The interest rate pass-through during the Effective Lower Bound: has the ECB lost control on the retail-banking markets?

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Abstract

The aim of this paper is to investigate if the interest rate pass-through is still functioning in the euro area when the policy rate reaches the effective lower bound (ELB). To that end, we estimate a panel-Error Correction Model. To account for non-stationarity and potential heterogeneities in the transmission channels, we first test for cointegration and then apply the mean-group estimator. Our findings suggest that European Central Bank monetary policy, measured by a shadow rate, have been effective in the euro area even after May 2009 when the ELB was reached. This result is robust to alternative measures of the monetary policy stance and it holds even when we distinguish core and peripheral countries.

Keywords: Interest rate pass-through, Fragmentation, Monetary policy, Heterogeneous panel.

JEL Classification: E43, G21, H63.

1. Introduction

Banks play a key role in the transmission of monetary policy, notably in the Euro Area (EA) where banks loans accounts for the bulk of external funding. The lending conditions consequently matter for central banks which aim to regulate aggregate demand (Altavilla, Canova and Ciccarelli, 2016). The financial fragility of the sovereign, the banking sector and the non-financial borrowers has impaired the transmission of monetary policy through the interest rate channel and the credit channel (Cicarreli, Maddaloni and Peydro, 2013). First, once the policy rate has hit the zero or the effective lower bound (ELB hereafter), the central banks loses the ability to influence directly the short-term cost-of-funding for banks, which is the standard channel through which monetary policy is passed-through the retail-banking interest rates.[1] Second, it has sometimes been argued that monetary policy would lose effectiveness during financial crises (Bech, Gambacorta and Kharroubi, 2014, and Gambacorta, Illes and Lombardi, 2015).[2] Third, the increased sovereign risk in some countries have weakened the soundness of national banking systems, which may have contributed to limit their access to external funding from non-domestic counterparties as emphasized by Mayordomo, Abascal, Alonso and Rodriguez-Moreno (2015).[3] It resulted in widening heterogeneities in the banking systems characteristics (Lucotte, 2015) and increasing dispersion – fragmentation – of the retail-banking interest rates as illustrated by figures A and B (in the Appendix).[4] Such an increase of interest rates dispersion is in line with the evidence that differences in the financial structures and banks' soundness affect the transmission of monetary policy.

The European Central Bank (ECB) felt concerned by the efficiency and the homogeneity of the transmission of monetary policy in the EA and decided to implement several measures. Given the role of banks in the transmission of monetary policy in the EA, the measures taken by the ECB aimed at restoring and enhancing the interest rate channel that is the transmission of policy rate decisions to retail banking interest rates. To that end, the ECB launched the Covered Bond Purchase Programme (CBPP) in May 2009 under which the ECB committed to purchase a given amount – € 60 billion for CBPP1 extended in November 2011 (CBPP2) and in June 2016 (CBPP3) – of covered-bonds, which is a source of funding for the banking system in the euro. The aim was to ease funding conditions for the banking system. Liquidity provision to the banking system were also extended and amplified in order to avoid a liquidity squeeze and then a credit crunch. Beyond measures specifically designed for the banking system, the Securities Market Program (SMP) in 2010 and the announcement of the Outright Monetary Transaction (OMT) in September 2012 intended to repair the monetary policy transmission mechanism impaired by drying up of some secondary markets for government bonds. The aim was then to restore homogeneous credit conditions throughout the EA. All those measures were implemented once the policy rate was at the ELB. Henceforth, they were addressed to circumvent the ELB and "*help restore the monetary policy transmission mechanism as correctly as possible*".[5] The aim of this paper is to assess the efficiency of those policy decisions (unconventional monetary policy measures) in steering retail-banking interest rates.

A growing literature has been devoted to assess the efficiency of unconventional measures in mitigating tensions in the interbank market (Abenassi and Linzert, 2012), in reducing

[1] Strictly speaking, the ZLB would be equivalent to a zero interest rate which was not the case until March 2016
[2] The argument of weaker effectiveness is yet fiercely rejected by Mishkin (2009).
[3] Bouvatier and Delatte (2015) report that these crises have triggered a halt in international banking activities leading.
[4] See also Darrac Paries, Moccero, Krylova and Marchini (2014).
[5] Jean-Claude Trichet, 3 févr. 2011. This expression, "*restore the transmission mechanism*" has been often used both by Jean-Claude Trichet and Mario Draghi.

sovereign debt spread (Altavilla, Giannone and Lenza, 2014; Szerbowicz, 2015; Gibson, Hall and Tavlas, 2016; Ghysels, Idier, Manganelli and Vergote, 2016), in supporting credit activity (Giannone, Lenza, Pill and Reichlin, 2012), credit conditions (Ciccarelli, Maddaloni and Peydro, 2013) and stock prices (Rogers, Scotti and Wright, 2014). Following Gambetti, Illes and Lombardi (2015), Creel, Hubert and Viennot (2016) and Altavilla, Canova and Ciccarelli (2016), the focus of this paper is on the retail banking interest rates. However, it departs from previous literature by using a panel approach and accounting for potential heterogeneities in the transmission of monetary policy during the ELB period. To this end, we first use the Westerlund (2007) approach to test for cointegation between retail-banking interest rates and the shadow rate, measuring the stance of monetary policy at the ELB. Second, we estimate panel-Error Correction Model (ECM) equations using the mean-group (MG) estimator proposed by Pesaran and Smith (1995) that enables to account for heterogeneity in non-stationary panels.

The main results of the paper are the following. First, we find that monetary policy measured by the shadow rate has a significant impact on retail banking interest rates during the ELB period. Second, the evidence on the ability for the ECB to mitigate fragmentation is more limited but some estimations suggest a stronger impact in the peripheral countries. This result is robust to alternative measures of the monetary policy stance and it holds even when we distinguish core and peripheral countries.

The paper is organized as follows. Section 2 reviews the literature and discusses the starting point for the ELB period and the separation between the core and the periphery of the EA. The empirical approach is exposed in section 3 while results are presented in section 4. Section 5 concludes.

2. Related Literature

The paper is mainly in line with the literature on the interest-rate pass-through.[6] It also shed lights on the consequences of the financial crisis on the integration of retail banking markets.[7] It is a crucial issue for monetary policy since a step back of integration may contribute to create some heterogeneity in the transmission of the common monetary policy. Blot and Labondance (2013) document this point and suggest that heterogeneity of the transmission of monetary policy has increased during the financial crisis. They also find that the long-term pass-through of the ECB policy rate to the banks' lending rate have decreased after the bankruptcy of Lehman Brothers. Aristei and Gallo (2014) and Gambacorta et al. (2015) reach similar conclusions while the evidence of significant distortions in the interest rate pass-through is less clear for Illes, Lombardi and Mizen (2015) and von Borstel, Eickmeier and Krippner (2016) and Hristov, Hülsewig and Wollmershaüser (2014) who suggest that the increase in the retail bank spreads in the EA would mainly result from an increased volatility of shocks in the periphery rather than from a significant divergence in the interest rate pass-through between the core countries and the periphery. Gambacorta et al. (2015) argue that the change in the pass-through and cross-country differences in the pass-through of money market rate to lending rate results from the risks associated to borrowers and depends on lenders characteristics. Besides, using informations on banks and firms in Italy, Gambacorta and Mistrulli (2014) find that lending interest rates increased less since the bankruptcy of Lehman Brother when banks are better capitalized and for firms engaged in long-term relationship with banks. Then, cross-country differences in the national banking system regarding the nature of bank-firm relationship and the capital structure of banks during the

[6] See Andries and Billon (2016) for a survey on the empirical literature devoted to the retail bank interest rate pass-through.
[7] See Arnold and van Ewijk (2014).

crisis should lead to heterogeneity in the setting of bank interest rates and to a different transmission of the common monetary policy. These results are in line with the evidence that differences in the financial structures, banks' characteristics and borrowers' financial situation affect the monetary policy transmission.[8] Consequently, it is crucial to allow for potential heterogeneity among EA countries when assessing the pass-through of policy decisions to the retail-market interest rates.

Our paper is related to Gambacorta et al. (2015), Creel, Hubert and Viennot (2015) and Altavilla et al. (2016) since it analyzes the pass-through of monetary measures on lending rates in the EA during the financial crisis. Altavilla et al. (2016) focus on the lending rates applied to Non-financial corporations and use monthly-disaggregated data allowing them to take into account banks' characteristics. They find that Targeted Long-term refinancing operations (TLTRO) and Asset Purchase Program (APP) (i-e post 2014 measures) helped to normalize lending conditions across countries by reducing the cross-sectional dispersion of lending rates. Gambacorta et al. (2015) and Creel et al. (2015) adopt a time-series approach and focus on a limited number of countries, 2 (Italy and Spain) and 4 (Germany, France, Italy and Spain) respectively. After identifying a break in the long-run relation between the policy rate proxied by the EONIA and lending rates on new loans in September 2008,[9] Gambacorta et al. (2015) report that unconventional measures measured by the ratio of the size of central bank's balance sheet to GDP has contributed to restore cointegration. Creel et al. (2015) identify the policy shock (for conventional and unconventional measures) from a VAR model estimated with EA aggregates and assess the response of bank interest rates applied to households and non-financial corporations in Germany, France, Italy and Spain to the shocks identified in the first step. Their results suggest that SMP and CBPP have helped to reduce retail banking interest rates in Italy and Spain. Here, we depart from previous literature by estimating panel-ECM models for 6 retail-banking markets: housing loans, loans for consumption, loans below € 1 Million to non-financial corporations, loans over € 1 Million to non-financial corporations, household and non-financial corporations deposit rates and by focusing on a large set of EA countries (15).[10] As emphasized, the transmission of policy decisions may be heterogeneous across EA countries, especially during the ELB period that has been a period of financial fragilities. To that end, we use the MG estimator proposed by Pesaran and Smith (1995) which accounts for heterogeneities in long and short-term coefficients of the panel error correction models. Finally, we also depart from previous literature by using the shadow rate calculated by Wu and Xia (2016) as a single and synthetic measure of the monetary policy stance in the ELB period.

3. Data and Empirical approach

3.1 Empirical approach

The empirical literature on the pass-through of monetary policy rate to retail-banking interest rates often relies on the estimations of error-correction models where the retail-banking interest rate in the long run is expressed as a constant markup on either the driving market rate – a sovereign yield at the same maturity – or the policy rate.[11] We adopt the same

[8] See Cottarelli and Kourelis (1994), Cechetti (2001), Mojon (2000 and 2001), Leroy and Lucotte (2015) and Altavilla et al. (2016).

[9] See also Blot and Labondance (2013) for a similar result and Belke, Beckman and Verheyen (2013) in a non-linear framework.

[10] Germany, France, Italy, Spain, the Netherlands, Belgium, Ireland, Austria, Finland, Portugal, Greece, Cyprus, Slovenia, Lithuania and Slovakia

[11] See Sander and Kleimeir (2004), de Bondt (2005), Marotta (2009) and Belcke, Beckmann and Verheyen (2013).

approach in a panel setting. However, EA countries have been differently affected by the banking, sovereign debt and economic crises. The rise in sovereign yields, the financial health of banks and borrowers influence the relationship between the monetary policy decisions implemented by the ECB and the retail-interest rate set by banks. It is therefore important to account for this potential heterogeneity, which may materialize in the estimations of the long-term pass-through, the error-correction term and the short-term pass-through. The standard fixed-effect model is not able to capture all these sources of heterogeneities. Consequently, we use the MG estimator proposed by Pesaran and Smith (1995), which is better suited for nonstationary heterogeneous panels. We also consider a robustness analysis where the ECM models are estimated using pooled mean group estimator proposed by Pesaran, Shin and Smith (1999) which is a compromise between the fixed-effect model and the mean-group estimation since it involves averaging the short-term coefficients but pooling for the long run coefficients.[12]

There are two critical issues before estimating the panel equations to assess the effectiveness of monetary policy in the ELB period. First, we need to define the appropriate indicator of the monetary policy stance to account for the unconventional measures implemented by the central bank. In normal times, the stance of monetary policy is signalled by the Main Refinancing Operation (MRO) rate – set by the ECB – and the EONIA – the overnight market rate – fluctuates around this rate. The implementation of unconventional measures has made liquidity abundant creating excess reserves. It follows that the MRO is no longer the relevant indicator of the monetary policy stance in the EA. Excess reserves create downward pressures on the EONIA that converges to the floor rate represented by the rate of deposit facilities. However, the monetary policy stimulus – through the asset purchase programmes – has gone beyond the level of the EONIA, which captures some but not all the impact of the measures taken by the ECB. The shadow rate proposed by Wu and Xia (2016), based on the term structure of interest rates, provides a proxy for the short-term policy rate encompassing unconventional measures. Before the implementation of unconventional measures, the shadow rate and the EONIA are closely correlated. They have started to diverge at the beginning of 2009 (Figure 1).

Second, we need to make a choice for the start of the ELB period. Strictly speaking, the MRO rate reached 0% in March 2016 while the EONIA had reached this level in July 2014 only. However, it was considered that the policy rate attained a floor before that date. The prolonged period, starting in May 2009, where the MRO rate was maintained at 1% was considered as the lower bound by most ECB watchers. It has also coincided with the implementation of unconventional measures. The CBPP programme was indeed announced in May 2009 and started effectively in July 2009.[13] Consequently, in the rest of the paper, we consider that the ELB starts in May 2009 and run all estimations from that date.

The following model is estimated for 6 retail-banking markets (housing loans, loans for consumption, loans below € 1 Million to non-financial corporations, loans over € 1 Million to non-financial corporations, household and non-financial corporations deposit rates):

[12] Following Pesaran, Shin and Smith (1999), we also consider an alternative estimator – PMG – where the parameters of the long run relationship are pooled, while heterogeneity remains for the short-term pass-through.
[13] The ECB had already introduced changes in the conduct of liquidity provision by the end of 2008 that might be considered as unconventional: full rate and fixed allotment liquidity provision and extension of the maturity of long-term refinancing operations. However, the policy rate was still decreasing and had not yet reached a lower bound.

$$\Delta ib_{j,t} = \delta_j + \alpha_j\left(ib_{j,t-1} - \lambda_j.shadow_{t-1}\right) + \sum_{k=1}^{p1}\rho_{j,k}\Delta ib_{j,t-k} + \sum_{k=1}^{p2}\gamma_{j,k}\Delta shadow_{t-k} + \\ + \sum_{k=1}^{p3}\theta_{j,k}\Delta x_{j,t-k} + \varepsilon_{j,t} \quad (1)$$

where $ib_{j,t}$ is the retail-banking interest rate for country (*j*), at date (*t*) for each retail-banking market, *shadow* stands for the indicator of monetary policy at the ELB and $x_{j,t}$ includes some country-specific control variables (inflation and industrial production) and an aggregate risk measure (the VIX). The number of lags *p1* and *p2* for exogenous variables in equation (1) is set according the average number of lags identified in the cointegration analysis, whereas *p3* is equal to 1. The introduction of country inflation may be reflected in nominal interest rates. It is expected to have a positive sign. The growth of industrial production aims at accounting for the economic situation of each country. Equation (1) is estimated since the ELB period. The aim is then to assess whether monetary policy has kept influence over the retail interest rates once the ELB has been reached. We also estimate equation (1) from January 2000 to April 2009 to illustrate the change in the long-term pass-through already documented in Blot and Labondance (2013).

The second research question raised by the paper is to analyse whether the measures taken by the ECB have enabled to mitigate fragmentation in the banking system. The sovereign debt crisis has hurt some countries impairing the transmission of the short term policy rate to long-term sovereign yields and retail-banking interest rates. The aim of unconventional measures was then to restore the transmission of monetary policy so that it is expected to have stronger effect in those countries hurt by the sovereign debt crisis. To that end, we identify two panels into which we classify member states that belong to the core and the periphery of the EA. Next, we estimate these separated panel equations to assess whether the impact of monetary policy has been stronger in the periphery. The separation between the core and the periphery is determined according to the average of the sovereign spread relative to Germany after May 2009. When the mean spread is below 2 point, the group of core countries is composed of Germany, Finland, the Netherlands, Austria, France, Belgium and Slovakia (Table 1).[14] Other countries belong to the periphery.[15]

3.2 Data

Data for retail banking interest rates are collected from the ECB MIR database. Data are harmonized for the EA and available on a monthly frequency from January 2000 to February 2017. Empirical analysis is carried out for loans to households (for consumption and house purchases), for loans to non-financial corporations (loans below one million euro and loans over one million euro) and for deposits made with agreed maturity by households and non-financial corporations. For each retail market, interest rates are provided for several maturities. We focus on series called "total maturity", which provides a reference rate summarizing all maturities. Data are collected for 15 countries (Germany, France, Italy, Spain, the Netherlands, Belgium, Ireland, Austria, Finland, Portugal, Greece, Cyprus, Slovenia, Lithuania and Slovakia). For those 15 countries, data on the retail-banking interest rates, inflation rates and growth of industrial production are available from May 2009 – the start of the ELB period – until February 2017. To deal with missing values, we have used

[14] Louri and Migiakis (2016) make the same decomposition which is based on the dispersion of bank lending margins (the difference between the rate charged by banks on loans for non-financial corporations and interests paid by banks on deposits. The only exception regarding core countries is for Slovakia that is not included in their analysis. For countries in the periphery, they do not include Slovenia, Lithuania and Cyprus.

[15] If the cut is set for an averaged spread below 1 point, only Slovakia would switch from the periphery to the core, which does not change our main results.

interest rates data equivalent or close data collected from national central banks.[17] Table 2 presents descriptive statistics for each retail-banking market for the EA as a whole, for core countries and for the periphery. Equations 1 is also estimated over a subsample covering the pre-ELB period to illustrate the change in the long-term pass-through. However, due to missing data for Cyprus, Slovenia, Lithuania and Slovakia, this analysis is restricted to a sample of the other 11-EA countries.

As mentioned above, monetary policy is traditionally measured with a monetary interest rate such as the EONIA. At the ELB, the EONIA may not fully capture all the measures implemented by the ECB. To quantify the stance of ECB monetary policy since the ELB, we use the shadow rate developed by Wu and Xia (2016), encompassing the change in the policy rate as well as the unconventional monetary policy measures.[18] Data for the sovereign yield are taken from the ECB as well as data on the outstanding amounts of LTRO and CBPP.

The country-specific control variables included in the estimations – the industrial production index (IPI) and the harmonized consumer inflation (HCPI) – are available from Eurostat. Systemic risk is measured by the VIX. Information and sources on data are provided in Table A in Appendix.

4. Results

The error-correction model relies on the hypothesis that the policy rate is cointegrated with the retail-banking interest rate. Before estimating equations (1) and (2), we first test for cointegration using the method developed by Westerlund (2007), which is also based on a mean-group approach. Each equation is estimated separately – without the control variables – with the lag order that is permitted to vary across countries and determined by the Akaïke information criteria. The Westerlund approach consists in testing directly that $\alpha_j = 0$, corresponding to the null hypothesis of no cointegration. Two alternative hypotheses are considered: the group-mean test where the alternative is $\alpha_j < 0$ for at least one (j) and the panel test where the alternative is $\alpha_j < 0$ for all (j). For each alternative hypothesis, Westerlund (2007) computes two statistics called G_α / G_τ for the group-mean statistics and P_α / P_τ for the panel statistics.[19] The results of cointegration tests are presented in Table A in Appendix. Tests are performed without including a deterministic trend.[20] The null hypothesis of no cointegration between the retail-banking interest rate and the shadow rate is clearly rejected for all markets. Moreover, the panel statistics suggest that a cointegration

[17] The main adjustments have been realized for Greek interest rates where interest rate data on « total » maturity exhibits numerous missing points. Yet, these series are generally highly correlated with the interest rate for agreed maturity up to one year. Missing values have been replaced accordingly for interest rates on loans below one million euros for Non-financial corporations, interest rates with an agreed maturity up to one year have been used. Data for loans for consumption in the Netherlands are missing from January 2003 to June 2010. Data have then been replaced by data from De Nederlandsche Bank available from January 2003. Data for Italy are also missing for consumption loans before January 2003. Data were also missing for interest from January 2003 to October 2006 on loans over 1 million in Belgium. They have been taken from the National Bank of Belgium but were yet available from March 2003 only. For deposit rates, missing values are taken from the Bank of Greece and De Nederlandsche Bank. The interest rate on deposits rate to households starts in January 2003 in Netherlands.

[18] As robustness test for monetary policy stance, we also use the shadow rate computed by Krippner (2013 and 2014).

[19] "α" refers to the estimation of the error correction estimate, while "τ" refers to the estimation for the standard error of "α". For further information see Westerlund (2007) and Persyn and Westerlund (2008).

[20] The results with a deterministic trend are not presented here but available from the authors.

relationship exist for all countries.[21] We thus conclude that the dynamic of retail-banking interest rates is best represented by an error-correction model.

4.1 Monetary policy and retail-banking interest rates during the ELB period

The second step involves estimating equation (1) using the mean-group estimator proposed by Pesaran and Smith (1995). The number of lags is identical for all countries and ($p1$) and ($p2$) have been set according to the average lag length selected by the AIC when cointegration is tested.[24] With equation (1), the effect of monetary policy is assessed in the long run and in the short run with parameters λ and γ_k respectively. It must be noted that the shadow rate does not only capture unconventional measures implemented at the ELB but also captures the decisions on the policy rate and notably the 2 interest hikes decided in 2011 as well as the decrease of the MRO rate from 1.25% to 0% that were implemented from the 9 November 2011 to 16 March 2016. The estimations will then be as close as possible to the standard model measuring the pass-through of monetary policy with part of the pass-through that is also related to unconventional measures. The results of the baseline estimation are presented in Table 3.

The error correction term α is significantly negative with an adjustment speed ranging from -0.06 for interest rate on housing loans to -0.19 for the interest rate on loans over € 1 Million for non-financial corporations. It is not surprising to find a more rapid adjustment for loans over € 1 Million for non-financial corporations since on this market, firms may also have access to market funding increasing competition between bank and market funding.[25] Regarding the long-term pass-though, results suggest a higher long-term pass-through for the households' deposit rate. It is also higher for loans granted to firms, over and below € 1 Million, than for loans granted to households. The coefficient is always significant indicating that a decrease in the shadow rate is transmitted to the retail-banking interest rates. Here we cannot disentangle between the effect of standard measures – increases and decreases in the policy rate – and unconventional measures. But as most changes in the shadow rate stem from non-standard measures, we may consider that those measures have been efficient. Indeed, they would have contributed to decrease the cost of funding for banks. The provision of excess liquidity first through the LTRO and then through the APP have pushed the EONIA rate below the MRO rate amplifying the decrease in the policy rate. CBPP have also eased financing conditions on the market of covered bonds, which is a source of market funding for banks. Besides, the SMP and the PSPP may have also had indirect impact through their effect of the sovereign yields.[26] Finally, the short-term effect of the shadow rate is rarely significant.

The results for the baseline estimation suggest that monetary policy has still been effective in influencing the bank interest rate. The long-term pass through is significantly different from zero. However, it may be noticed that coefficient for this long-term pass-through seems to be lower relative to previous results in the literature.[27] Blot and Labondance (2013) have notably emphasized that those pass-through would have declined during the financial crisis. We document this issue by comparing long-term pass-through with before and since the ELB. As pre-2009 data for retail banking interest rates are not available for Slovakia, Cyprus,

[21] The conclusions change marginally when a deterministic trend is added. The null of no cointegration cannot be rejected for the deposits of non-financial corporations and the panel statistics do no confirm cointegration for all countries for loans below € 1 million and households' deposits.
[24] It is sometimes marginally adjusted to make sure that the MG panel estimation converges.
[25] A frequent interpretation is that loans over € 1 Million are those granted to biggest firms.
[26] See Gibson et al. (2016), Szczerbowicz (2015) and De Santis (2016) for recent evidence of the effectiveness of those programmes on the sovereign yields.
[27] See table 2 in Andries and Billon (2016) for a survey of a large set of empirical estimates.

Lithuania and Slovenia, the estimation of equation (1) for the pre-ELB and the ELB period is realized on a smaller sub-sample of 11 countries. The comparison of long-term pass-through is illustrated by Figure 2. For the 6 markets considered, the long-term pass through has declined once the policy rate has reached the ELB in May 2009. It is now always below 0.5 whereas it was higher before the ELB period. Besides, it should also be noticed that in the pre-ELB period, the long-term pass-through was not statistically different from unity except for the banking interest rate on consumption loans. More importantly, the results highlight significant differences between the parameters for the long-term pass-through estimated before and during the ELB so that even if monetary policy still succeeds in influencing banking interest rates, its effectiveness has declined since the policy rate has reached the ELB.

We assess the sensitivity of the baseline results in controlling for the sovereign risk. To that end, we add the sovereign CISS measured by the ECB in the short run dynamic of equation (1).[28] As the indicator of sovereign risk is not provided for all 15 countries, the estimation of equation (1) is performed on a sub-sample of 11 countries, excluding Cyprus, Lithuania, Slovenia and Slovakia. We also compare the baseline estimations with estimations using the PMG estimator proposed by Pesaran et a. (1999). Actually, the PMG is a constrained version of the MG estimator since the long-term effect (λ) and the adjustment speed (α) are pooled across countries. This estimator is a compromise between MG estimations and fixed-effect models. Finally, the calculations of shadow rates to measure the stance of monetary policy when unconventional measures are implemented has gained momentum. Krippner (2013) has also made available an alternative measure of the shadow rate, which is frequently updated. The overall dynamic is close for the two measures except for 2 periods. In April 2015 and October 2016, the Krippner shadow rate suggests a tightening of monetary policy that is not or less identified by the Wu and Xia measure (Figure C in the Appendix). The robustness of our results is subsequently assessed by using the shadow rate calculated by Krippner instead of the measures of Wu and Xia. Robustness estimates are presented in Table 4. They provide evidence that despite the ELB, the financial and the sovereign crises, the ECB has kept influence on the retail-banking interest rates.

4.2 Is the monetary policy transmission stronger in the periphery?

We now assess whether the monetary policy has a stronger impact on the retail-banking interest rates of countries hit more severely by the sovereign debt crisis. The sovereign debt crisis impinged the decrease of the policy rate and was a major cause of fragmentation in the European banking sector. It has led the ECB to take measures to address the consequences of the crisis and mitigate heterogeneity in the transmission of monetary policy. More precisely, we assess whether the transmission of the change in the shadow rate has been stronger in the periphery. To address this issue, we estimate equation (1) separately on the core and the periphery of the EA with the list of countries belonging to the two groups indicated in Table 1.

When the stance of monetary policy is measured by the shadow rate calculated by Wu and Xia (2016), we find that the long-term pass-through of the shadow rate is stronger in core countries for the retail-banking interest rates applied to housing and consumption loans, whereas it is lower in the four other markets (Table 5). Those differences are not statistically significant for housing and consumption loans whereas the difference is statistically significant in other markets (Figure 3). Besides, the adjustment to the long run relationship

[28] The CISS is a real-time composite indicator of systemic risk computed by the ECB. For the EA as a whole, it includes several market indicators. A country-indicator is also computed by the ECB. However, it only captures the sovereign stress.

would have been quicker in the core except for the retail-banking interest rate on housing loans. Finally, regarding the short-term effect, there is no clear evidence that retail-banking interest rates in the periphery have responded more rapidly to the change in the shadow rate. Our results suggest that the measures taken by the ECB have partly reduced fragmentation in the retail-banking markets. The long-term pass-through of the shadow rate is significantly higher in 4 out of 6 markets and notably for loans granted to non-financial corporations. For those markets, the implementation of unconventional measures, proxied by the decrease of the shadow rate have contributed to a reduction of retail banking interest rates that was stronger in the periphery countries. For interest rates applied to housing and consumptions loans, the long-term pass-through was not statistically different in the core and in the periphery.

The sovereign debt crisis was particularly severe for Greece that went into default on public debt. The market for sovereigns has shut down and the sovereign yield has risen at levels far higher than in other countries as indicated in Table 1. Greece may therefore appear as an outlier relative to other countries of the periphery. Equation (1) has therefore been re-estimated by dropping Greece out of the sample of peripheral countries in order to check that previous results are not driven by a specific country. Results in Table 5 suggest that it was not the case. The coefficient for the shadow rate is of similar magnitude in the periphery when Greece is not included in the sample.

4.3 Controlling for endogeneity

One can argue that our baseline estimates suffer from an endogeneity bias coming from the fact than since the ELB, the shadow rate encompasses measures designed to mitigate financial instability. Indeed, the ECB has abandoned its separation principle (Clerc and Bordes, 2010). Interest rate policy together with unconventional measures may have not only reacted to macroeconomic goals but also to financial stress. Therefore we can implement financial stress in a traditional Taylor rule as follows: $Shadow_t=\alpha+\beta_1 CPI_t+\beta_2 GDP_t+\beta_3 \Phi_t+\varepsilon_t$ The monetary policy stance measured through the shadow rate is explained three main variables: the consumer price inflation rate (CPI_t), the gross domestic product growth rate (GDP_t) and a variable capturing financial stress (Φ_t). The objective here is not to model precisely all the variables that can explain ECB reactions but to measure in ECB decisions what can be attributed to financial instability. All other potential explaining variables are in the error term. After having estimated this equation, we can remove in the shadow rate the contribution of financial stress. We can therefore calculate a new shadow rate cleaned from the potential ECB decisions taken in order to insure financial stability: $NewShadow_t=Shadow_t - \beta_3 \Phi_t$.

To measure financial tensions, we develop an indicator of financial stress using a Principal Component Analysis (PCA) to extract the common denominator that captures stress of the interbank and sovereign markets. We include in the PCA the following variables for the interbank markets: spreads between the Euribor and the Overnight Index Swap (OIS) at the maturities of one-week, one-month, three-month, six-month, nine-month and one-year. And to capture financial stress on sovereign markets, we include spreads between EA countries sovereign long-tem interest rates and the German one. Data came from Eurostat and Datastream. Quarterly data have been linearly interpolated to monthly frequency. The $\beta 3$ coefficient associated to financial stress is significant and negative indicating that when financial stress rises, the shadow rate decreases. Nevertheless, NewShadow and the shadow rate are highly correlated (0.99).

We then include in our baseline equation $NewShadow_t$ instead of the initial shadow rate and estimate equation (2) as follows:

$$\Delta ib_{j,t} = \delta_j + \alpha_j\left(ib_{j,t-1} - \lambda_j . Newshadow_{t-1}\right) + \sum_{k=1}^{p1} \rho_{j,k} \Delta ib_{j,t-k} + \sum_{k=1}^{p2} \gamma_{j,k} \Delta shadow_{t-k} + \\ + \sum_{k=1}^{p3} \theta_{j,k} \Delta x_{j,t-k} + \varepsilon_{j,t} \quad (2)$$

Results presented in Table 6 show that the error correction term α is significantly negative with an adjustment speed ranging from -0.07 for interest rate on housing loans to -0.18 for the interest rate on loans over € 1 Million for non-financial corporations. Regarding the long-term pass-though, coefficient is always significant indicating that a decrease in the Newshadow rate is transmitted to the retail-banking interest rates. We can observe that long-term coefficients are smaller than in the baseline estimates. We assess the sensitivity of these results in several ways. In the traditional Taylor Rule, GDP has been replaced by the unemployment rate. Moreover, the financial stress indicator has been computed with a PCA that includes dispersion measures of the retail-banking interest rates (see Figures A and B). Finally, two other PCA have been computed to capture financial stress focusing only on interbank and sovereign tensions respectively. Results presented in Table 6 show that the interest-rate pass-through continued to operate even when the ELB was reached

5. Conclusion

This paper investigates whether the ability for the ECB to influence retail-banking interest rates is annihilated when the policy rate reaches the ELB. To that end, we estimate panel-ECM equations where we account for potential heterogeneity in the transmission process of monetary policy. While there is a large body of evidence that unconventional measures have significant effect on asset prices and sovereign yields, empirical analysis on the interest rates applied by banks for households and non-financial corporations is much more limited whereas it plays a crucial role in the transmission of monetary policy in the EA. Our findings suggest that monetary policy has still been effective and that the interest-rate pass-through continued to operate even when the ELB was reached. The shadow rate, which measures the monetary policy stance and encompasses both the conventional and unconventional measures implemented after May 2009, has a significant effect on the retail-banking interest rates for all markets (loans to households and non-financial corporations as well as deposits).

Besides, those measures were also taken during a period characterized by a fragmentation of the banking systems. The financial and sovereign debt crises have impaired the transmission of monetary policy notably in the peripheral countries. It has increased dispersion of banking interest rates breaking the convergence process that had taken place since the end of the nineties. We disentangle the effect of monetary policy in the core from the peripheral countries by estimating separate equations for the two groups. Our estimations suggest that the ECB would have partly been able to restore the homogeneity of the interest rate pass-through. The impact of the shadow rate on the retail-banking interest rates is indeed stronger in the peripheral countries than in the core countries for some but not all the markets for credits and deposits. Besides, the liquidity provision on a long-term basis may also have contributed to reduce banking interest rates in the periphery.

However, we must keep in mind that the interest rate channel is not the only through which monetary policy measures have been pass-through the banking system. We may also contemplate that it might have eased lending standards, that is other non-price factors, an issue that is not dealt with in this paper. Consequently, here we only capture one dimension of the transmission of monetary policy in the ELB but it is certainly a substantial one.

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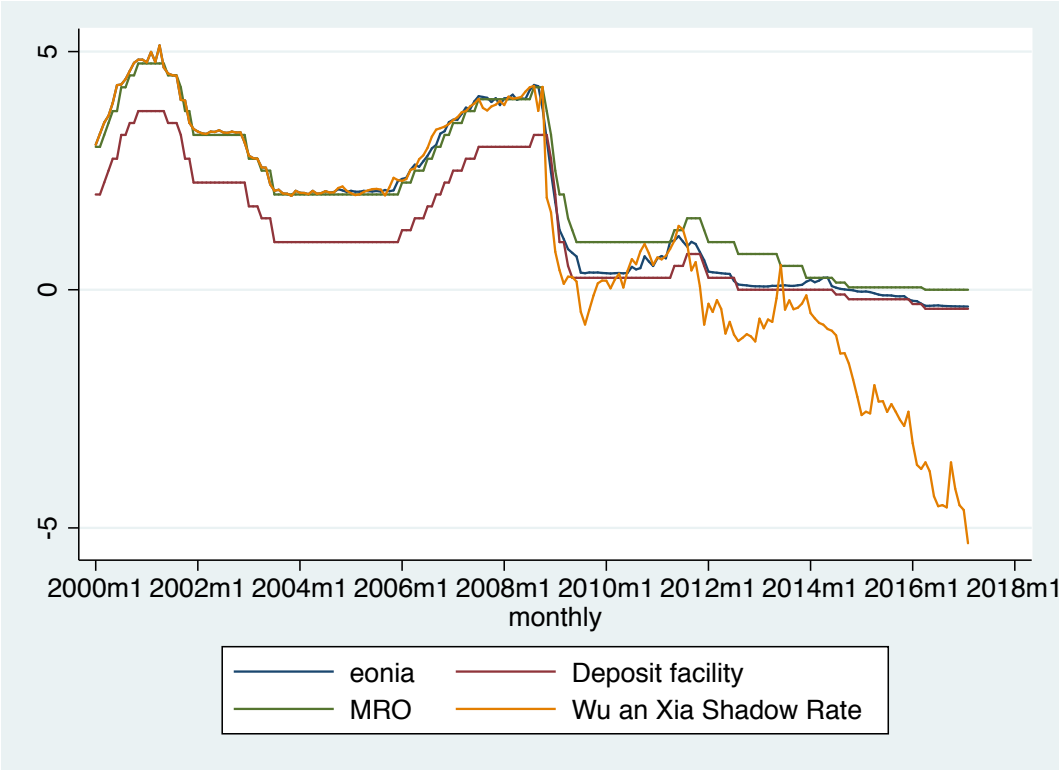
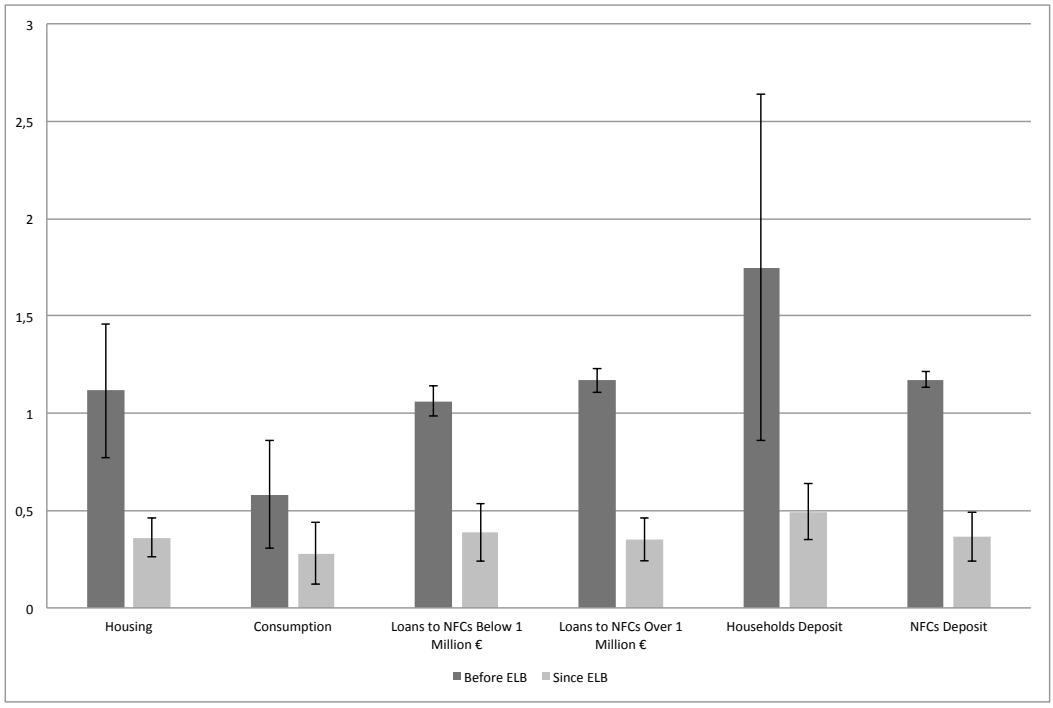
Figure 1. Comparing the policy stance with the EONIA and the shadow rate (in%)



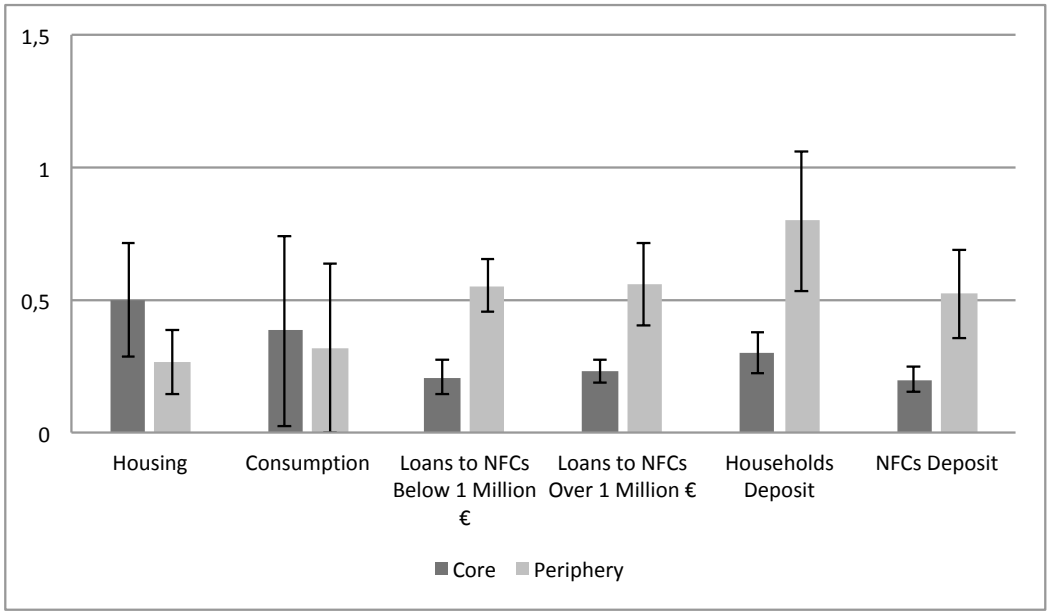
Source: ECB, Wu and Xia (2016).

Figure 2. Comparing the pre-ELB and ELB long-term pass-through



Note: The figure shows the long-term Before and since the ELB estimated with equation (1) with 90% confidence interval. Wu and Xia shadow rate is used as the monetary policy instrument.

Figure 3. Comparing the long-term pass-through of the core and of the periphery during the ELB



Note: The figure shows the long-term coefficient in the Core and in the Periphery estimated with equation (1) during the ELB with 90% confidence interval. Wu and Xia shadow rate is used as the monetary policy instrument.

Table 1. Sovereign spreads with Germany (in %)

Country	Mean spread	Maximum spread
Core		
Finland	0,3	0,7
Netherlands	0,3	0,7
Austria	0,5	1,5
France	0,6	1,5
Belgium	0,8	3
Slovakia	1,3	3,5
Periphery		
Italy	2,1	5,2
Spain	2,1	5,6
Slovenia	2,1	5,5
Ireland	2,6	9,7
Lithuania	2,6	11,3
Cyprus	3,7	5,9
Portugal	4,1	12
Greece	9,4	27,4

Source: Data from the ECB, authors' calculations.

Table 2: Descriptive statistics

	N	Mean	Standard-deviation	min	max
ALL					
Housing loans	1425	3.15	0.93	1.1	6.4
Consumption loans	1425	7.12	2.80	2.4	25.3
Loans to NFC < € 1 M	1425	2.89	1.36	1.0	7.3
Loans to NFC > € 1 M	1425	3.97	1.39	1.6	7.6
Households deposits	1425	1.03	0.96	-0.2	4.5
NFC deposits	1425	1.68	1.01	0.1	5.0
Long-term sovereign interest rate	1425	3.83	3.61	-0.1	38.8
CORE					
Housing loans	665	3.06	1.04	1.1	6.1
Consumption loans	665	6.17	3.10	2.4	14.7
Loans to NFC < € 1 M	665	2.01	0.52	1.1	4.2
Loans to NFC > € 1 M	665	3.01	0.71	1.6	5.3
Households deposits	665	0.53	0.41	-0.2	1.9
NFC deposits	665	1.49	0.63	0.3	3.2
Long-term sovereign interest rate	665	2.14	1.30	-0.1	5.2
PERIPHERY					
Housing loans	760	3.23	0.80	1.7	6.4
Consumption loans	760	7.95	2.21	3.4	25.3
Loans to NFC < € 1 M	760	3.66	1.40	1.0	7.3
Loans to NFC > € 1 M	760	4.81	1.28	2.2	7.6
Households deposits	760	1.46	1.08	0.0	4.5
NFC deposits	760	1.86	1.22	0.1	5.0
Long-term sovereign interest rate	760	5.31	4.28	0.3	38.8

Source: ECB, authors' calculations.

Table 3: Baseline estimates

	Loans to Households		Loans to Non Financial Corportations		Deposit	
	Housing	Consumption	Below 1 Million €	Over 1 Million €	Households	Non Financial Corporations
Using Wu & Xia Shadow rate						
Speed of adjustment	-0.064***	-0.127***	-0.105***	-0.193***	-0.103***	-0.0999***
	(0.009)	(0.017)	(0.022)	(0.023)	(0.032)	(0.014)
Long Run Pass-through						
$Shadow_{t-1}$	0.382***	0.336**	0.462***	0.412***	0.591***	0.379***
	(0.073)	(0.147)	(0.076)	(0.070)	(0.114)	(0.070)
Short Run Pass-through						
$\Sigma \Delta shadow_{(t-}$	0.027	0.034	0.083**	0.028	-0.094***	-0.080
	(0.018)	(0.065)	(0.042)	(0.116)	(0.035)	(0.051)
Δvix_{t-1}	0.001*	0.000	0.002	0.001	0.002**	0.001
	(0.000)	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)
$\Delta.ipi_{t-1}$	-0.001	0.003	0.000	-0.001	-0.001	0.002
	(0.000)	(0.003)	(0.001)	(0.002)	(0.001)	(0.002)
Δcpi_{t-1}	0.015**	-0.069	0.010	0.046**	0.002	0.018
	(0.007)	(0.050)	(0.011)	(0.022)	(0.011)	(0.012)
Constant	0.208***	0.885***	0.424***	0.606***	0.175***	0.120***
	(0.038)	(0.131)	(0.086)	(0.089)	(0.044)	(0.026)
N	1350	1350	1335	1320	1335	1335
Log Likelihood	1655.1	-13.97	987.5	316.5	1155.1	1075.3

Note: Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to equation (1) estimated for six retail banking interest rates.

Table 4: Robustness

	Loans to Households		Loans to Non Financial Corportations		Deposit	
	Housing	Consumption	Below 1 Million €	Over 1 Million €	Households	Non Financial Corporations
Using Wu & Xia Shadow rate and controlling for Sovereign CISS						
Speed of adjustment	-0.064***	-0.146***	-0.091***	-0.177***	-0.098**	-0.098***
	(0.010)	(0.023)	(0.019)	(0.032)	(0.041)	(0.016)
Long Run Pass-through	0.328***	0.251***	0.393***	0.348***	0.465***	0.372***
	(0.043)	(0.092)	(0.074)	(0.071)	(0.093)	(0.084)
Using Wu and Xia shadow rate with PMG estimator						
Speed of adjustment	-0.049***	-0.079***	-0.083***	-0.149***	-0.065***	-0.076***
	(0.008)	(0.020)	(0.021)	(0.027)	(0.013)	(0.013)
Long Run Pass-through	0.303***	0.182***	0.230***	0.252***	0.343***	0.181***
	(0.022)	(0.037)	(0.020)	(0.022)	(0.032)	(0.020)
Using Krippner shadow rate						
Speed of adjustment	-0.068***	-0.146***	-0.118***	-0.199***	-0.109***	-0.107***
	(0.010)	(0.017)	(0.025)	(0.021)	(0.025)	(0.012)
Long Run Pass-through	0.504**	0.158	0.286***	0.293***	0.346***	0.247***
	(0.254)	(0.107)	(0.057)	(0.053)	(0.055)	(0.047)

Note: Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to equation (1) estimated for six retail banking interest rates.

Table 5: Core Vs Periphery

	Loans to Households		Loans to Non Financial Corportations		Deposit	
	Housing	Consumption	Below 1 Million €	Over 1 Million €	Households	Non Financial Corporations
Core						
Speed of adjustment	-0.0513***	-0.144***	-0.154***	-0.214***	-0.157***	-0.126***
	(0.0126)	(0.0310)	(0.0397)	(0.0380)	(0.0584)	(0.0219)
Long Run Pass-through	0.502***	0.383*	0.208***	0.230***	0.301***	0.200***
	(0.131)	(0.219)	(0.0401)	(0.0260)	(0.0469)	(0.0301)
Periph						
Speed of adjustment	-0.0766***	-0.113***	-0.0620***	-0.195***	-0.0530***	-0.0762***
	(0.0150)	(0.0187)	(0.00762)	(0.0338)	(0.0155)	(0.0135)
Long Run Pass-through	0.263***	0.319*	0.553***	0.560***	0.797***	0.524***
	(0.0729)	(0.194)	(0.0604)	(0.0962)	(0.162)	(0.102)
Periph without Greece						
Speed of adjustment	-0.0785***	-0.120***	-0.0584***	-0.198***	-0.0563***	-0.0779***
	(0.0172)	(0.0200)	(0.00776)	(0.0389)	(0.0175)	(0.0155)
Long Run Pass-through	0.263***	0.364*	0.565***	0.570***	0.733***	0.449***
	(0.0841)	(0.218)	(0.0684)	(0.110)	(0.172)	(0.0798)

Note: Standard errors in parentheses, $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$. Each column corresponds to equation (1) estimated for six retail banking interest rates.

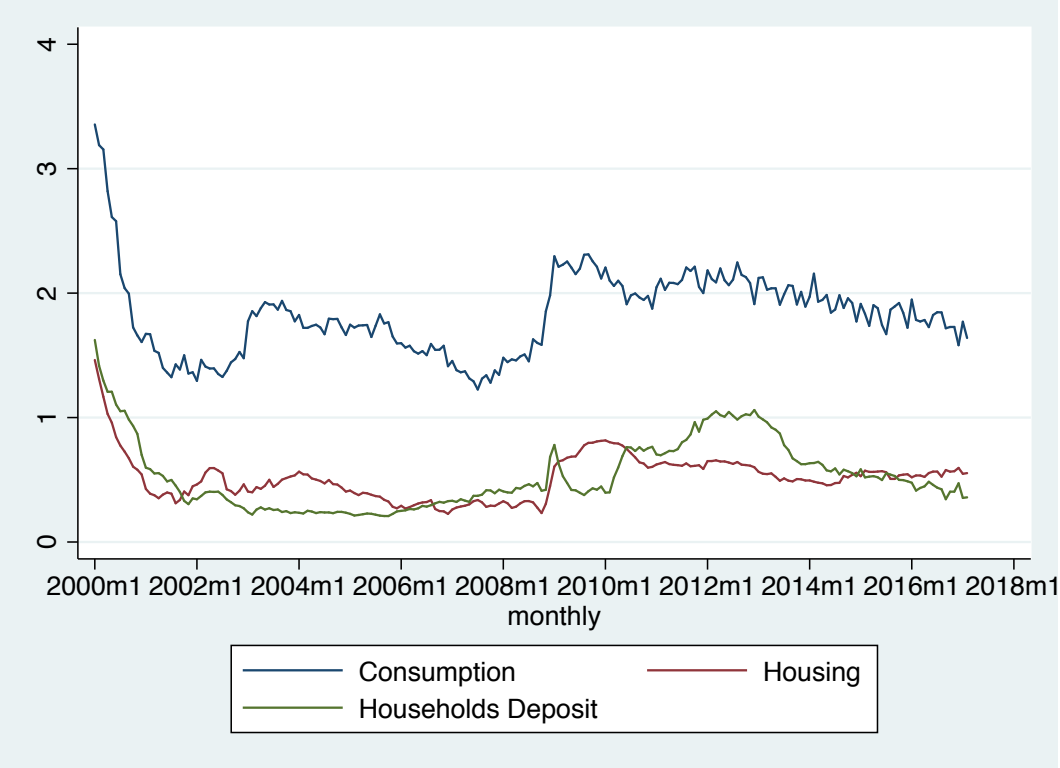
Table 6: Controlling for endogeneity

	Loans to Households		Loans to Non Financial Corportations		Deposit	
	Housing	Consumption	Below 1 Million €	Over 1 Million €	Households	Non Financial Corporations
NewShadow through a Traditional Taylor Rule						
Speed of adjustment	-0.077***	-0.158***	-0.094***	-0.183***	-0.113**	-0.112***
	(0.012)	(0.025)	(0.017)	(0.023)	(0.045)	(0.018)
Long Run Pass-through	0.292***	0.200**	0.329***	0.290***	0.451***	0.310***
	(0.039)	(0.091)	(0.074)	(0.059)	(0.095)	(0.069)
NewShadow - Unemployment rate instead of GDP						
Speed of adjustment	-0.059***	-0.144***	-0.085***	-0.171***	-0.091**	-0.102***
	(0.010)	(0.028)	(0.020)	(0.026)	(0.038)	(0.017)
Long Run Pass-through	0.363***	0.301***	0.498***	0.382***	0.745***	0.404***
	(0.045)	(0.102)	(0.120)	(0.083)	(0.225)	(0.092)
NewShadow - Alternative financial stress: Dispersion						
Speed of adjustment	-0.079***	-0.167***	-0.100***	-0.210***	-0.127**	-0.105***
	(0.013)	(0.026)	(0.014)	(0.022)	(0.055)	(0.017)
Long Run Pass-through	0.240***	0.166**	0.258***	0.231***	0.284***	-0.033
	(0.035)	(0.083)	(0.065)	(0.048)	(0.066)	(0.243)
NewShadow - Alternative financial stress: PCA interbank						
Speed of adjustment	-0.052***	-0.132***	-0.080***	-0.150***	-0.075**	-0.080***
	(0.011)	(0.033)	(0.020)	(0.031)	(0.033)	(0.014)
Long Run Pass-through	0.498***	0.448***	0.501***	0.466***	1.068**	0.452***
	(0.107)	(0.167)	(0.100)	(0.092)	(0.496)	(0.087)
NewShadow - Alternative financial stress: PCA sovereign						
Speed of adjustment	-0.075***	-0.160***	-0.086***	-0.160***	-0.111***	-0.093***
	(0.014)	(0.029)	(0.016)	(0.028)	(0.038)	(0.015)
Long Run Pass-through	0.395**	0.178**	0.265***	0.218***	0.331***	0.245***
	(0.159)	(0.086)	(0.081)	(0.058)	(0.063)	(0.058)

Note: Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to equation (2) estimated for six retail banking interest rates.

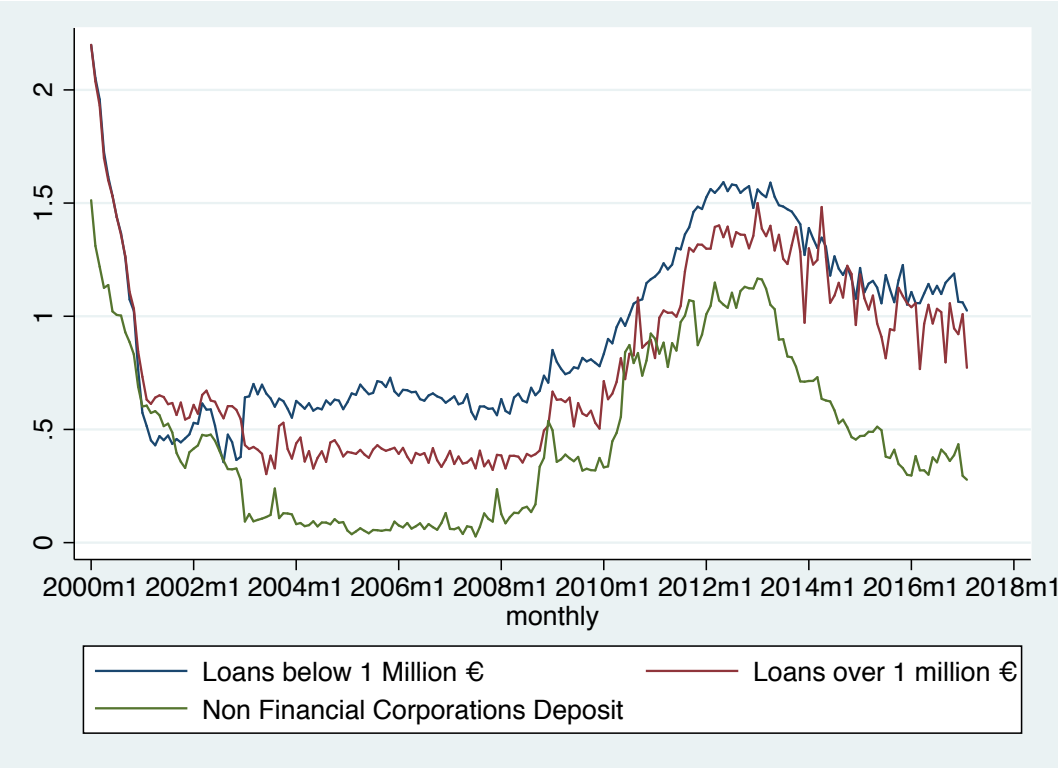
APPENDIX

Figure A. Dispersion of the retail-banking interest rates applied to households



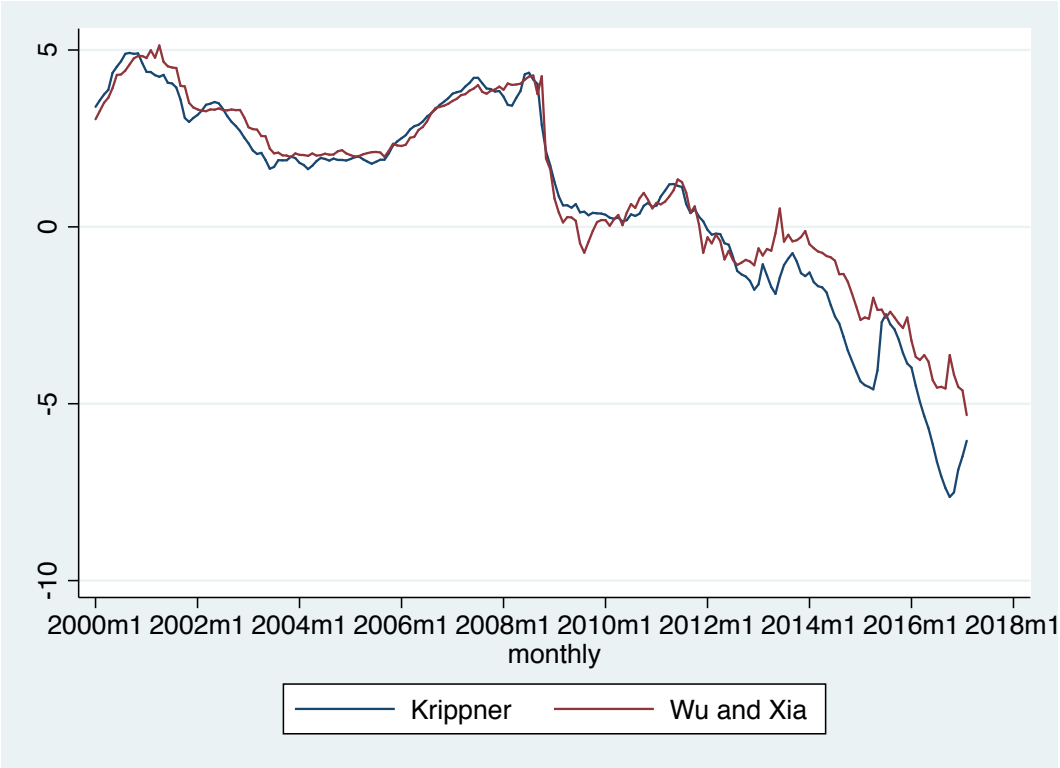
Note: This Figure presents the dispersion of the retail-banking interest rates applied to households among EA countries. Dispersion is measured with Standard deviations. Source: Authors calculations.

Figure B. Dispersion of the retail-banking interest rates applied to Non Financial Corporations



Note: This Figure presents the dispersion of the retail-banking interest rates applied to Non Financial Corporations among EA countries. Dispersion is measured with Standard deviations. Source: Authors calculations.

Figure C. Comparing shadow rates (in %)



Note: This Figure compares shadow rates from two distinct sources. Source: ECB, Wu and Xia (2016).

Table A. Data description

Variable	Source
Housing loans	ECB
Consumptions loans	ECB, De Nederlandsche Bank
Loans to Non-financial corporations below € 1M	ECB
Loans to Non-financial corporations over € 1M	ECB, National Bank of Belgium
Households' deposits	ECB, Bank of Greece and De Nederlandsche
NFC depostits	ECB, Bank of Greece and De Nederlandsche
Sovereign yield	ECB
Shadow rate (Wu & Xia)	https://sites.google.com/site/jingcynthiawu/home/wu-xia-shadow-rates
Shadow rate (Krippner)	http://www.rbnz.govt.nz/research-and-publications/research-programme/research-staff-profiles/leo-krippner
CISS	ECB
Industrial production	Eurostat
Consumer price inflation	Eurostat
VIX	Thompson Reuters

Table B. Cointegration tests – Models with the shadow rate (without trend)

	G tau	P tau	G alpha	P alpha	Average lag length
Housing loans	-2.21**	-7.67**	-10.16**	-6.84***	4.47
Consumption loans	-2.32**	-7.81**	-12.18**	-11.41***	4.4
Loans to NFC < € 1 M	-2.39***	-8.37***	-10.37**	-7.36***	5
Loans to NFC > € 1 M	-2.44****	-8.69***	-14.74***	-10.51***	5.33
Households deposits	-2.58***	-8.95***	-10.44***	-7.86***	4.60
NFC deposits	-2.26**	-8.23***	-8.85	-7.59***	4.87

Note: (***), (**), (*) indicates that the null hypothesis of no cointegration is rejected at 1% ; 5% and 10% levels respectively.
Source: Authors estimations based on Westerlund (2007) test.