard errors for the long-term pass-through are calculated according to the Delta-Method (e.g. Greene, 2000, p. 330). The sample of mortgage lending rates in the U.S. was shortened to 2000, where there seems to be a structural break. After 2000 the short as well as the long-run pass-through decline significantly. Because of the structural break in the mortgage rate, the sample of the weighted average was also adjusted to 1995-2000.

are strictly smaller than those reported in De Bondt (2005).[7] However, the position of deposit rates regarding the relative strength of the pass-through is the same in both analysis.

We conclude that the long-run pass-through is less complete in the euro area than in the U.S. for all categories of deposit rates. The weighted average, which is a summary indicator for deposit rates in the euro area, amounts to 0.32. The short-run pass-through is quite heterogeneous in the euro area. For deposit rates with short maturities a third of the amount passed on in the long run is passed on within one month. For deposit rates with longer maturities the short-run and the long-run pass-through are equal, meaning that the long-run pass-trough is already passed on within the first month.

The main message, namely that the long-run pass-through is more com-

[7] De Bondt (2005) uses the same data for the euro area. However, he investigates a shorter time period and assumes that nearly all series are co-integrated.

Table 2: Short and long-run pass-through in the euro area, 1995-2003

	short-run pass-through		long-run pass-through	
Deposit rates				
Saving deposits, < 3months	0.09	(0.02)	0.27	(0.04)
Saving deposits, > 3months	0.32	(0.04)	0.60	(0.08)
TD, up to 2 years	0.36	(0.04)	0.66	(0.08)
TD, over 2 years	0.40	(0.06)	0.41	(0.10)
Weighted average	0.16	(0.02)	0.32	(0.03)
Lending rates				
Business, up to 1 year	0.27	(0.04)	0.69	(0.15)
Business, over 1 year	0.47	(0.07)	0.55	(0.08)
Mortgage, households	0.35	(0.06)	0.53	(0.09)
Households, short-term	0.09	(0.05)	0.43	(0.09)
Weighted average	0.34	(0.05)	0.48	(0.06)

Notes: TD abbreviates Time Deposit. Standard errors in parenthesis. The standard errors for the long-term pass-through are calculated according to the Delta-Method (e.g. Greene, 2000, p. 330).

plete in the U.S. than in the euro area, is also true for lending rates. However, in the U.S. the diversity in the pass-through processes is rater high. On the one hand mortgage rates in the U.S. are smoothed heavily. In the long run only 29 basis points are passed on from a change of 100 basis points in the policy rate. On the other hand, in the case of short-term business loans the long-run pass-through is complete. Statistically it is not significantly different from one. Furthermore, nearly half of the long-run pass-through is passed on within the first month. The weighted average of lending rates in the U.S. amounts to 0.57.

In the euro area, the long-run pass-through ranges between 0.43 for short-term loans for households and 0.69 for business loans with a maturity of up to 1 year. Like in the case of deposit rates, our estimates of the long-run pass-through are strictly smaller than those in De Bondt (2005). The position of lending rates with regard to the relative strength of their final pass-through again matches his results. The weighted average of lending rates, which summarizes short-term and long-term loans to businesses and households, lies at 0.48. The comparison between the summary lending rates in the two economic areas shows clearly that the long-run pass-through of the weighted average of lending rates is significantly smaller in the euro area than in the U.S.

5 Discussion

Ultimately, the goal of this paper is to analyze how the pass-through process to retail interest rates influences equilibrium determinacy and macroeconomic stability. However, a precise quantitative evaluation appears difficult for the following reason: It is not clear to what extent retail interest rates as opposed to market interest rates are relevant for the determination of aggregate demand. Only a fraction of the households and firms in the economy relies on financial intermediaries, whereas the rest participates in financial markets directly. Assuming that at least the long-run pass-through from policy rates to market rates is close to complete, the overall pass-through to interest rates more generally is likely to be higher than to retail rates.

For the U.S., the long-run pass-through, λ, is nearly complete for most categories of deposit rates and on average approximately 0.57 for lending rates. Thus, our empirical results suggest that $\bar{\kappa}_\pi$, the minimum value for κ_π, consistent with a determinate equilibrium, lies between unity and 1.75 in the U.S.[8] However, the banking sector and therefore retail rates play only a relatively minor role for the determination of U.S. aggregate demand. Thus,

[8]Note that this calculation assumes $\kappa_y = 0$. For empirically plausible values of κ_y, differences are negligible.

we may conclude that $\bar{\kappa}_\pi$ is likely to lie substantially closer to be lower bound of this interval.

In the euro area, the average long-run pass-through appears to be lower than in the U.S. Consequently, larger values of κ_π are needed for determinacy. Our estimate of the average pass-through to lending rates suggests a value for $\bar{\kappa}_\pi$ of approximately two. Looking at the average pass-through to deposit rates suggests an even lager value of around three. Again, the overall pass-through relevant for aggregate demand and macroeconomic stability is likely to be higher. Therefore, these numbers for $\bar{\kappa}_\pi$ should be interpreted as upper bounds. However, in a bank-based system like the euro area, the difference should not be as large as in the U.S. Overall, the higher pass-through to U.S. retail rates together with the smaller relative size of the U.S. banking sector suggest that $\bar{\kappa}_\pi$ is lower in the U.S. than in the euro area.

How do our results compare to empirically estimated interest rate rule coefficients? For the U.S., Clarida et al. (2000) find a value of 2.15 for κ_π for the Volcker-Greenspan period. Based on real-time-data Orphanides (2005) reports lower values of around 1.8. For the euro area Gerdesmeier and Roffia (2004) estimate several specifications. Based on their preferred specification they obtain estimates ranging from 1.9 to 2.2. A precise evaluation is again complicated and the caveats mentioned above have to be kept in mind. However, the estimated values for κ_π appear to fall within the determinate region for both economies. Nevertheless, the euro area, as a more bank-based system, may be closer to the indeterminate region than the U.S.

6 Concluding Remarks

The influence of monetary policy on aggregate demand and inflation depends on the degree to which changes in policy interest rates are 'passed trough' to market and retail interest rates. In this paper we focus on the possibility of sunspot fluctuations that arise from self-fulfilling revisions to expectations. If the pass-through from policy to retail interest rates is incomplete in the long run, the standard Taylor principle turns out to be insufficient for equilibrium determinacy. Our empirical estimates indicate that this result is particularly relevant for bank-based financial systems like the euro area.

Nevertheless, our quantitative results have to be interpreted with some caution, since it is not clear to what extent aggregate demand is sensitive to retail interest rates as opposed to market interest rates. Despite this caveat, we interpret our results as casting some doubt on the usual interpretation of interest rule coefficients and their implications for macroeconomic stability.

A Data Description

Table A1: Money market and retail interest rates

	Source	Codes	Time Period
U.S.			
Deposit rates			
TCD, 1 month	BIS	HPEAUS12	1995:01 - 2003:09
TCD, 3 months	BIS	HPEAUS02	1995:01 - 2003:09
TCD, 6 months	BIS	HPEAUS62	1995:01 - 2003:09
U.S. deposits, 1 year	IFS	111 60LDF	1995:01 - 2003:09
Lending rates			
Business, short-term	BIS	HLBAUS02	1995:01 - 2003:09
Mortgage, long-term	BIS	HLLAUS01	1995:01 - 2003:09
Consumers, short-term	Fed	G.19	1995:01 - 2003:09
Weighted average			1995:01 - 2003:09
Money market rate			
Money market, 3 months	BIS	JFBAUS02	1995:01 - 2003:09
Euro area			
Deposit rates			
Sight deposits	BIS	HPBAXM02	1995:12 - 2003:09
Saving deposits, < 3 months	BIS	HPHAXM16	1995:01 - 2003:09
Saving deposits, > 3 months	BIS	HPHAXM36	1995:01 - 2003:09
TD, up to 2 years	BIS	HPFAXM16	1995:12 - 2003:09
TD, over 2 years	BIS	HPFAXM26	1995:12 - 2003:09
Weighted average			1995:12 - 2003:09
Lending rates			
Business, up to 1 year	BIS	HLBAXM12	1995:12 - 2003:09
Business, over 1 year	BIS	HLHAXM02	1996:11 - 2003:09
Mortgage, households	BIS	HLMAXM22	1995:12 - 2003:09
Households, short-term	BIS	HLBAXM22	1995:12 - 2003:09
Weighted average			1996:11 - 2003:09
Money market rates			
Money market, 3 months	BIS	JFBAXM02	1995:01 - 2003:09

Notes: TCD abbreviates Time Certificates of Deposit and TD Time Deposit. BIS stands for the Data Bank of the Bank for International Settlements. IFS stands for the International Financial Statistics of the International Monetary Fund and Fed stands for the monthly statistical release of the Board of Governors of the Federal Reserve Systems of the U.S.

B Unit Root and Co-integration Test Results

Table B1: Unit root test results for U.S. interest rates, 1995:01-2003:09

	ADF-test	PP-test	NgP-test MZa	NgP-test MZt	NgP-test MSB	NgP-test MPT
Deposit rates						
TCD, 1 month	-0.64	-0.08	-5.15	-1.31	0.25 *	5.49
1^{st} difference	-3.82 ***	-9.66 ***	-13.28 **	-2.56 **		1.90 **
TCD, 3 months	-0.16	-0.13	0.96	0.53	0.56	26.28
1^{st} difference	-5.10 ***	-6.76 ***	-8.30 **	-2.03 **	0.24 *	2.97 **
TCD, 6 months	-0.46	-0.29	0.91	0.51	0.56	26.28
1^{st} difference	-6.57 ***	-6.93 ***	-6.81 *	-1.84 *	0.27 *	3.62 *
U.S. deposits, 1 year	-0.56	-0.49	0.28	0.13	0.48	19.25
1^{st} difference	-7.72 ***	-7.94 ***	-15.72 ***	-2.80 ***	0.18 **	1.56 ***
Lending rates						
Business, short-term	-0.86	-0.02	0.35	0.17	0.47	18.86
1^{st} difference	-3.50 ***	-5.34 ***	-6.55 *	-1.81 *	0.28 *	3.74 *
Mortgage, long-term	-3.01	-2.61	-6.71	-1.83	0.27	13.57
1^{st} difference	-5.15 ***	-7.87 ***	-22.01 **	-3.29 **	0.15 **	4.31 **
Consumers, short-term	-0.50	-0.28	-0.66	-0.24	0.36	11.97
1^{st} difference	-3.58 **	-6.69 ***	-309.39 ***	-12.43 ***	0.04 ***	0.09 ***
Weighted average	-0.23	-0.42	-0.81	-0.32	0.39	12.54
1^{st} difference	-4.17 ***	-4.00 ***	-8.35 **	-2.03 **	0.24 *	3.00 **
Money market rate						
Money market, 3 months	-0.14	-0.08	0.98	0.54	0.56	26.24
1^{st} difference	-6.35 ***	-6.60 ***	-8.15 **	-2.01 **	0.25 *	3.03 **

Note,s: TCD abbreviates Time Certificates of Deposit. $^{***(**)[*]}$ stands for significant at the 1% (5%) [10%] level. All tests are based on estimated equations including a constant. In the case of lending rates for mortgages we include a constant and a time trend in the estimated equation. Furthermore, for the four NgP-tests we use the Modified AIC in order to select the adequate lag length. Exceptions are the TCD (1 month) and the U.S. deposits (1 year), where we use the "normal" AIC, because the use of the Modified AIC gives implausible results in the sense that the non-stationary null hypothesis is always rejected.

Table B2: Unit root test results for EU-12 interest rates, 1995:01-2003:09

	ADF-test	PP-test	NgP-test MZa	NgP-test MZt	NgP-test MSB	NgP-test MPT
Deposit rates						
Sight deposits	-2.56	-1.97	-7.15	-1.86	0.26	12.79
1^{st} difference	-2.60	-7.28 ***	-8.58	-2.07	0.24	10.62
2^{nd} difference	-15.59 ***		-142.78 ***	-8.45 ***	0.06 ***	0.64 ***
Saving deposits, $<$ 3 months	-2.57	-2.17	-4.40	-1.48	0.34	20.68
1^{st} difference	-4.92 ***	-7.95 ***	-29.78 ***	-3.86 ***	0.13 ***	3.06 ***
Saving deposits, $>$ 3 months	-2.89	-1.73	-4.90	-1.51	0.31	18.30
1^{st} difference	-5.18 ***	-5.11 ***	-33.24 ***	-4.07 ***	0.12 ***	2.75 ***
TD, up to 2 years	-2.06	-2.27	-4.48	-1.49	0.33	20.32
1^{st} difference	-4.26 ***	-4.16 ***	-21.25 **	-3.25 **	0.15 **	4.33 **
TD, over 2 years	-1.45	-1.49	-5.64	-1.59	0.28	15.97
1^{st} difference	-5.79 ***	-5.92 ***	-16.76 *	-2.90 *	0.17 *	5.44 **
Weighted average	-1.80	-2.09	-4.56	-1.50	0.33	19.89
1^{st} difference	-4.40 ***	-4.32 ***	-16.20 *	-2.84 *	0.18 *	5.64 *
Lending rates						
Business, up to 1 year	-1.86	-2.20	-0.51	-0.26	0.51	17.69
1^{st} difference	-4.32 ***	-4.16 ***	-6.45 *	-1.73 *	0.27 *	4.03 *
Business, over 1 year	-1.65	-1.84	-1.39	-0.55	0.39	11.52
1^{st} difference	-3.03 **	-6.50 ***	-6.28 *	-1.76 *	0.28	3.96 *
Mortgage, households	-1.09	-1.21	0.82	0.52	0.63	31.06
1^{st} difference	-5.09 ***	-5.10 ***	-7.75 *	-1.92 *	0.25 *	3.34 *
Households, short-term	-2.32	-2.74	-1.48	-0.84	0.57	59.48
1^{st} difference	-6.96 ***	-7.05 ***	-21.93 **	-3.30 **	0.15 **	4.22 **
Weighted average	-1.50	-1.42	-0.21	-0.10	0.45	16.35
1^{st} difference	-3.40 **	-4.87 ***	-6.89 *	-1.82 *	0.26 *	3.69 *

Notes see next page.

Table B2: Unit root test results for EU-12 interest rates, 1995:01-2003:09 (continued)

	ADF-test		PP-test		NgP-test MZa		NgP-test MZt		NgP-test MSB		NgP-test MPT	
Money market rates												
Money market, 3 months	-2.78		-2.01		-13.71		-2.61		0.19		6.69	
1^{st} difference	-3.59	**	-8.39	***	-1442.44	***	-26.86	***	0.02	***	0.06	***

Notes: TD abbreviates Time Deposit. $^{***(**)[*]}$ stands for significant at the 1% (5%) [10%] level. Generally, all tests are based on estimated equations including a constant. Furthermore, for the four NgP-tests we use the Modified AIC. In the case of deposit rates, money market rates and short-term lending rates to households, however, we include a constant and a time trend in the estimated equation and apply the "normal" AIC, because the use of the Modified AIC gives implausible results in the sense that the non-stationary null hypothesis is always rejected.

Table B3: Results from co-integration tests for U.S. interest rates, 1995:01-2003:09

	Co-integrating coefficient	ADF-test		PP-Test		PR-Test ADF-GLS		PR-Test MZa
Deposit rates								
TCD, 1 month	0.98	-4.40	***	-6.64	***	-1.51		-4.09
TCD, 3 months	1.01	-3.25	**	-3.29	**	-2.19		-8.10
TCD, 6 months	1.02	-4.57	***	-4.44	***	-1.47		-3.95
US deposits, 1 year	1.01	-4.53	***	-4.39	***	-1.70		-5.64
Lending rates								
Business, short-term	0.96	-4.66	***	-4.96	***	-1.55		-3.85
Mortgage, long-term	0.35	-3.60	***	-3.66	***	-1.38		-3.82
Consumers, short-term	0.35	-3.50	**	-3.50	**	-2.65	*	-10.92
Weighted average	0.59	-3.26	**	-3.26	**	-1.24		-2.86

Notes: TCD abbreviates Time Certificates of Deposit. $^{***(**)[*]}$ stands for significant at the 1% (5%) [10%] level. The ADF-test and the PP-test are based on estimated equations including a constant. The PR-tests are set up without constant. Furthermore, we select the lag-length for the ADF-test using the AIC. Following Rapach and Weber (2004) for the PR-tests we select the adequate lag-length using the "Modified" AIC.

Table B4: Results from co-integration tests for euro area interest rates, 1995:01-2003:09

	Co-integrating coefficient	ADF-test		PP-Test		PR-Test ADF-GLS	PR-Test MZa
Deposit rates							
Saving deposits, < 3m	0.49	-1.96		-1.93		-1.82	-6.57
Saving deposits, > 3m	0.64	-1.53		-1.65		-1.45	-4.86
TD, up to 2 years	0.90	-3.23	**	-2.49		-1.61	-4.02
TD, over 2 years	0.72	-3.22	**	-1.77		-2.16	-9.19
Weighted average	0.58	-2.31		-1.81		-1.69	-4.68
Lending rates							
Business, up to 1 year	1.03	-2.76	*	-1.86		-2.03	-7.94
Business, over 1 year	0.69	-3.58	***	-4.16	***	-0.74	-1.14
Mortgage, households	0.92	-3.63	***	-1.61		-2.36	-7.24
Households, short-term	0.68	-2.81	*	-2.47		-1.63	-4.75
Weighted average	0.73	-3.69	***	-4.14	***	-0.77	-1.34

Notes: TD abbreviates Time Deposit. $^{***(**)[*]}$ stands for significant at the 1% (5%) [10%] level. The ADF-test and the PP-test are based on estimated equations including a constant. The PR-tests are set up without constant. Furthermore, we select the lag-length for the ADF-test using the AIC. Following Rapach and Weber (2004) for the PR-tests we select the adequate lag-length using the "Modified" AIC.

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