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Interest Rate Pass-Through in the EMU – New Evidence from Nonlinear Cointegration Techniques for Fully Harmonized Data

Abstract

This study puts the monetary transmission process in the eurozone between 2003 and 2011 under closer scrutiny. For this purpose, we investigate the interest rate pass-through from money market to various loan rates for up to twelve countries of the European Monetary Union. Applying different cointegration techniques, we first test for a long-run relationship between loan rates and the Euro OverNight Index Average (EONIA). Based on these findings, we allow for different nonlinear patterns for short-run dynamics of loan rates. Our investigation contributes to the literature in mainly two ways. On the one hand, we use fully harmonized data stemming from the ECB's MFI interest rate statistics. In addition, we consider smooth transition models as an extension of conventional threshold models. Our results point to considerable differences in the size of the pass-through with respect to either different loan rates or countries. In the majority of cases, the pass-through is incomplete and the dynamics of loans adjustment are different for reductions and hikes of money market rates.

JEL Classification: E43, E52, F36, G21

Keywords: Interest rate pass-through; EMU; cointegration; ARDL bounds testing; smooth transition models

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1. Introduction

Monetary transmission is a key issue when analyzing monetary policy decisions. Since the beginning of the crisis, most central banks have found themselves stuck in a liquidity trap, unable to provide further stimulus to the real economy by lowering interest rates. From a general point of view, a key question is whether the interest rate pass-through (IRPT) mechanism from money market rates to different credit categories continues to operate. Such a mechanism is important for achieving the aims of monetary policy, i.e. achieving price stability or influencing the path of the real economy.

When analyzing the European Monetary Union (EMU) the question arises whether asymmetric effects of a single European monetary policy across countries exist. Such a result may be traced back to structural divergences in the transmission mechanism of monetary policy across countries (Sander and Kleimeier, 2004). However, previous studies struggled to clearly attribute different findings across countries to varying IRPT dynamics instead of different data characteristics owing to a lack of harmonized data. Another caveat is that they do not allow for threshold related asymmetric IRPT dynamics in their empirical framework.

Our study analyzes the issue of a nonlinear IRPT process in the eurozone between 2003 and 2011 based on a completely harmonized dataset for EMU countries. The framework we apply carefully analyzes various dynamic patterns. After testing for a long-run relationship between the EONIA and credit categories with various maturities, we allow for different patterns of nonlinearity when analyzing adjustment and short-run dynamics. More precisely, the LSTR and ESTR models we apply refer to different IRPT dynamics for positive and negative (LSTR) as well as small and large (ESTR) changes of the EONIA. The remainder of this paper is organized as follows. The following section summarizes previous empirical findings. Section 3 first describes our data as well as our modeling cycle. Afterwards, in section 4 the results are presented and analyzed. Section 5 concludes.

2. Literature review

Cottarelli and Kourelis (1994) can probably be seen as the pioneer work for the investigation of the IRPT mechanism. While they investigate the IRPT for 31 developing and developed countries, afterwards and in the advent of EMU, several studies focus on the IRPT in Europe. Instead of surveying these studies in detail, we refer to de Bondt (2002, 2005) who provides a comprehensive survey of the plethora of studies. He concludes that there is considerable cross-country variation in the IRPT mechanism in Europe whereas no clear pattern emerges. Further, Sander and Kleimeier (2006) conclude that the IRPT in Europe can be characterized as sticky and that there are differences between the IRPT to lending and deposit rates as well as between countries. Furthermore, asymmetries and nonlinearities can be found in the IRPT mechanism. However, they cannot detect any clear structure of these asymmetries. Finally, there are some hints of an accelerating and more homogenous pass-through (PT).

Generally, one can roughly differentiate between three strands of the IRPT literature (Chionis and Leon, 2006).[1] The first strand focuses on the theoretical explanation of interest rate stickiness.[2] The second one takes a look at cross-country differences of PT coefficients and lastly, differences in the IPRT mechanism are related to characteristics of the financial system.[3] In our study, we leave out the first and third strand and focus especially on the second one.

Methodologically, Cottarelli and Kourelis (1994) use an autoregressive distributed lag model. However, this approach was soon replaced by the application of cointegration techniques. For example de Bondt (2002, 2005) uses the single equation approach of Engle and Granger (1987) as well as the Johansen (1991) systems approach. Nowadays, for example Mojon (2000), Sander and Kleimeier (2004, 2006) or Hofmann (2006) take asymmetric adjustment of the PT mechanism into account.

Turning now to specific results for the IRPT mechanism of EMU countries based all on cointegration and error correction methods, Sander and Kleimeier (2002) focus on pre-EMU data for 15 European countries, from which 12 are now members of the single currency area. While confirming the short-run stickiness of lending rates, they find a complete PT in the long-run in most cases. In a following study, Sander and Kleimeier (2004) investigate the IRPT for 10 EMU countries for the period 1993-2002. They find evidence of structural change in the PT. In a more recent period the PT to credit rates has increased and become more complete. However, this finding does not hold for deposit rates. Additionally, they find an incomplete PT in the long-run for most retail rates which is somewhat at odds with their study from 2002.

[1] Recently, a fourth kind of studies based on disaggregate data which examines the heterogeneity in bank pricing policies and its determinants has emerged (de Graeve et al., 2007, Gambacorta, 2008, Horvath and Podpiera, 2012).

[2] Cottarelli and Kourelis (1994) or de Haan et al. (2001) provide reasons for a delayed PT.

[3] Here as well, Cottarelli and Kourelis (1994) deliver early evidence. For a more recent investigation, see Gigineishvili (2011).

De Haan et al. (2001) estimate PT coefficients for the six largest EMU countries. Their evidence points to country differences in the PT in the short- as well as the long-run. Furthermore, they cannot find any clue for convergence. While these results almost completely rely on pre EMU data, Angeloni and Ehrmann (2003) compare the IRPT mechanism before and after the introduction of the single currency. Additionally, they take up other non EMU countries as well as Japan and the US as a control group to figure out, whether there are specific developments in EMU. Specific to the EMU, they find that the coefficients of the IRPT are less dispersed for the post EMU sample. Thus, there is evidence of convergence. While Angeloni and Ehrmann (2003) more or less a priori set the structural break equal to the introduction of the single currency (which is supported by their analysis), Sander and Kleimeier (2004) find that there is indeed a structural break in the IRPT in EMU. However, according to their results, the break occurred well before 1999 – on average they detect a structural break in October 1996. In contrast, Chionis and Leon (2006) find a structural break in the PT mechanism for Greece when the country accessed the eurozone in 2001.

Kok Sørensen and Werner (2006) estimate a dynamic panel for several European countries and test the two hypotheses of equal long-run PT and equal speed of adjustment. Both hypotheses can clearly be rejected which points to considerable heterogeneity in the European PT mechanism. However, they cannot detect a clear pattern of heterogeneity apart from the fact that countries with a slow adjustment tend to have a lower long-run PT as well. Furthermore, the degree of competition in the national banking sector seems to be a major determinant for the IRPT. This view is supported by Gropp et al. (2007) and van Leuvensteijn et al. (2008). Van Leuvensteijn et al. (2008) estimate a dynamic panel model for eight EMU countries and investigate the PT to loan as well as deposit rates. An interesting finding of them is that banks compensate for small margins in loan markets by higher margins in less competitive deposit markets.

Mojon (2000) investigates the IRPT for six EMU economies. He splits his sample into two parts, both corresponding to complete interest rate cycles. His results show that short term retail rates respond fastest to changes in the money market. Moreover, the PT differs between times of rising and falling money market rates. Credit rates are adjusted faster, when market rates are rising and slower when the money market rate declines. For deposit rates, this scheme is reversed. This finding is supported by Gropp et al. (2007) who use a panel model for the individual euro area countries and draw the same conclusion. Comparable evidence of asymmetric interest rate setting is found by Karagiannis et al. (2010). For the whole EMU, banks do not pass-through increases in money market rates to depositors. Hofmann (2006) takes a look at the interest rate PT for France, Germany, Italy and Spain. Since the beginning of EMU he finds a quicker PT. However, German rates seem to be the stickiest ones. In contrast to Sander and Kleimeier (2006), Hofmann (2006) cannot discover nonlinearities in the PT. The non-existence of asymmetries is found by Kwapil and Scharler (2010) as well.

Finally, Čihák et al. (2009) focus on the IRPT mechanism during the financial crisis. For the EMU as a whole, they find a slower PT during the crisis. Thus, monetary policy impulses have been less effective during the last years. Karagiannis et al. (2010) hint at a widening spread between money market and retail rates at the beginning of the financial crisis meaning that the PT was limited to some extent. Jobst and Kwapil (2008) do not support the view that the PT is impaired by the financial crisis. They investigate the PT to loan rates in Austria and cannot detect striking differences in the PT process since the beginning of the financial turmoil. What is more, ECB (2009) provides no evidence for a structural change in the PT mechanism during the financial crisis as well.

With regard to the differences found for the IRPT mechanism in Europe, one should keep in mind that to the best of our knowledge no study besides Vajanne (2007)[4] and von Borstel (2008) rests on completely harmonized interest rate data. Hofmann (2006) hints at this drawback that there are no fully comparable time series of sufficient length. In fact, there are only some authors that use at least partly harmonized data.[5]

Therefore, this study tries to overcome this caveat. By using a completely harmonized dataset for EMU countries we will investigate the IRPT mechanism. Accordingly, possible differences will no longer be attributable to different characteristics of the underlying data.

3. Empirical Analysis

3.1 Data

As mentioned before, this study is one of the first that is based on purely harmonized data which makes the results fully comparable across countries. We obtained the interest rate series from the MFI interest rate statistics of the ECB and cross-checked with the statistics of the national central banks to complete the data set. Nevertheless, for quite a few countries

[4] However, her focus in on β- and σ-convergence rather than estimating PT coefficients.

[5] For example Kok Sørensen and Werner (2006), van Leuvensteijn et al. (2008) or ECB (2009) use the MFI interest rate statistics for data since January 2003. Interest rates prior to 2003 are counted back.

some data is not available. All data refer to loans for households and non-profit institutions and are monthly averages and exclusively new business. In our investigation we consider up to twelve EMU countries.[6] The sample ranges from January 2003 which is the beginning of the MFI interest rate statistics until September 2011.[7,8] In detail, we investigate the IRPT for the following three credit categories with various maturities: loans for consumption (up to 1 year, 1 to 5 years, over 5 years), credits for house purchase (up to 1 year, 1 to 5 years, 5 to 10 years) and other lending (up to 1 year, 1 to 5 years, over 5 years). In total we have got 86 time series for which we estimate PT models. As money market rate we consider the EONIA because it reflects the stance of monetary policy best. Additionally, using the same money market rate for each model makes the results more comparable.[9]

Furthermore, we use a dummy variable which takes the value of one since September 2008 to cover the financial market turmoil.[10]

3.2 Modeling cycle and methodological issues

3.2.1 Analyzing the long-run

In order to explain our modeling cycle in greater detail, we start with a general consideration of the relationship under investigation. Equation (1) describes the possible long-run relationship between the retail bank rate and the money market rate (EONIA).

$$br_t = \pi_0 + \pi_1 mm_t + \pi_2 dum_t + \mu_t. \quad (1)$$

Thereby, br_t denotes the retail interest rate, mm_t represents the short-term money market rate and dum_t is a dummy variable for the financial crisis taking the value one since September 2008. π_0 and μ_t are a constant and the usual i.i.d. error term, respectively. If the retail interest rate and the short-term money market rate are integrated of order one (I(1)) and share a

[6] The countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. We do not have data for all countries for each loan category. See the results section for details.

[7] The loans for consumption up to 1 year time series for the Netherlands ends in April 2011.

[8] We are aware that about 100 observations are probably at the lower limit when working with time series. However, we believe that using fully harmonized data overcomes this caveat because our focus is on comparing the IRPT mechanism across EMU.

[9] Thus, our approach could be labeled as "monetary policy approach". Another possibility would be to use the so called "cost-of-funds approach". This implies that the corresponding market rate is chosen according to the highest correlation with the retail rate under study. This emphasizes the funding cost of banks (Sander and Kleimeier, 2004).

[10] Imbalances in money markets did already start in August 2007. However, monetary policymakers in the eurozone started to radically cut down interest rates in September 2009.

common stochastic trend, equation (1) corresponds to a cointegrating relationship and the resulting error term ε_t is stationary (I(0)).

In this case, the following error correction representation for the retail bank rate arises

$$\Delta br_t = a_1 \hat{\mu}_{t-1} + \sum_{i=1}^{m} a_2 \Delta br_{t-i} + \sum_{j=1}^{n} a_3 \Delta mm_{t-j} + \eta_t \quad (2)$$

where a_1 denotes the adjustment coefficient with respect to deviations from the long-run relations in the previous period ($\hat{\mu}_{t-1}$). The second and third terms on the right-hand side correspond to short-run dynamics and are also included to avoid any misspecification due to autocorrelation, while η_t is an i.i.d. variable which follows a normal distribution with zero mean (Enders, 2009). If no long-run relationship is found, a_1 is zero and the model may be considered as a traditional AR model estimated in first differences. We will reconsider equation (1) and (2) further below when introducing nonlinearities into our model.

Several approaches which allow testing for a long-run relationship as given in equation (1) exist. In this paper, we consider two popular approaches:[11] The multivariate approach of Johansen (1988, 1991) and the ARDL approach provided by Pesaran et al. (2001).[12] We now proceed by describing both approaches in a nutshell before we turn to the issue of nonlinearity in this context.

Starting with the approach of Pesaran et al. (2001) it is useful to modify equation (2) as follows

$$\Delta br_t = \alpha_0 + \alpha_1 br_{t-1} + \alpha_2 mm_{t-1} + \alpha_3 dum_{t-1} + \sum_{i=1}^{m} \beta_i \Delta br_{t-i} + \sum_{j=0}^{n} \gamma_j \Delta mm_{t-j} + \sum_{k=0}^{p} \delta_k \Delta dum_{t-k} + \varepsilon_t \quad (3)$$

The test for cointegration then corresponds to the null hypothesis $\alpha_1 = \alpha_2 = \alpha_3 = 0$. For this approach, Pesaran et al. (2001) tabulate critical value bounds for the two border cases where all time series are either I(0) or I(1). Evidence for a long-run relationship among the variables is delivered if the test statistic exceeds the upper critical value. In case of a value between the critical bounds, the test is inconclusive and if it falls below the lower critical value, there is no evidence of cointegration. To obtain the long-run coefficients in case of cointegration, we normalize on the retail rate. Accordingly, the long-run PT coefficients are calculated from Equation (3) as $\pi_0 = -\frac{\alpha_0}{\alpha_1}$, $\pi_1 = -\frac{\alpha_2}{\alpha_1}$ and $\pi_2 = -\frac{\alpha_3}{\alpha_1}$.

[11] We also carried out estimations based on the fully modified OLS (FMOLS) estimator. However, to keep the modeling cycle clearly laid out, we do not incorporate the findings into the modeling cycle. The findings do not differ significantly with respect to the overall findings on the number and character of the long-run relationships.
[12] For an early review of the different methods of estimating cointegrating relationships see Phillips and Loretan (1991), Hargreaves (1994) and Caporale and Pittis (1999).

The second approach we consider is the multivariate cointegration test of Johansen (1988), which draws upon the following vector autoregressive representation (VAR):

$$\Delta Y_t = \Pi Y_{t-1} + \Gamma(L)\Delta Y_{t-l} + \Phi D_t + \varepsilon_t \qquad (4)$$

The vector $Y = (br_t, mm_t)$ contains the retail interest rate and the short-term money market rate. The non-stationary behaviour is accounted for by a reduced rank $(r < p)$ restriction of the long-run level matrix Π, which can be decomposed into two $r \times p$ matrices α and β' $(\Pi = \alpha\beta')$. β' gives the coefficients of the r long-run relations, while α contains the adjustment coefficients describing the reaction of each variable to disequilibria from the r long-run relations given by the $r \times 1$ vector $\beta' Y_{t-1}$. The deterministic components are given by the $(p \times 1)$ vector ΦD_t, while ε_t describes an independent and identically distributed error term (Juselius, 2006). The deterministic terms also include a shift dummy variable which has been included in order to account for extraordinary effects in the long-run relationship stemming from the recent crisis. Juselius (2006) applies a similar setting when accounting for specific events in the context of monetary policy. The term $\Gamma(L)\Delta Y_{t-l}$ describes the short-run dynamics of the model which will not be explicitly considered in the following since we focus on a nonlinear short-run model at a later stage of the analysis. To identify the number of cointegrating relations r we rely on the trace test developed by Johansen (1988).[13] The results reported in the following correspond to the standard configuration of the test. If the Bartlett correction for small samples described in Juselius (2006) is applied, the character of the findings does not change to a significant degree.

3.2.2 Asymmetric short-run dynamics

Regardless of the choice of the two cointegration techniques, it is useful to allow for asymmetric adjustment when analyzing the resulting short-run and error correction dynamics. In contrast to previous studies,[14] we adopt a smooth transition instead of a threshold model since the first offers a more realistic setting according to our view. More precisely, we modify equation (3) as follows:

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[13] The idea of the test is to separate the eigenvalues $\lambda_i, \mathrm{i} = 1 \dots \mathrm{r}$, which correspond to stationary relations, from those eigenvalues λ_i, $\mathrm{i} = \mathrm{r} + 1 \dots, \mathrm{p}$ which belong to non-stationary eigenvectors. The test statistic of the corresponding likelihood test, the so-called trace test, is given by $trace(r) = -T\sum_{i=r+1}^{p}\log(1-\hat{\lambda}_i)$.
Under the null hypothesis of $(p-r)$ unit roots, λ_i, $\mathrm{i} = (\mathrm{r}+1 \dots, \mathrm{p})$ should behave like random walks and the test statistic should be small. Starting with the hypothesis of full rank, the number of cointegrating relations is determined using a top-bottom procedure until the null cannot be rejected (Juselius, 2006).

[14] For example, Sander and Kleimeier (2004, 2006) use models with a sharp cut-off.

$$\Delta br_t = \tau_{1,t}\hat{\varepsilon}_{t-1} + \sum_{k=1}^{o} \alpha_{1k}\Delta br_{t-i} + \sum_{i=0}^{m} \beta_{1i}\Delta mm_{t-i} + F(z_t,\gamma,c)(\tau_{2,t}\hat{\varepsilon}_{t-1} + \sum_{l=1}^{p} \alpha_{2l}\Delta br_{t-i} + \sum_{j=0}^{n} \beta_{2j}\Delta mm_{t-i}) + u_t \quad (5)$$

where $F(z_t,\gamma,c)$ is a transition function which ascertains the speed of adjustment and could either be a logistic or an exponential function. The terms α_1 and β_1 correspond to the lower regime, while $(\alpha_1 + \alpha_2)$ and $(\beta_1 + \beta_2)$ belong to the upper regime of the adjustment process (van Dijk et al., 2002). Hence, equation (5) can be described as a nonlinear error correction framework.

Although a logistic and an exponential formulation are closely related, they refer to different kinds of dynamics. If $F(z_t,\gamma,c)$ is a bounded continuous logistic transition function which lies between 0 and 1, the following form arises

$$F(z_t,\gamma,c) = [1 + \exp(-\gamma(z_t - c)/\sigma_{zt})]^{-1} \text{ with } \gamma > 0, \quad (6)$$

where z_t indicates the transition variable, σ_{zt} represents its standard deviation, γ denotes a slope parameter and c is a location parameter. The normalization by the standard deviation is necessary to obtain a scale-free smoothness parameter (Teräsvirta, 1998). The logistic function increases monotonically from 0 to 1 as the transition variable increases. Since, $F(z_t,\gamma,c) \to 0$ as $z_t \to -\infty$ and $F(z_t,\gamma,c) \to 1$ as $z_t \to +\infty$ the lower (upper) regime is associated with negative (positive) values of the transition variable relative to the location parameter c. If $z_t = c$ equation (2) reduces to the linear model given by equation (3) with $\alpha = \alpha_1 + 0.5\alpha_2$ and $\beta = \beta_1 + 0.5\beta_2$. The slope parameter γ determines the speed of the transition between the extreme regimes (Teräsvirta, 1994).

Turning to the second configuration, $F(z_t,\gamma,c)$ may also be approximated by a bounded continuous exponential transition function which lies between 0 and 1:

$$F(z_t,\gamma,c) = 1 - \exp(-\gamma(z_t - c)^2/\sigma_{zt}) \text{ with } \gamma > 0. \quad (7)$$

The exponential transition function (7) is symmetrically inverse-bell-shaped ($F(z_t,\gamma,c) \to 1$ for $z_t \to \pm\infty$), so that an adjustment for deviations of the basis above and below the threshold c is symmetric as opposed to the logistic function and the parameter γ again determines the smoothness of the transition with lower absolute values implying slower transition (Taylor et al., 2001).

An important choice is the identification of an adequate transition variable which is required to be stationary. In the following we use the change of the EONIA as the transition variable.

This choice is intuitive as it allows for asymmetries stemming from positive and negative (LSTR) or small and large (ESTR) EONIA changes. An alternative specification would be to use the size of deviations from the established long-run relation or time as the transition variable. However, such a setting is not possible when no cointegration is found and also seems less attractive in terms of interpretation. As a first step, we test for nonlinearity and choose the most adequate transition function in terms of lags for Δmm_{t-l} by relying on a Lagrange multiplier (LM) test which has been introduced by Luukkonen et al. (1988). As a starting point, consider the following third order Taylor approximation of the transition function (Teräsvirta, 1998, Franses and van Dijk, 2000):[15]

$$\Delta br_t = \varphi_0(a_{1,t}\hat{\varepsilon}_{t-1} + \Delta br_{t-1} + \Delta mm_{t-1}) + \varphi_1(a_{1,t}\hat{\varepsilon}_{t-1} + \Delta br_{t-1} + \Delta mm_{t-1})z_t + \varphi_2(a_{1,t}\hat{\varepsilon}_{t-1} + \Delta br_{t-1} + \Delta mm_{t-1}){z_t}^2 + \varphi_3(a_{1,t}\hat{\varepsilon}_{t-1} + \Delta br_{t-1} + \Delta mm_{t-1}){z_t}^3 + \varepsilon_t \tag{8}$$

The first test corresponds to the question whether a nonlinear framework is adequate or not by testing whether the higher order terms are significant (Teräsvirta, 1998).

$$H_{01}: \varphi_1 = \varphi_2 = \varphi_3 = 0$$

The test statistic has a χ^2 distribution with three degrees of freedom (Teräsvirta, 1998). If the null is rejected, three further tests allow to determine whether an exponential or a logistic transition function is more adequate (Granger and Teräsvirta, 1993; Teräsvirta, 1998; van Dijk et al., 2002).

$$\begin{aligned} H_{04}&: \varphi_3 = 0, \\ H_{03}&: \varphi_2 = 0 \mid \varphi_3 = 0, \\ H_{02}&: \varphi_1 = 0 \mid \varphi_2 = \varphi_3 = 0. \end{aligned} \tag{9}$$

If the rejection of H_{03} is the strongest one in terms of the largest test statistic, the ESTR model should be chosen, otherwise the LSTR model should be preferred (Teräsvirta, 1994).[16]

3.2.3 The overall modeling cycle

Based on the previous considerations, the modeling cycle we adopt is illustrated in figure 1. As previously mentioned, the short-term money market rate mm_t is integrated of order one (I(1)) while the retail rates are either stationary or also integrated of order one. Based on these

[15] In the case of small samples in combination with a large number of explanatory variables, F versions of the LM test statistics are preferable (Teräsvirta, 1998, van Dijk et al., 2002).
[16] See Granger and Teräsvirta (1993) or Teräsvirta (1994) for details.

findings, the first distinction is whether the pair under investigation is both integrated of order one or whether this is only the case for the short-term money market rate. In the first case, we start by testing for a long-run relationship based on both the procedure of Johansen (1988, 1991) and Pesaran et al. (2001). If both tests detect cointegration, we rely on the Johansen (1988, 1991) estimates for the error correction framework since this approach is less restrictive. If only one methodology points to cointegration we adopt the corresponding estimates. If the unit root tests are inconclusive whether the retail rate is I(0) or I(1) we prefer the approach of Pesaran et al. (2001) as it is specially designed to handle a combination of I(0) and I(1) variables.

Altogether, it is worth mentioning that the estimates only marginally differ if cointegration is found in both cases. If cointegration is evident according to one procedure, we include the long-run estimates into the short-run framework since the failure to detect a long-run relationship according to the other procedure may be attributed to nonlinear adjustment which possibly biases downward the speed of adjustment if a linear specification is used (Taylor, 2006).

After analyzing the underlying long-run dynamics, we proceed by testing for nonlinearity in either an error correction or a VAR framework as given in equation (5) with $\tau_{1,t}$ being zero in the latter case where no long-run relationship is found in the first step. If evidence for nonlinear adjustment is provided, we apply the procedure described above to further distinguish between an ESTR and LSTR setting before estimating our final model.

4. Working hypotheses and estimation results

To achieve an adequate modeling strategy, we now identify different working hypothesis which are then empirically tested based on the modeling cycle explained in the previous section. We start with the fairly question whether a long-run relationship between the EONIA and the different retail rates prevails over the long-run.

H1: The EONIA and the retail rates are cointegrated.

As a next step, we would expect that changes in the EONIA transmit to retail market rates even if a complete pass-through is not always detected.

H2: Retail rates react positively but probably not always proportionally to changes of the EONIA.

If H1 and H2 are not rejected, the next question is whether it is possible to identify asymmetries in the interest rate pass-through process.

H3: The adjustment of the retail rates to changes of the EONIA or long-run deviations follows a nonlinear path.

When evaluating the first three hypotheses, an obvious question is whether differences can be traced back to either cross-country differences or different kinds of retail rates.

H4: The degree of pass-through and asymmetry varies with respect to countries or retail interest rates.

The empirical results are summarized in Tables 1-4 according to the chosen model class. It is first worth mentioning that most retail interest rates are integrated of order one. When carrying out the tests for cointegration, the choice of the lag length was based on tests for autocorrelation, ARCH-effects and the Schwarz information criterion.[17] For each pass-through model we estimate Equation (3) with a maximum lag length of twelve months for each variable when applying the ARDL approach.

Tables 1 to 4 about here

Turning to the results of the cointegration test, a long-run relationship between the EONIA and the retail rate is frequently detected according to the results given in Table 1 and 2. Table 5 summarizes the overall findings with regard to the long-run coefficients according to countries and interest rates.

Table 5 about here

The established relationship between the retail bank rate and the money market rate mostly match theoretical predictions with both variables always being positively correlated in case of linear cointegration (Table 1). This is also true for the case of nonlinear cointegration (Table 2) where a negative coefficient is only observed for one interest rate of Germany and Spain, a finding which may be attributed to the nonlinear adjustment process. In all other cases, the significant values for π_1 always display a positive relationship and mostly range from 0 to 1. However, in order to test H2, we analyze whether a strictly proportional pass-through mechanism holds by testing $\pi_1 = 1$ based on a likelihood ratio procedure suggested by Juselius (2006) in the Johansen (1988, 1991) framework and an F-test in the framework of

[17] According to Rahbek et al. (2002), the results we gain in the following are still robust under the ARCH-effects that remain in some cases.

Pesaran et al. (2001). The findings show that this restriction is frequently rejected for most interest rates pointing to an imperfect PT in the long-run. For example, for Belgium the hypothesis of a complete PT is rejected in each case. Similarly, the hypothesis is rejected in five out of seven cases for Germany. The country in which the PT seems to be most complete or even more than complete is Spain. In Spain, there is only one case out of eight where the hypothesis of a complete PT is rejected. There are even cases where the PT turns out to be significantly greater than one. Generally, the finding of an incomplete PT in many cases may be attributed to the short sample under investigation, nonlinear adjustment patterns or the impact of the recent crisis. Altogether, H1 and H2 cannot be rejected since a long-run relationship is frequently detected and the PT is incomplete in the majority of cases. Hence, a preliminary finding is that the long-run relationship between EONIA and retail rates is frequently found for the comparable small period under investigation.

As a next step we put the issue of asymmetric adjustment under closer scrutiny. Table 6 provides a general overview with regard to the findings with respect to evidence of nonlinearity.

Table 6 about here

The detailed findings with regard to the nonlinearity of coefficients are given in Table 2 and Table 4. The overall results obtained by the test for nonlinearity show that the null hypothesis of linearity is rejected in most cases. In addition, the LSTR specification is chosen ahead of an ESTR model in nearly all cases, pointing to asymmetries stemming from positive or negative changes in interest rates. Hence, H3 cannot be rejected. The results of the nonlinear estimation in both Table 2 and 4 clearly indicate that the IRPT mechanism works much more efficient in the first regime where the direct impact of EONIA changes on the retail rates (β_{1i} in Equation (5)) as well as the adjustment towards long-run equilibrium ($\tau_{1,t}$ in Equation (5)) is faster. Since the EONIA serves as a transition variable, the first regime corresponds to decreasing interest rates while the second regime refers to an increase of interest rates in cases of LSTR configuration. Hence, the pass-through mechanism and the adjustment to disequilibria occur faster if interest rates decrease which is good news for borrowers. These findings may be related to an advanced banking competition or lower costs of monitoring credit rates which does not allow for a direct transmission of higher interest rates. This part of our results is at odds with the results of Mojon (2000). However, his results are based on data prior to 2000 which might explain the differences.

The evaluation of hypothesis H4 is the most demanding task in our context since identifying cross-country differences or differences with respect to maturities of credit rates demands a careful comparison of the results. According to our synthesis of the long-run relationships in Table 5, cointegration is found in at least 70 percent of all cases for the most economies. On the one hand, in Greece, a long-run relationship is only detected in one out of six cases. Thus, the Greek interest cycle seems to differ considerably from the EMU cycle. Furthermore, the long-run PT coefficient even enters with the wrong sign. For Luxemburg and Ireland, a long-run relationship is found in two out of four cases. On the other hand, for countries which are typically referred to as core EMU countries like Austria, Belgium or Germany cointegration is much more evident pointing to a much more synchronous interest cycle. This finding highlights the fact that conversion in EMU still has not finished yet and that substantial differences remain.

When averaging the long-run PT coefficients by countries, it is apparent that the average PT in Belgium, France and Germany of about 0.35-0.45 is only half as large as in Austria, Finland, Ireland, Luxembourg and Spain.

With respect to the duration of interest rates, two important implications arise. First, the relative frequency to which cointegration is detected is higher for short term interest rates compared to long-term interest rates. Furthermore, cointegration is especially evident for other lending and to a somewhat lesser extent credits for house purchases. Secondly, the degree of pass-through according to the long-run coefficient is also higher on average for interest rates with a shorter duration. Both patterns are intuitively plausible since long-term interest rates also reflect additional factors, such as inflationary expectations. Regarding the short-run PT, our results suggest that it is incomplete in most cases. This can be justified for example by menu costs or short-run disturbances (Golosov and Lucas, 2007, as the seminal reference). However, there does not seem to be such a clear pattern compared to the long-run PT. There does neither seem to be a declining short-run PT by maturity nor country specific properties. But in many cases, the short-run PT is lower than the long-run effect. Turning to the degree of asymmetries, a nonlinear pattern in terms of ESTR or LSTR models is slightly more frequently observed than a long-run relationship, pointing to the fact that asymmetries are also observed if cointegration is not found. No clear pattern arises with respect to nonlinearity and the duration of interest rates.

5. Conclusion

This study has analyzed the interest rate pass-through from money market to various loan rates for up to twelve countries of the European Monetary Union between 2003 and 2011. Applying different cointegration techniques, we first test for a long-run relationship between loan rates and the EONIA before allowing for asymmetric short-run adjustment. Our results based on completely harmonized data point to considerable differences in the size of the pass-through with respect to either different loan rates or countries. In the majority of cases, the pass-through is incomplete and the dynamics of loan rate adjustment are different for reductions and rises of money market rates. The relative frequency to which cointegration is detected is higher for short-term compared to long-term interest rates. The degree of pass-through according to the long-run coefficient is also higher on average for loan rates with shorter maturity. Turning to the country level, it is especially Greece that stands out. While for most of the countries under study, there is a long-run relationship between retail rates and the short-term money market rate, in Greece, cointegration is found only in one out of six cases. With regard to the extent of the PT, it is on the one hand Spain which seems to have the most complete or even more than complete PT and on the other hand there are Belgium and Germany where the hypothesis of a complete PT is rejected most often.

To sum up, our results confirm the findings of for example de Bondt (2002, 2005) or Sander and Kleimeier (2006) that the interest rate pass-through mechanism is characterized by considerable cross-country variation and it is difficult to identify a clear pattern. This conclusion even holds when using harmonized data as in this investigation. A possible caveat is that our findings correspond to a comparable short period of time, owing to the fact that harmonized data are only available from 2003.

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Table 1: Results for linear cointegration

interest rate	Long-run PT coefficient	Constant	Dummy	Cointegration	complete PT	Short-run PT coefficient	EC-term	model
brc0_bel	0.364 (8.484)	5.726 (24.926)	-0.076 (-0.671)	42.058***	0.000	-0.053 (-0.189)	-1.001 (-6.649)	Johansen
brc2_ger	0.004 (0.149)	8.822 (4.775)	-0.549 (-4.480)	7.831**	0.000	-0.277 (-2.453)	-0.746 (-4.912)	ARDL
brc2_ita	0.477 (3.790)	6.345 (3.563)	0.813 (3.148)	5.392*	0.006	0.279 (3.022)	-0.253 (-4.064)	ARDL
brh0_fin	0.953 (36.022)	0.655 (4.657)	0.461 (6.706)	36.265***	0.169	0.054 (0.520)	-0.313 (-4.880)	Johansen
brh0_ger	0.861 (3.723)	2.57 (2.846)	0.314 (2.516)	5.771**	0.135	0.197 (2.668)	-0.273 (-4.206)	ARDL
brh0_ire	0.957 (3.360)	1.397 (2.501)	1.07 (3.652)	5.645*	0.539	0.323 (3.715)	-0.273 (-4.167)	ARDL
brh0_ita	1.018 (46.544)	0.869 (7.402)	0.539 (9.326)	36.724***	0.987	0.276 (3.840)	0.145 (1.970)	Johansen
brh0_lux	0.713 (29.685)	2.486 (19.013)	-0.447 (-6.896)	48.741***	0.000	0.032 (0.331)	-0.458 (-6.964)	Johansen
brh1_bel	0.549 (3.914)	2.886 (3.311)	0.599 (2.481)	5.620*	0.010	0.042 (0.556)	-0.130 (-4.152)	ARDL
brh1_fin	0.485 (5.692)	2.884 (6.194)	0.026 (0.113)	24.17*	0.017	0.065 (0.592)	-0.239 (-3.925)	Johansen
brh1_ger	0.560 (3.645)	3.010 (3.173)	0.038 (0.193)	5.134*	0.012	0.149 (2.820)	-0.131 (-3.971)	ARDL
bro0_aut	0.917 (19.198)	1.759 (6.834)	0.218 (1.727)	29.036**	0.223	0.132 (0.864)	-0.430 (-5.022)	Johansen
bro0_ger	0.796 (24.778)	2.077 (11.898)	-0.009 (-0.104)	24.605*	0.000	0.363 (2.680)	-0.548 (-4.726)	Johansen
bro0_lux	0.929 (4.780)	1.586 (4.232)	-0.025 (-0.222)	7.619**	0.146	0.458 (3.738)	-0.409 (-4.836)	ARDL
bro0_ned	0.806 (3.552)	1.452 (3.294)	0.457 (2.024)	4.780*	0.030	0.461 (3.430)	-0.310 (-3.826)	ARDL
bro0_por	0.764	5.162	0.172	7.287**	0.121	0.032	-0.424	ARDL

	(3.658)	(4.137)	(0.506)			(0.094)	(-4.728)	
bro1_aut	0.742	2.564	0.655	11.764***	0.005	0.812	-0.638	ARDL
	(5.702)	(4.859)	(3.382)			(3.392)	(-6.006)	
bro1_bel	0.653	2.172	0.878	30.747**	0.015	0.412	-0.419	Johansen
	(9.973)	(6.107)	(4.992)			(2.580)	(-4.285)	
bro1_ger	0.617	2.823	0.640	24.958*	0.177	0.329	-0.232	Johansen
	(9.428)	(7.941)	(3.644)			(3.278)	(-3.579)	
bro2_bel	-0.090	6.155	-0.811	23.263*	0.002	0.167	-0.075	Johansen
	(-0.861)	(10.886)	(-2.908)			(1.700)	(-1.910)	
bro2_ger	-0.011	6.041	-0.903	25.270*	0.007	0.066	-0.071	Johansen
	(-0.098)	(10.032)	(-3.045)			(0.740)	(-2.061)	
bro2_ned	0.524	3.129	0.681	4.753*	0.044	0.261	-0.304	ARDL
	(3.481)	(2.676)	(2.089)			(1.690)	(-3.816)	

Notes: brc, brh and bro denote loans for consumption, house purchase and other purposes respectively. 0, 1 and 2 stand for the different maturities of up to 1 year, 1-5 years and over 5 years (5-10 years for brh). The values in brackets give the t-values of the coefficients. The column labeled "Cointegration" gives either the trace test (Johansen system approach) or the F-test (ARDL approach) for the null hypothesis of no cointegration against the alternative of at least one cointegrating relationship. Asterisk (*, **, ***) denote significance at the 10-, 5- and 1%-level respectively. The column "complete PT" gives the p-value of a test (LM test in the Johansen system approach and F-test in the ARDL approach) for a long-run PT coefficient equal to one. The last column shows the chosen model. The coefficients are derived from equations (2) and (3) for the ARDL approach and equation (4) for the Johansen approach.

Table 2: Results for nonlinear cointegration

interest rate	Long-run PT coefficient	Constant	Dummy	Cointegration	complete PT	β_{10}	β_{20}	τ_1	τ_2	γ	model
brc0_aut	0.890	2.143	1.057	26.424**	0.446	0.258	-0.081	-0.444	0.486	1.792	ARDL,
	(3.594)	(5.982)	(5.979)			(2.497)	(-0.558)	(-6.807)	(3.598)	(1.412)	LSTR
brc0_esp	-1.681	22.198	-7.829	27.912**	0.769	-0.706	1.673	0.329	-0.642	1.041	Johansen,
	(-2.679)	(6.705)	(-4.868)			(-0.545)	(0.688)	(1.069)	(-1.099)	(0.999)	LSTR
brc0_ire	0.652	3.745	1.357	5.061*	0.047	1.584	-0.844	-0.452	0.141	-15.057	ARDL,
	(2.816)	(3.218)	(2.850)			(3.003)	(-0.851)	(-1.020)	(0.355)	(-0.767)	LSTR
brc0_ita	-0.285	15.693	-3.791	24.619*	0.001	-0.648	0.429	-0.575	0.516	469.061	Johansen,
	(-0.989)	(10.063)	(-4.929)			(-0.683)	(0.378)	(-7.350)	(6.961)	(4.366)	ESTR
brc0_por	0.396	6.276	1.057	5.464*	0.171	0.611	-0.732	-0.090	0.002	0.559	ARDL,

	(1.270)	(2.043)	(1.167)			(-6.967)	(-1.791)	(-3.067)	(0.060)	(1.278)	ESTR
brc1_aut	1.395 (4.082)	1.463 (2.181)	2.219 (3.409)	7.515**	0.002	0.047 (0.095)	1.194 (3.996)	-0.456 (-3.205)	0.410 (2.377)	8.836 (0.500)	ARDL, LSTR
brc1_bel	0.035 (0.392)	8.622 (17.739)	-1.215 (-5.070)	36.647***	0.000	0.273 (1.217)	-0.745 (-1.333)	0.007 (0.089)	-0.349 (-2.039)	1.328 (2.214)	Johansen, LSTR
brc1_esp	0.948 (13.811)	2.731 (7.371)	2.511 (13.690)	39.250***	0.949	0.772 (6.798)	-0.478 (-1.952)	-0.455 (-8.842)	0.412 (4.447)	74.487 (0.583)	Johansen, LSTR
brc1_fra	0.018 (0.214)	7.165 (15.824)	-0.596 (-2.673)	26.911**	0.003	-0.257 (-5.858)	0.180 (2.665)	-0.300 (-5.372)	0.177 (2.175)	15.695 (0.650)	Johansen, LSTR
brc1_ger	-0.449 (-4.645)	9.037 (17.160)	-1.752 (-6.728)	29.076**	0.000	0.068 (0.531)	-0.732 (-2.697)	-0.011 (-0.158)	-0.145 (-1.282)	3.101 (0.798)	Johansen, LSTR
brc2_aut	0.589 (4.065)	3.407 (3.421)	0.773 (2.712)	6.360**	0.012	-0.137 (-0.612)	0.509 (2.241)	-0.388 (-2.109)	-0.590 (-2.377)	30.781 (1.997)	ARDL, LSTR
brc2_bel	0.037 (0.164)	10.815 (8.878)	-1.228 (-2.039)	25.499*	0.011	-3.774 (-1.276)	6.617 (1.133)	-0.395 (-1.283)	0.448 (0.806)	0.503 (0.599)	Johansen, LSTR
brc2_esp	1.064 (14.757)	0.803 (2.072)	3.925 (20.545)	57.410***	0.481	0.340 (3.232)	-0.247 (-1.849)	0.001 (0.112)	-0.015 (-1.286)	5.519 (1.058)	Johansen, LSTR
brh0_aut	0.924 (18.260)	1.965 (7.386)	0.091 (0.710)	56.243***	0.288	0.524 (3.297)	-0.799 (-2.432)	-0.307 (-10.320)	0.176 (2.420)	1.123 (1.647)	Johansen, LSTR
brh0_esp	1.171 (3.919)	0.812 (2.751)	1.278 (3.706)	5.324*	0.006	0.515 (3.196)	-0.250 (-0.745)	-0.329 (-2.811)	0.155 (0.530)	1.723 (0.621)	ARDL, LSTR
brh0_fra	0.850 (5.045)	1.729 (3.252)	1.082 (3.966)	9.331***	0.158	0.619 (3.479)	-0.835 (-1.882)	-0.277 (-5.869)	0.193 (1.611)	0.888 (1.013)	ARDL, LSTR
brh0_ned	1.181 (4.732)	0.966 (2.462)	2.229 (4.490)	8.856***	0.014	0.524 (7.515)	-0.175 (-2.193)	-0.073 (-2.195)	-0.064 (-1.551)	19.244 (0.619)	ARDL, LSTR
brh1_aut	0.531 (4.939)	2.021 (3.522)	0.084 (0.304)	24.637*	0.048	0.105 (0.544)	-0.162 (-0.343)	0.054 (0.668)	-0.460 (-2.479)	1.447 (0.905)	Johansen, LSTR
brh1_esp	1.314 (19.321)	-1.274 (-3.492)	1.915 (10.669)	32.538***	0.000	0.883 (8.512)	-0.586 (-5.785)	0.260 (6.112)	-0.149 (-2.815)	3.475 (1.108)	Johansen, LSTR
brh1_fra	0.636 (6.273)	2.329 (4.244)	0.633 (3.276)	15.869***	0.004	0.076 (2.132)	-0.117 (-2.797)	-0.142 (-8.438)	0.024 (0.867)	40.158 (0.777)	ARDL, LSTR
brh2_fra	0.780 (5.021)	1.935 (2.476)	0.697 (2.421)	10.897***	0.245	-0.133 (-1.801)	0.302 (3.026)	-0.105 (-5.889)	0.069 (2.088)	81.253 (0.209)	ARDL, LSTR
brh2_gre	-0.837	11.039	-2.928	25.346*	0.000	-0.329	0.730	-0.040	0.076	1.571	Johansen,

	(-4.527)	(10.922)	(-5.863)			(-0.683)	(0.770)	(-0.601)	(0.719)	(0.426)	LSTR
bro0_bel	0.822	2.262	-0.074	39.039***	0.001	0.710	-0.512	-0.598	0.452	1.528	Johansen,
	(20.960)	(10.628)	(-0.706)			(3.735)	(-1.513)	(-8.839)	(3.013)	(1.417)	LSTR
bro0_esp	0.854	0.974	-2.350	28.486**	0.045	2.333	-3.504	0.068	-0.164	0.405	Johansen,
	(12.089)	(2.626)	(-20.030)			(0.856)	(-0.643)	(0.447)	(-0.523)	(0.511)	LSTR
bro0_fra	0.261	5.504	-1.440	35.348***	0.000	0.295	0.039	-0.118	0.086	80.488	Johansen,
	(2.502)	(9.736)	(-5.164)			(1.884)	(0.234)	(-3.151)	(1.524)	(0.118)	LSTR
bro0_ita	1.206	0.351	1.666	24.109*	0.001	1.247	-1.285	-0.348	0.034	1.161	Johansen,
	(26.621)	(1.425)	(13.677)			(5.883)	(-4.846)	(-2.357)	(0.138)	(1.897)	LSTR
bro1_esp	1.134	-0.680	2.816	25.469*	0.345	1.048	-0.987	0.024	-0.037	12.411	Johansen,
	(9.585)	(-1.056)	(8.843)			(7.302)	(-5.544)	(1.869)	(-1.438)	(2.355)	LSTR
bro1_fra	-0.142	7.332	-1.832	37.037***	0.000	0.421	-0.539	0.045	-0.154	123.862	Johansen,
	(-1.395)	(13.255)	(-6.732)			(3.610)	(-1.979)	(1.225)	(-1.971)	(0.245)	LSTR
bro1_ita	0.846	1.599	1.448	28.158**	0.031	0.708	0.019	-0.358	-0.163	91.221	Johansen,
	(17.748)	(6.181)	(11.322)			(5.672)	(0.087)	(-4.944)	(-1.286)	(0.509)	LSTR
bro2_esp	0.894	0.093	3.368	24.554*	0.352	1.375	-0.841	-0.536	0.286	1.731	Johansen,
	(9.173)	(0.177)	(12.939)			(3.149)	(-1.086)	(-2.673)	(0.876)	(0.527)	LSTR
bro2_fin	0.810	2.494	0.873	4.666	0.376	0.015	0.519	-0.277	-0.365	6.524	ARDL,
	(3.314)	(2.349)	(1.711)			(0.078)	(1.676)	(-3.663)	(-3.217)	(1.039)	LSTR
bro2_fra	0.734	0.590	1.369	28.924**	0.496	0.466	-0.266	-0.022	-0.058	8.358	Johansen,
	(5.085)	(0.764)	(3.674)			(6.062)	(-1.766)	(-0.558)	(-0.694)	(0.540)	LSTR
bro2_ita	0.696	2.001	1.411	33.916***	0.004	1.043	-0.986	-0.231	0.167	1.303	Johansen,
	(14.060)	(7.439)	(10.608)			(1.713)	(-0.820)	(-0.925)	(0.395)	(0.735)	LSTR

Notes: brc, brh and bro denote loans for consumption, house purchase and other purposes respectively. 0, 1 and 2 stand for the different maturities of up to 1 year, 1-5 years and over 5 years (5-10 years for brh). The values in brackets give the t-values of the coefficients. The column labeled "Cointegration" gives either the trace test (Johansen system approach) or the F-test (ARDL approach) for the null hypothesis of no cointegration against the alternative of at least one cointegrating relationship. Asterisk (*, **, ***) denote significance at the 10-, 5- and 1%-level respectively. The column "complete PT" gives the p-value of a test (LM test in the Johansen system approach and F-test in the ARDL approach) for a long-run PT coefficient equal to one. The last column shows the chosen model. The coefficients are derived from equations (2), (3), (4) and (5).

Table 3: Results for linear 1st differences

interest rate	Short-run PT coefficient
brc0_fra	-0.225 (-1.146)
brc2_gre	-0.196 (-0.608)
brc2_ned	0.002 (0.007)
brh0_gre	0.445 (4.581)
brh2_aut	0.181 (1.210)
brh2_fin	0.413 (3.148)
brh2_ger	0.079 (1.778)
brh2_ita	0.106 (0.853)
bro0_fin	0.499 (3.681)
bro2_aut	-0.435 (-1.390)

Notes: brc, brh and bro denote loans for consumption, house purchase and other purposes respectively. 0, 1 and 2 stand for the different maturities of up to 1 year, 1-5 years and over 5 years (5-10 years for brh). The values in brackets give the t-values of the coefficients.

Table 4: Results for nonlinear 1st differences

interest rate	β_{10}	β_{20}	τ_1	τ_2	γ	model
brc0_ger	0.214	-2.310	0.332	-0.795	0.425	ESTR
	(0.675)	(-0.716)	(1.08)	(-0.841)	(1.647)	
brc0_gre	1.679	1.658	-1.655	-1.681	60.392	ESTR
	(2.855)	(3.476)	(-5.186)	(-6.990)	(2.339)	
brc0_fin	0.329	0.242	0.606	-0.631	9.231	ESTR
	(1.226)	(0.456)	(1.68)	(-1.483)	(0.450)	
brc0_ned	0.650	12.145	-0.482	-10.255	0.541	LSTR
	(1.626)	(0.750)	(-0.812)	(-0.820)	(1.030)	
brc1_fin	0.178	0.368	0.522	-0.416	149.693	LSTR
	(0.910)	(0.896)	(3.390)	(-2.020)	(1.194)	
brc1_gre	0.103	-4.051	0.143	8.550	7.222	LSTR
	(0.281)	(-0.323)	(0.454)	(0.391)	(0.769)	
brc1_ita	0.447	1.738	-0.253	-1.014	2.912	LSTR
	(2.751)	(1.811)	(-1.578)	(-1.877)	(0.499)	
brc1_ned	0.176	2.401	-0.082	-11.934	42.289	LSTR
	(0.685)	(0.244)	(-0.251)	(-0.266)	(0.126)	
brc1_por	-0.446	1.856	0.552	-2.516	24.940	ESTR
	(-1.137)	(1.477)	(1.413)	(-1.564)	(0.944)	
brc2_fin	0.547	3.361	-0.519	-5.466	5.017	ESTR
	(1.268)	(0.873)	(-1.366)	(-1.399)	(3.156)	
brc2_fra	0.112	-6.15	0.023	18.244	0.983	ESTR
	(0.611)	(-0.135)	(0.167)	(0.141)	(0.668)	
brc2_lux	0.438	-0.427	1.073	-1.723	-5.6792	LSTR
	(1.934)	(-0.886)	(3.138)	(-6.051)	(-1.708)	
brh0_por	-0.019	3.335	0.027	56.460	1.181	LSTR
	(-0.225)	(0.239)	(0.227)	(0.222)	(1.37)	
brh1_gre	-0.557	0.946	0.502	-1.056	3.363	LSTR
	(-2.246)	(2.45)	(1.864)	(-3.549)	(0.871)	
brh1_ita	0.253*	-1.173	0.246	1.858	15.533	LSTR
	(1.894)	(-0.870)	(1.897)	(1.101)	(0.825)	
brh1_ned	0.279	-2.030	0.222	-1.050	0.670	ESTR
	(1.716)	(-0.640)	(0.747)	(-0.598)	(0.771)	

brh2_bel	0.027	-0.061	0.267	-0.721	17.002	ESTR
	(0.206)	(-0.125)	(4.080)	(-2.840)	(0.819)	
brh2_esp	-0.600	1.625	0.703	-1.075	5.285	ESTR
	(-1.918)	(3.207)	(2.664)	(-0.994)	(0.937)	
brh2_ned	0.056	0.191	0.043	-1.396	50.590	LSTR
	(0.798)	(0.114)	(1.117)	(-2.441)	(0.484)	
bro1_fin	0.951	1.355	-0.490	-3.540	-3.295	LSTR
	(1.881)	(0.763)	(-0.647)	(-1.103)	(-0.616)	
bro1_ned	0.467	-0.731	0.550	-0.989	-29,176	LSTR
	(2.922)	(-0.626)	(3.000)	(-1.564)	(-0.485)	

Notes: brc, brh and bro denote loans for consumption, house purchase and other purposes respectively. 0, 1 and 2 stand for the different maturities of up to 1 year, 1-5 years and over 5 years (5-10 years for brh). The values in brackets give the t-values of the coefficients. The last column shows the chosen model. The coefficients are derived from equations (2), (3), (4) and (5). The coefficients are derived from equation (5).

Table 5: Synthesis of empirical results for the long-run

	brc0	brc1	brc2	brh0	brh1	brh2	bro0	bro1	bro2	Cointegration
AUT	0.89	1.395	0.589	0.924	0.531	---	0.917	0.742	---	7/9
BEL	0.364	0.035	0.037	---	0.549	---	0.822	0.653	-0.09	7/9
ESP	-1.681	0.948	1.064	1.171	1.314	---	0.854	1.134	0.894	8/9
FIN	---	---	---	0.953	0.485	---	---	---	0.81	3/9
FRA	---	0.018	---	0.85	0.636	0.78	0.261	-0.142	0.734	7/9
GER	---	-0.449	0.004	0.861	0.56	---	0.796	0.617	-0.011	7/9
GRE	---	---	---	---	---	-0.837	/	/	/	1/6
IRE	0.652	/	/	0.957	/	/	/	/	/	2/2
ITA	-0.285	---	0.477	1.018	---	---	1.206	0.846	0.696	6/9
LUX	/	---	---	0.713	/	/	0.929	/	/	2/4
NED	---	---	---	1.181	---	---	0.806	---	0.524	3/9
POR	0.396	---	/	---	/	/	0,764	/	/	2/4
Cointegration	6/11	5/11	5/10	10/12	6/9	2/9	9/10	6/8	7/8	

Note: The table summarizes the findings with regard to the long-run coefficients obtained from cointegration according to Tables 1 and 3. "/" denotes cases where the interest rate is not available while "---" corresponds to the case where cointegration is not detected.

Table 6: Synthesis of the findings with regard to nonlinearity

	brc0	brc1	brc2	brh0	brh1	brh2	bro0	bro1	bro2
AUT	LSTR	LSTR	LSTR	LSTR	LSTR	---	---	---	---
BEL	---	LSTR	LSTR	ESTR	---	LSTR	LSTR	---	---
ESP	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR
FIN	ESTR	LSTR	LSTR	---	---	---	---	LSTR	LSTR
FRA	---	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR	LSTR
GER	ESTR	LSTR	---	---	---	---	---	---	---
GRE	ESTR	LSTR	---	---	LSTR	LSTR	/	/	/
IRE	LSTR	/	/	---	/	/	/	/	/
ITA	ESTR	LSTR	---	---	LSTR	---	LSTR	LSTR	LSTR
LUX	/	---	LSTR	---	/	/	---	/	/
NED	LSTR	LSTR	---	LSTR	LSTR	LSTR	---	LSTR	---
POR	ESTR	ESTR	/	LSTR	/	/	---	/	/

Note: The table summarizes the findings with regard to nonlinearity according to Tables 2 and 4. LSTR corresponds to a transition function of the logistic type while ESTR corresponds to the exponential type. “/” denotes cases where the interest rate is not available while “---“ corresponds to the case where nonlinearity is not detected.

Figure 1: Illustration of the modeling cycle