

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

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Abstract

In this paper we analyze equilibrium determinacy in a sticky price model in which the pass-through from policy rates 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 as for instance that in the euro area.

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

JEL codes: E32, E52, E58

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1 Introduction

The stability properties associated with monetary policy rules have attracted a substantial amount of attention. In principle, 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 unique and stable 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

Empirically it appears that retail interest rates respond less than one-for-one to policy rates (e.g. Cottarelli and Kourelis, 1994; Borio and Fritz, 1995; Moazzami, 1999; Hofmann and Mizen, 2004; Sander and Kleimeier, 2004; De Bondt, 2005; Kok Sorensen and Werner, 2006). Moreover, retail interest rates are likely to influence aggregate demand. Thus, it seems conceivable that although monetary policy is tightened sufficiently, obeying the Taylor principle, retail interest 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).

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 rates. Although we model the limited interest rate pass-through in a highly simplified way without providing explicit micro foundations, we still

¹Nevertheless, this view is not without controversy. In a series of papers, Orphanides (2004, 2003, 2002) argues that the instability observed in the 1970s was the consequence of too ambitious goals for output stabilization and too pessimistic real-time estimates of the output gap.

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.

Equilibrium determinacy is usually analyzed in models without capital accumulation. In models with capital investment, the Taylor principle may no longer be sufficient to guarantee uniqueness (see Benhabib et al., 2005, and the references therein). However, to our knowledge 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. 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 no longer guarantees 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 bank-based and market-based financial systems, respectively. Our estimates suggest that the pass-through is limited in both systems, but smaller in the euro area than in the U.S. Comparing our empirical results with monetary policy reaction functions estimated in the literature, 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. However, because the banking sector is more important and the pass-through is smaller in the euro area, it might be closer to the indeterminate region than 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 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, B_t , that pays an interest rate of R_t . However, we assume that households cannot buy bonds directly, but have to deposit funds, D_t , at a financial intermediary instead.

The financial intermediaries operate in a perfectly competitive environment and use the deposits of the households to buy 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. Theoretically, several explanations for the stickiness of retail interest rates have been put forward in the literature. Hofmann and Mizen (2004) present a model based on adjustment costs. 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. Berlin and Mester (1999) provide empirical evidence for this idea. However, a consensus has not yet emerged in the literature, and our approach allows us to remain agnostic with respect to the ultimate source of a limited pass-through.

The financial intermediaries maximize profits, given by $R_t B_t - \Psi_t R_t^D D_t$, by the choice of bonds and deposits, 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, the zero-profit condition gives

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

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

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

where $\sigma > 0$ and $\eta > 0$, β is a discount factor, C_t is the 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 denotes dividends distributed at the end of the period. Household behavior is summarized by the usual consumption Euler equation and a labor supply equation:

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

$$\hat{W}_t - \hat{P}_t = \eta \hat{L}_t + \sigma \hat{C}_t, \quad (4)$$

where $\pi_t = \log P_t - \log P_{t-1}$ is the inflation rate.

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. Moreover, 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:

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

where $\delta = \frac{(1-\theta)(1-\theta\beta)(1-\alpha)(1-\omega)}{(1+\alpha(\epsilon-1))} \phi^{-1}$, $\phi = \theta + \omega(1 - \theta(1 - \beta))$ 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:

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

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

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

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 immediate pass-through from policy rates 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 :

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

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, respectively.

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 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 10 percent. 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 four 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, we first 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 $\bar{\kappa}_\pi$, where $\kappa_\pi > \bar{\kappa}_\pi$ is consistent with a determinate equilibrium. Clearly, a lower long-run pass-through, λ , 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 $\bar{\kappa}_\pi$, 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 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 of κ_y the implications for $\bar{\kappa}_\pi$ are negligible.

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 additionally 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. The empirical analysis is based on (8), which describes the dynamics of the retail interest rate in the model. As our model does not explicitly account for investment, we interpret C_t more broadly as the interest-rate 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, including lending as well as deposit rates.

The empirical strategy consists of the following steps: We start by testing for unit roots in our retail rate and monetary policy rate series, where we take the three-month money market rate as a proxy for the policy rate. For those series that are found to be $I(1)$, we proceed with testing for cointegration between retail and policy rates, since this would suggest to generalize our estimating equation to an error-correction model. Finally, we use an extended version of (8) to estimate the pass-through.

4.1 Data

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 for lending rates we take loans that cover businesses and consumers over short as well as long horizons. We use 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 longer series are not available for the euro area. Details on the data used are reported in Appendix A.

In addition to the individual series, we conduct our empirical analysis with a weighted average of the interest rates. This gives us a summary measure for the pass-through process of deposit and lending rates, respectively. 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 (Z.1), which offer information on different lending categories. However, deposits are not reported according to their maturities, which does not allow for setting up a weighted average for U.S. bank deposit rates. For weighting euro area retail rates

we can directly refer to balance sheet information from Monetary Financial Institutions, which are published by the ECB.

4.2 Unit Root and Cointegration Tests

We first test for unit roots 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). Since these tests may suffer from power and size distortions, we also apply the four tests developed by Ng and Perron (2001) (NgP tests). In almost all cases these six tests give the same results, namely that the series are $I(1)$. There is one series likely to be $I(2)$, which we exclude from the following analysis.

We proceed with testing for cointegration between money market rates and retail rates. 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 tests developed by Perron and Rodriguez (2001) (PR tests), who use GLS-detrended data and construct test statistics similar to those by Ng and Perron (2001). While there is mixed evidence on a cointegrating relationship according to the OLS-residual-based tests (ADF test and PP test), the PR tests, which should have more power and suffer less from size distortions, clearly reject the hypothesis of cointegration in all cases

(the test results are reported in Appendix B). Thus, our evidence is in favor of a non-cointegrating relationship between money market rates and retail rates. In addition, it has to be kept in mind, that due to limited data availability our sample may be too short to analyze long-run relationships. Hence, we conclude that money market and retail rate series are not characterized by a stable long-run relationship.

4.3 Long-Run Pass-Through

As we have seen in Section 3, the determinacy of the equilibrium depends crucially on the long-run pass-through. To estimate the pass-through we generalize (8) 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 in first differences. Since our data series do not appear to be cointegrated, we do not include an error-correction term. We choose the number of lags according to the Akaike Information Criterion with the maximum number of lags set at six.

$$\Delta R_t^D = c_0 + \sum_{i=0}^n a_i \Delta R_{t-i} + \sum_{j=1}^m b_j \Delta R_{t-j}^D, \quad (10)$$

where n and m denote the number of lags chosen. While the immediate pass-through is equal to a_0 , we calculate the long-run pass-through, λ , as

$$\lambda = \frac{\sum_{i=0}^n a_i}{1 - \sum_{j=1}^m b_j}. \quad (11)$$

Tables 1 and 2 give the results for the U.S. and the euro area, respectively. From the upper block of Table 1, we see that the long-run pass-through to U.S. deposit rates is close to unity. In particular, for U.S. deposits with short maturities (one and three months) the null hypothesis of a complete long-run pass-through is not rejected. Moreover, changes in money market rates are passed on quickly, as is indicated by the high values of the immediate pass-through. The lower block of Table 1 shows that the picture is less clear for U.S. lending rates. On the one hand, mortgage rates are smoothed heavily. In the long run only 29 percent of a change in money market rates are passed on. On the other hand, for short-term business loans the long-run pass-through is not significantly different from unity. On average, the long-run pass-through to lending rates in the U.S. amounts to 0.57. Put differently, in the long run slightly below 60 percent of a change in money market rates are passed on to U.S. borrowers.

The results given in Table 2 show that we generally observe a smaller pass-through to retail interest rates in the euro area than in the U.S. According

to the upper block of the table, the long-run pass-through to deposit rates ranges from 0.27 (saving deposits with a maturity of less than three months) to 0.66 (time deposits with a maturity of up to two years). On average the final pass-through amounts to 0.32. The lower block of Table 2 shows the results for lending rates in the euro area. Here, the long-run pass-through ranges between 0.43 for short-term loans to households and 0.69 for business loans with a maturity of up to one year. On average, the long-run pass-through to lending rates lies at 0.48. Hence, in the euro area approximately 50 percent of a change in the money market rate is on average passed on to borrowers. These results are roughly similar to what De Bondt (2005) reports.

In short, we conclude that the long-run pass-through to bank deposit rates is nearly complete in the U.S. and amounts on average to 0.32 in the euro area. Moreover, the average long-run pass-through to lending rates is also higher in the U.S. (0.57) than in the euro area (0.48).

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. 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, after taking the limited pass-through into account, we see that $\bar{\kappa}_\pi$, the lower bound for κ_π , consistent with a determinate equilibrium, lies between unity and 1.75 in the U.S.²

However, a precise quantitative evaluation appears difficult, since it is not clear to what extent bank retail interest rates as opposed to market interest rates (e.g. long-term bond yields) are relevant for the determination of aggregate demand.³ Only a fraction of the households and firms in the economy relies on financial intermediaries, whereas the rest participates in financial markets directly. If the limited pass-through to retail rates is indeed due to the formation of relationships and implicit contracts, it follows that market rates in general should track policy rates more closely. Assuming that 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. Thus, we may conclude that $\bar{\kappa}_\pi$ is likely to lie substantially closer to the lower bound of the above mentioned interval

²Note that $\bar{\kappa}_\pi = 1/\lambda$. Furthermore, the calculation assumes $\kappa_y = 0$. However, for empirically plausible values of κ_y , the differences are negligible.

³Allen and Gale (2000) and De Fiore and Uhlig (2005) argue that the banking sector and therefore retail rates play only a relatively minor role for the determination of U.S. aggregate demand.

for the U.S.

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 larger value of around three. Again, the overall pass-through to market interest rates relevant for aggregate demand 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 one in 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 (2004) 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. How-

ever, the estimated values for κ_π appear to fall within the determinate region for both economies. Nevertheless the euro area, with its 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 through’ to retail interest rates. In this paper we focus on the possibility of sunspot fluctuations that arise from self-fulfilling revisions in expectations. If the pass-through from policy rates 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 that in 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 Appendix: Data Description

Table A1: Retail Interest Rates and Money Market 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 rate			
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 System of the U.S.

B Appendix: Unit Root and Cointegration Test Results

Table B1: Unit Root Test Results for U.S. Interest Rates, 1995:01-2003:09

	ADF test	PP test Zt	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
Δ (TCD, 1 month)	-3.82	-9.66 ***	-13.28 **	-2.56 **	0.19 **	1.90 **
TCD, 3 months	-0.16	-0.13	0.96	0.53	0.56	26.28
Δ (TCD, 3 months)	-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
Δ (TCD, 6 months)	-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
Δ (U.S. deposits, 1 year)	-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
Δ (Business, short-term)	-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
Δ (Mortgage, long-term)	-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
Δ (Consumers, short-term)	-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
Δ (Weighted average)	-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
Δ (Money market, 3 months)	-6.35	-6.60 ***	-8.15 **	-2.01 **	0.25 *	3.03 **

Notes: TCD abbreviates Time Certificates of Deposit. Δ stands for the first difference of the respective series. The null hypothesis is that the series have a unit root. ***(**)[*] stands for rejecting the null hypothesis at the 1 (5) [10] percent level. The 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). All tests are based on equations including a constant. In the case of lending rates for mortgages, we include a constant and a time trend. Furthermore, for the four NgP tests we use the 'Modified' AIC in order to select the adequate lag length. Exceptions are the TCD (one month) and the U.S. deposits (one year), where we use the 'normal' AIC, because the use of the 'Modified' AIC gives implausible results in the sense that the nonstationary null hypothesis is never rejected.

Table B2: Unit Root Test Results for Euro Area Interest Rates, 1995:01-2003:09

	ADF test	PP test Zt	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
Δ (Sight deposits)	-2.60	-7.28 ***	-8.58	-2.07	0.24	10.62
Δ^2 (Sight deposits)	-15.59 ***	-17.33 ***	-142.78 ***	-8.45 ***	0.06 ***	0.64 ***
Saving deposits, < 3 months	-2.57	-2.17	-4.40	-1.48	0.34	20.68
Δ (Saving deposits, < 3 months)	-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
Δ (Saving deposits, > 3 months)	-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
Δ (TD, up to 2 years)	-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
Δ (TD, over 2 years)	-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
Δ (Weighted average)	-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
Δ (Business, up to 1 year)	-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
Δ (Business, over 1 year)	-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
Δ (Mortgage, households)	-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
Δ (Households, short-term)	-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
Δ (Weighted average)	-3.40 **	-4.87 ***	-6.89 *	-1.82 *	0.26 *	3.69 *

Notes: See next page.

Table B2: Unit Root Test Results for Euro Area Interest Rates, 1995:01-2003:09 (continued)

	ADF test	PP test Z _t	NgP test MZa	NgP test MZt	NgP test MSB	NgP test MPT
Money market rate						
Money market, 3 months	-2.78	-2.01	-13.71	-2.61	0.19	6.69
Δ (Money market, 3 months)	-3.59	-8.39	-1442.44	-26.86	0.02	0.06

Notes: TD abbreviates Time Deposit. Δ (Δ^2) stands for the first (second) difference of the respective series. The null hypothesis is that the series have a unit root. ***(**)[*] stands for rejecting the null hypothesis at the 1 (5) [10] percent level. The 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). Generally, all tests are based on 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 equation and apply the 'normal' AIC, because the use of the 'Modified' AIC gives implausible results in the sense that the nonstationary null hypothesis is never rejected.

Table B3: Results of Cointegration Tests for U.S. Interest Rates, 1995:01-2003:09

	Cointegrating 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. We test the null hypothesis of no cointegration. ***(**)[*] stands for rejecting the null hypothesis at the 1 (5) [10] percent level. The ADF test and the PP test are based on 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 of Cointegration Tests for Euro Area Interest Rates, 1995:01-2003:09

	Cointegrating 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. We test the null hypothesis of no cointegration. ***(**)* stands for rejecting the null hypothesis at the 1 (5) [10] percent level. The ADF test and the PP test are based on 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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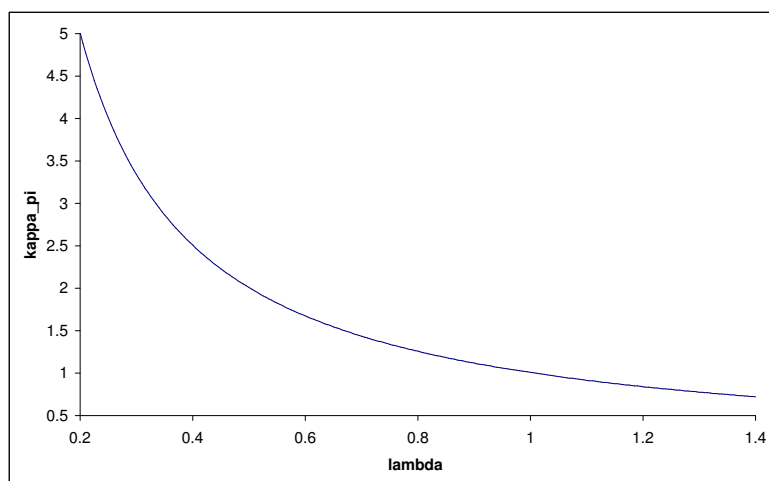
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Figure 1: Regions of Determinacy and Indeterminacy



Notes: The frontier divides the parameter space (λ, κ_π) into regions corresponding to determinate and indeterminate equilibria, where the long-run pass-through $\lambda = \lambda_1/(1 - \lambda_2)$. Points to the right of the frontier correspond to parameter combinations that are consistent with a determinate equilibrium.

Table 1: Immediate and Long-Run Pass-Through in the U.S., 1995-2003

	immediate		long-run	
	pass-through		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 parentheses. 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.

Table 2: Immediate and Long-Run Pass-Through in the Euro Area, 1995-2003

	immediate		long-run	
	pass-through		pass-through	
Deposit rates				
Saving deposits, < 3 months	0.09	(0.02)	0.27	(0.04)
Saving deposits, > 3 months	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 Deposits. Standard errors in parentheses. The standard errors for the long-term pass-through are calculated according to the delta method (see e.g. Greene, 2000, p. 330).