NBP Narodowy Bank Polski

NBP Working Paper No. 171

Heterogeneous monetary transmission process in the Eurozone: Does banking competition matter?

Aurélien Leroy, Yannick Lucotte

NBP Working Paper No. 171

Heterogeneous monetary transmission process in the Eurozone: Does banking competition matter?

Aurélien Leroy, Yannick Lucotte

Economic Institute
Warsaw, 2014

Aurélien Leroy – Laboratoire d'Economie d'Orléans (LEO); UMR CNRS 7322, Rue de Blois, BP 26739, 45062 Orléans Cedex 2, France; e-mail : aurelien.leroy@univ-orleans.fr
Yannick Lucotte – ESG Management School; Department of Economics, 25 rue Saint-Ambroise, 75011 Paris, France; e-mail: ylucotte@esgms.fr

We would like to express our gratitude for the comments and suggestions provided on this paper by Grégory Levieuge, Bojan Markovic, Jean-Paul Pollin, Christophe Schalck, Peter Sinclair, Patrick Villieu, as well as seminar participants at the 2013 National Bank of Poland MTM workshop.

Print:
NBP Printshop

Published by:
Narodowy Bank Polski
Education & Publishing Department
ul. Świętokrzyska 11/21
00-919 Warszawa, Poland
phone +48 22 653 23 35
www.nbp.pl

ISSN 2084-624X

Contents

Abstract

This paper examines the implications of banking competition for the interest rate channel in the Eurozone over the period 2003-2010. Using an Error Correction Model (ECM) approach to measure the long-run and short-run relationships between money market rates, bank interest rates, and our competition proxy, namely, the Lerner index. We find that competition *(i)* reduces the bank lending interest rates, *(ii)* increases the long-term interest pass-through and *(iii)* speeds up the adjustment towards the long-run equilibrium in the short-run. Therefore, increased competition would improve the effectiveness of monetary policy transmission through the interest rate channel, and from this point of view should be fostered in the Eurozone. Because the 2007-2009 financial crisis has undoubtedly led to a modification of the monetary policy and an increase of the heterogeneity in the Eurozone, we control and extend our results by considering many other aspects than the market structures that can affect the interest rate pass-through. Even if we observe that other factors (economic heterogeneity, systemic risk, banking stability, and capitalization) matter for monetary policy transmission, bank competition remains a key determinant of the pass-through.

Keywords: interest rate pass-through; bank competition; Lerner index; euro area countries; error-correction model.

JEL Codes: C23; D4; E43 ; E52 ; G21 ; L10.

1. Introduction

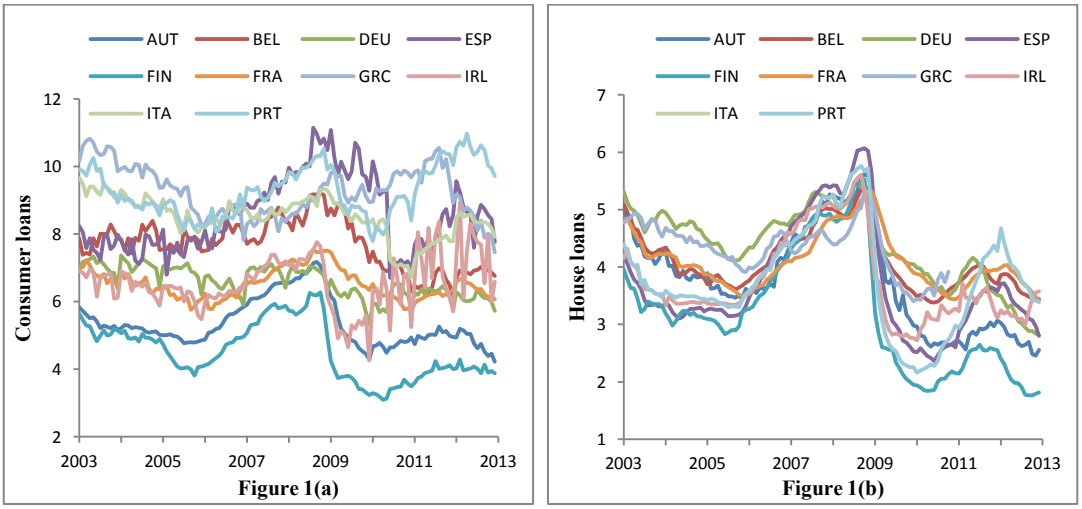
While the European Monetary Union (hereafter, the EMU) will celebrate its 15th anniversary in 2014, it is currently experiencing its deepest economic crisis since its creation. This economic crisis, whose origins lie on the financial turmoil on the other side of the Atlantic, has especially highlighted one of the major shortcomings of the Eurozone: its heterogeneity. The latter issue, which has been known for a long time but too often ignored, was exacerbated during the crisis due to the sizeable cross-country differentials in terms of economic and financial conditions. The economic dimension of heterogeneity refers to disparities in economic growth, inflation rates, unemployment rates, or exchange rate exposure. The divergence in the economic conditions within the Eurozone is particularly evident between the central countries and peripheral countries, as there is an ever-widening gap between economies of the "North" and the "South" as the economic crisis deepens. The second dimension of heterogeneity in the EMU refers to the financial conditions, which are undoubtedly the key dimension of the current heterogeneity in the Eurozone.

Indeed, after a significant financial integration and a strong convergence in the financial conditions across euro area economies from the start of the EMU, the financial crisis, erupted in September 2008 with the default of Lehman Brothers, marked the reemergence of differentiated financial conditions within the Eurozone. Lending rates and sovereign bond yields started to diverge significantly, which reflected the sudden repricing of risks after years of accumulated fiscal, macroeconomic and financial imbalances. This renewed heterogeneity is illustrated in figures 1(a) and 1(b), which represent the evolution of interest rates on consumer loans and on house loans for ten euro area countries over the period 2003-2012.

As we can see in figures 1(a) and 1(b), the financial conditions have tended to be more heterogeneous since 2008. Moreover, there has been a high level of dispersion in the rates charged by banks to households for both consumer loans and real estate loans, although the divergence of interest rates appears more pronounced for house loans. According to the European Central Bank (ECB, 2012), this significant

increase of the heterogeneity in the financial conditions within the Eurozone now constitutes a major challenge for its single monetary policy. Indeed, the financial system is the primary channel through which the monetary policy reaches the economy, and ultimately, the price level. However, if the national financial markets are fragmented, there can be some differentiation in the transmission of the monetary policy across countries, which creates risks to the price stability in the monetary union as a whole. Consequently, the current divergence observed in the financial conditions in the euro area countries, naturally raises the question of the effectiveness of continuing to have a single Eurozone monetary policy after the crisis (see, e.g., Blot and Labondance, 2013; Ciccarelli *et al.*, 2013).

Figure 1. Interest rates on consumer loans (fig. 1a) and house loans (fig. 1b) in selected euro area countries



Source: European Central Bank (ECB) website.

However, the financial crisis only tells part of the story. In other words, the existence of heterogeneous financial conditions in EMU is not new even if the decline in the nominal interest rates in all euro area countries over the two decades preceding the financial crisis has tended to mask this heterogeneity in some financial market segments. Since the start of the EMU, some degree of national differentiation in the financial conditions has existed despite policy initiatives to foster financial integration, such as the Financial Services Action Plan (FSAP) launched in 1999. For example, as shown in figure 1(a), this "structural" heterogeneity seems

especially strong in the consumer loans segment, with a cross-sectional standard deviation across euro area countries of 1.58 on average prior to the financial crash and 1.98 after.

Furthermore, this persistence of cross-country differentials in terms of the financial conditions suggests that other factors than the country-specific imbalances revealed by the crisis have driven the financial heterogeneity within the EMU. Among these driving factors, the literature has highlighted the central role of the financial and banking structures (see, e.g., Cecchetti, 1999), and particularly the role of the banking sector competition. Indeed, we can expect that because of a fear of losing market share, commercial banks operating in a competitive market will supply loans with lower rates and will adjust their retail rates more quickly in response to changes in monetary policy interest rates than banks operating in concentrated markets. Given the predominantly bank-based nature of financing to households and firms in the Eurozone, heterogeneous degrees of banking competition may constitute a major impediment to a smooth transmission of the ECB's monetary policy. Naturally, the level of competition and concentration in the banking sector is also expected to influence the pass-through from the monetary policy to the deposit rates, which may have adverse effects from a macroeconomic perspective. As theoretically shown by Güntner (2011), by amplifying the changes in private households' liquidity premiums, a sluggish adjustment of the deposit rates amplifies the magnitudes and frequencies of fluctuations in output, consumption and employment in business cycles.

Starting from the seminal theoretical paper of Klein (1971), a strand of the empirical literature has studied whether the degree of bank competition affects monetary transmission. This literature has both focused on individual countries and been conducted at a cross-country level. In this second category of studies, we find in particular the pioneering papers of Cottarelli and Kourelis (1994) and of Borio and Fritz (1995), whose empirical results support the fact that lending rates adjust more sluggishly to changes in money market rates in a less competitive environment, proxied by the existence of barriers to entry. Thereafter, using different measures of banking competition, a number of studies have tried to test the effect of competition

on the interest rate pass-through in the euro area (see, e.g., Mojon, 2001; Sander and Kleimeier, 2004; De Bondt, 2005; Kok Sørensen and Werner; 2006; Gropp *et al.*, 2007). Overall, the results of these studies support the previous empirical findings by highlighting a tight relationship between the level of banking competition and the degree and speed of bank rates' adjustment to changes in market interest rates. In a recent study, van Leuvensteijn *et al.* (2013) reassessed this question by using a further measure of banking competition: the Boone (2008) indicator. In line with previous papers, van Leuvensteijn *et al.* (2013) found for eight euro area countries over the period 1994-2004 that the degree of banking competition is a major determinant of the interest rate pass-through, and furthermore, stronger competition implies a stronger responsiveness of loan rates to market rate changes.

Against this background, the aim of our study is to extend the existing empirical evidence on euro area countries by reassessing the effect of banking competition on the interest rate pass-through in the context of the recent financial crisis. In other words, our aim is to evaluate whether the degree of banking competition still matters in the transmission of monetary policy, as there is increasing evidence that country-specific imbalances have become more important in driving financial conditions in the aftermath of the financial crisis. More precisely, our paper extends the study of van Leuvensteijn *et al.* (2013) in at least three major dimensions: first, to take into account the potential effect of the crisis on the interest rate pass-through, we extend the study period considered by van Leuvensteijn *et al.* (2013), and in our empirical framework we take into account the breakdown in pass-through that is implied by the crisis. In fact, our study covers the period from January 2003 to December 2010 for a large sample of eleven euro area countries. Second, unlike van Leuvensteijn *et al.* (2013), we use the traditional Lerner index (Lerner, 1934) as a competition measure, which is popular in the empirical literature. Indeed, although the Boone index has a better theoretical foundation (see, e.g., Boone, 2008; Delis, 2012), the empirical robustness of this indicator remains unclear (Schiersch and Schmidt-Ehmcke, 2011). Finally, in the last part of the paper we control for the fact that rigidity in retail rates is certainly not only due to a lack of competition, but may also be due to credit risk factors and banks' risk aversion.

Three main conclusions emerge from our empirical results. First, we find that bank interest rate spreads are significantly lower under stronger banking competition. In particular, this result implies that bank loan rates are lower in more competitive markets, which improves social welfare. Second, from a monetary policy viewpoint, our results show that stronger bank competition reinforces the long-term and short-term interest rate pass-through. Consequently, competition improves a monetary policy's effectiveness. Finally, extensions in the last section of the paper confirm that bank competition remains a powerful driver of retail banks' price-setting behavior despite the role played by other factors and the financial crisis.

The remainder of the paper is structured as follows: section 2 provides an overview of the theoretical and empirical studies of the interest rate pass-through by discussing the literature on competition and monetary policy transmission, and in section 3, we document the main stylized facts concerning the evolution of banking competition within the EMU. Section 4 describes our data and the econometric methodology, section 5 presents and discusses our empirical results and provides some robustness checks. In section 6, we extend our baseline empirical framework by considering many risk measures to study whether bank competition still explains lending-behavior heterogeneity in times of financial crisis. Finally, section 7 concludes and discusses the main policy implications of our empirical findings.

2. Literature review

In this paper, our main interest lies in the observation of the impact of competition on the pass-through. Following Freixas and Rochet (2008), an extension of the Monti-Klein model (Klein, 1971; Monti, 1972), the net interest margin increases with concentration or market power increases (Corvoisier and Gropp, 2002; Maudos and Fernández de Guevara, 2004). This model also shows that as the intensity of competition increases, lending rates become less sensitive to changes in market rates. Nevertheless, industrial economics shows that in theory, a firm reacts more quickly to a change of the input price in a competitive environment; this idea founded the H-statistic, which is one of the most popular measures of competition. These conflicting theoretical effects of competition on the monetary transmission are also expressed in the literature by the opposition of two hypotheses related to the bank pricing behavior (see, e.g., Corvoisier and Gropp, 2002). According to the "structure-conduct-performance" hypothesis, concentration will have a negative impact on monetary adjustment due to collusion among banks. In contrast, the "efficient-structure" hypothesis states that concentration would be the result of greater bank efficiency. Consequently, concentration (low competition) would increase the speed with which banks change their interest rates following a policy rate change. Hannan and Berger (1991) disprove the latter argument to the extent that they find that the deposit rates are "sticky" when the banking industry is concentrated. Indeed, concentration reduces the elasticity of banks' deposit supply.

The two seminal papers in the pass-through literature (Cottarelli and Kourelis, 1994; Borio and Fritz, 1995) have also explored this question, and both find that rate stickiness is more important in concentrated and less competitive environments. Mojon (2001) finds similar results, but he adds that competition reduces the interest rate asymmetry. Similar results have been found by Sander and Kleimeier (2004). The authors note that market power leads to faster downward than upward adjustment of deposit rates. Furthermore, the competition among financial markets could also influence the pass-through (Mojon, 2001). De Bondt (2005) observes that competition from capital markets speeds up the monetary transmission. The impact

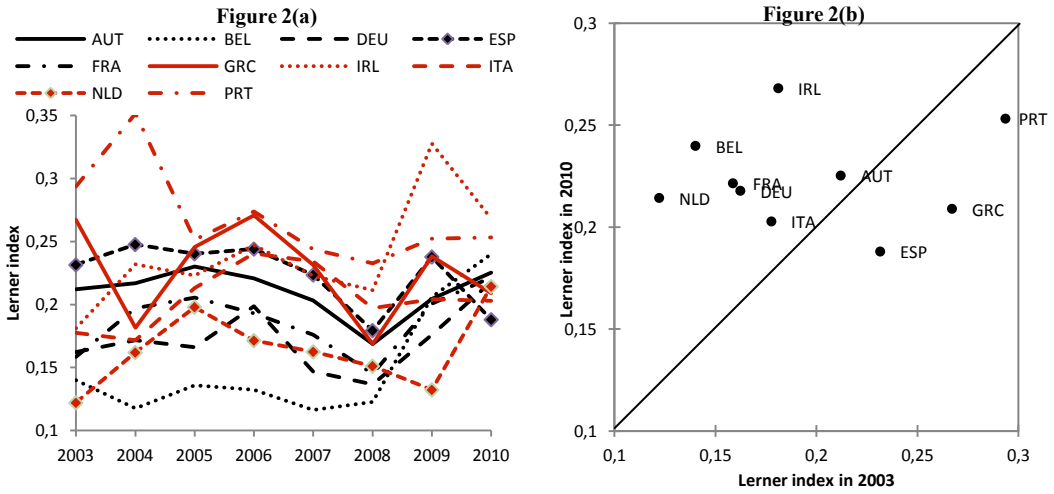
of competition from non-banks would be important for bank-independent borrowers, who can finance themselves directly in the financial market, which forces banks to quickly adjust their rate and narrow their spreads (Corvoisier and Gropp, 2002). The financial markets, and especially money market funds, could also affect the adjustment of deposit rates. Indeed, in theory households are indifferent to putting money in banks or in financial markets.

More recent research tends to improve the previous results with new statistical methods and more sophisticated competition proxies. For instance, Kok Sørensen and Werner (2006) discern the effects of concentration and competition. Nevertheless, their two measures lead to similar results: low competition and concentration reduce the speed of a pass-through. In addition, it appears that the different degrees of competition are the most plausible structural factors to explain the heterogeneity of pass-through among euro area countries. In contrast to numerous studies, Gropp *et al.* (2007) do not use a dynamic econometric model (e.g., a VECM). Their approach does not allow testing the long-term adjustment as well as knowing whether the pass-through is complete; it only focuses on the short-term adjustment and the speed of pass through. To compute the proxy concentration and competition, the authors use the Herfindahl Hirschman Index and the H-statistic, respectively. Despite these singularities, the results confirm the previous findings of Kok Sørensen and Werner (2006). Finally, van Leuvensteijn *et al.* (2013) use a dynamic econometric framework to show that competition: *(i)* reduces the bank interest rates; *(ii)* allows a more complete long-term pass-through, and *(iii)* does not increase the speed of adjustment significantly. One of the particularities of their framework is that it uses a new competition measurement: the Boone indicator (Boone, 2008).

3. Banking competition in the Eurozone: how has it evolved?

A number of studies have shown that the deregulation process in conjunction with the strengthening of the European banking integration led to a marked increase in competition in the 1980s. However, this process ended rapidly. The competition seemed to stagnate or even decline during the 1990s. Fernández de Guevara *et al.* (2005) found no decrease in market power, which they estimated by means of the Lerner index for the period 1992-1999. In a second contribution (Fernández de Guevara *et al.*, 2007), they even concluded that there has been a decline in the competition in many European countries. The period 2003-2010, which is the period of our study, was marked by significant structural changes that could have been due to both the introduction of the Euro and measures of financial convergence (the adoption of the FSAP in 1999, for instance). Furthermore, the financial crisis that started in 2007 and the economic recession that followed it, have undoubtedly led to a change in the level of competition in the banking industry.

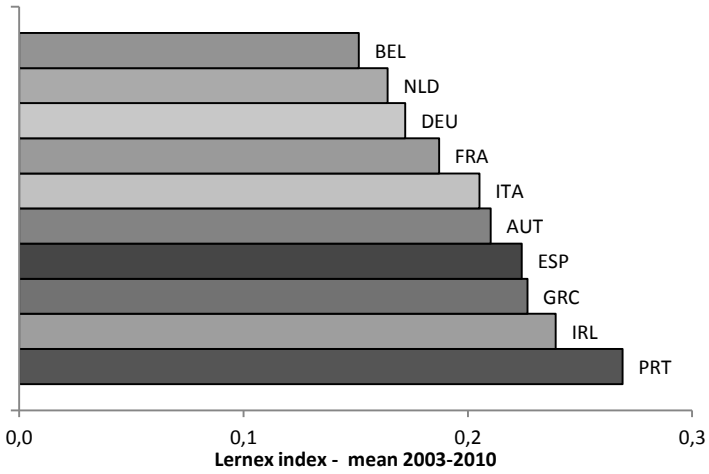
Figure 2. The evolution of banking competition in the Eurozone



Source: The Global Financial Development Database, the World Bank.

Figures 2(a) and 2(b) show the evolution of the banking competition in the Eurozone[1]. In figure 2(a), we can observe temporal fluctuations of competition, but not upward or downward trend. It appears that the market power has shrunk as a result of the financial crisis in 2008 in all the euro area countries we considered. In figure 2(b), we plot the values of the Lerner index for 2003 and 2010, which are reported on the horizontal and vertical axes, respectively. The fact that most countries are located above the 45° line indicates a general decrease in the banking competition within the EMU. This decrease in competition appears especially pronounced for Belgium, the Netherlands, Ireland, France, and Germany. Overall, figures 2(a) and 2(b) underline the heterogeneity of the banking structure and competition in the Eurozone. The level of competition varies significantly from country to country, and figure 3 displays these divergences. We note that the banking sectors in Southern Europe are on average less competitive than in Northern Europe.

Figure 3. The heterogeneity of the banking competition in the Eurozone



Source: The Global Financial Development Database, the World Bank.

[1] Note that an increase of the Lerner index indicates less competition. Furthermore, note that (for readability reasons) Finland is not reported in the graphs of section 3 because the Lerner index is negative for this country in some years.

Therefore, these basic facts raise the question of convergence in the Eurozone. In a recent contribution, Weill (2013) showed that bank competition was not enhanced during the 2000s; instead, it converged across European countries. We confirm this process of convergence with our data. The less competitive banking sectors (Greece, Spain, and Portugal) have been faced to a greater improvement of competition than the more competitive banking sectors (Belgium, Germany, and the Netherlands). Figure 2(a) allows us to refine these findings. We note that competition in the banking system was initially more competitive but decreased over time, whereas more collusive environments became more competitive. All these trends highlight how the EMU's banking structures have converged towards a more homogenous intermediate competitive environment.

4. Data and methodology

This section provides a brief description both of the data and methodology used to assess the interest rate pass-through in the Eurozone and the impact of bank competition on this pass-through. Due to the availability of data, our study covers the period from January 2003 to December 2010 (i.e., there are 96 monthly observations) and focuses on countries that joined the EMU before 2003, except for Luxembourg. Therefore, our sample contains eleven countries: Austria, Belgium, Germany, Finland, France, Ireland, Italy, the Netherlands, Portugal, and Spain, which are the founding countries of the EMU, plus Greece, which joined the Eurozone in 2001. The data are drawn from two principal sources: the ECB statistics and the World Bank.

4.1. Data

To assess the effect of banking competition on the interest rate pass-through, we need three types of data: bank retail interest rates, a money market rate, and a measure of the banking competition. For bank retail rates, we use harmonized monthly data from the MFI Interest Rate Statistics (or MIR Statistics), which provide aggregate data for retail banking loans and deposits for a large sample of EMU countries from January 2003. More particularly, these statistics cover interest rates applied by resident monetary financial institutions (MFIs) to euro-denominated loans and deposits to households and non-financial firms that are residents of the euro area, and these data exclusively refer to new business. Our empirical investigation considers six bank retail rates. For households, we consider the following three interest-rate categories: consumer loans (all maturities), real estate loans (all maturities), and short-term deposits (≤ 1 year). Concerning the non-financial firms, we investigate the interest rate pass-through for credit rates up to one

year for amounts below and above one million euros, and for short-term deposits (≤ 1 year)[2].

Table 1. Average bank retail rates in euro area countries over the 2003-2010 period

	Consumer loans	Real estate loans	Households deposits	Loans to firms < 1 million €	Loans to firms > 1 million €	Firms deposits
AUT	5.47	4.03	2.43	3.93	3.35	2.42
BEL	7.94	4.20	2.30	-	-	2.22
DEU	6.68	4.60	2.37	4.78	3.83	2.28
ESP	8.61	3.84	2.78	4.43	3.44	2.60
FIN	4.67	3.43	2.59	4.03	3.39	2.25
FRA	6.57	4.18	2.56	4.31	3.33	2.40
GRC	9.29	4.34	3.08	-	-	2.77
IRL	6.41	3.86	2.36	4.97	4.40	2.37
ITA	8.63	4.16	1.86	4.40	3.41	2.39
NLD	-	4.56	2.93	4.42	3.40	2.37
PRT	9.05	3.77	2.47	6.21	4.28	2.60
St. Dev	1.37	0.28	0.24	0.47	0.35	0.13

Source: Authors' calculation.

Concerning the money market rate variable to consider, we face a trade-off between using a short-term interest rate or a market rate of comparable maturity. Indeed, a short-term interest rate is supposed to better reflect the monetary policy stance, whereas a market rate of comparable maturity better reflects the marginal cost-of-funds considerations inherent in banks' rate-setting behavior (Kok Sørensen and Werner, 2006). In our study, inasmuch as our main objective is to investigate the transmission of monetary policy impulsions on bank retail rates, we make the choice of employing the Euro Overnight Index Average (hereafter, EONIA) as the money market rate, which is the most closely related market rate to the ECB policy rate. The majority of studies that focused on monetary policy transmission, which is the so-called "monetary policy approach", typically used a short-term market rate to avoid issues with the term structure of interest rates[3]. Moreover, as argued by Belke

[2] Unfortunately, some data are either not available for all countries, or are incomplete. When data are not available in the overall period, our choice of whether to exclude this country depends on the time period not covered by the database. For example, we drop the Netherlands when we study the pass-through from the money market rate to consumer loans because the data for this bank rate begin only in June 2010.

[3] The literature usually distinguishes two types of approaches: the "monetary policy approach" and the "cost-of-funds approach" (see, e.g., Belke *et al.*, 2013). According to Sander and Kleimeier

et al. (2013), using the same money market rate for each bank retail rate that is considered makes the empirical results more comparable. Furthermore, in normal times a close relationship is observed between the EONIA and the EURIBOR rates[4]. Finally, with regard to the measure of banking competition, there is not a strong consensus in the literature regarding the "best" indicator with which to gauge competition (Northcott, 2004). This lack of consensus can be explained by the large number of available banking competition indicators; each of them measures different dimensions of competition. The literature traditionally distinguishes two types of competition measures: the structural measures and the non-structural measures. The former measures refer to the Structure-Conduct-Performance paradigm and are based on the assumption that banks' competitive behavior is principally determined by the structure of the market, such as the degree of market concentration. However, this type of measure has been criticized on the grounds that higher profits in the banking sector could also be the result of a greater production and managerial efficiency, as shown by Smirlock (1985), Evanoff and Fortier (1988), and Berger (1995) for the U.S. banking sector.

Because of this limitation, a number of recent studies analyzing the competitive features of the banking industry prefer to use non-structural competition measures. Numerous non-structural measures of competition have been developed in the academic literature. Among them, the two best known are probably the H-statistic developed by Panzar and Rosse (1987) and the Lerner index (Lerner, 1934). Compared to the structural measures, the main advantage of these indexes is that they are micro-founded, and therefore, offer a more realistic setting to estimate the competitive conditions in the banking sector. Recently, Boone (2008) extends the existing set of non-structural competition measures by proposing an index based on the efficient structure hypothesis. Briefly, this index is based on the assumptions that

(2004), the second approach implies that the corresponding market rate is chosen according to the highest correlation with the bank retail rate that is studied. For example, van Leuvensteijn *et al.* (2013) selected two market rates: a three-month money market rate for bank rates that are either floating or fixed for short periods (< 1 year) and the long-term government bond yields for long-term fixed bank rates.

[4] In the last section of the paper, we will check the robustness of our results using the six-month EURIBOR rate as an alternative market rate.

more efficient firms (i.e., firms with lower marginal costs) gain higher profits or market shares, and moreover, that this effect is stronger the greater the competition in the market is.

Against this background, and given the large debate in the literature concerning the reliability of the above competition measures[5], we adopt a conservative approach and choose to use the Lerner index as a measure of banking competition. Indeed, the majority of recent studies in the literature have still used the Lerner index, except the studies of van Leuvensteijn *et al.* (2011, 2013). Our choice of using the Lerner index is also driven by the fact that in practice, the Lerner index is often meaningfully and statistically related with the Boone indicator[6].

Formally, the Lerner index is constructed for each bank and each year as $\left(P_{i,t} - MC_{i,t}\right)/P_{i,t}$, where $P_{i,t}$ is the price of the bank output and $MC_{i,t}$ is the marginal cost. Usually, $P_{i,t}$ is computed as the ratio of the total operating income (interest and non-interest revenues) to the total assets. $MC_{i,t}$ is derived from a standard translog function with a single aggregate bank output (namely, the total assets) and three input prices (fixed assets, labor, and borrowed funds)[7]. As can be seen, the Lerner index has the advantage of capturing the impact of the pricing power on the asset and funding sides of the banks. In the case of our study, because we work at a macroeconomic level, the Lerner index represents the weighted average market power of individual banks in a given country, and an increase of the Lerner index indicates less competition. Data on the Lerner index are obtained from the Global Financial Development Database of the World Bank, which provides estimates of the Lerner index for a large sample of developed and developing countries from 1996 to 2010. However, because these data are provided on an annual frequency, we have followed van Leuvensteijn *et al.* (2013) and temporally

[5] In recent years, there has been a heated debate in the literature between the proponents of the Lerner index and those of the Boone index. For an illustration of this debate, see, for example, van Leuvensteijn (2008) or Schiersch and Schmidt-Ehmcke (2011).

[6] For example, Delis (2012) finds for a large sample of 84 industrialized and developing countries a statistically significant correlation between these two indicators that is equal to 0.46. In our case, the cross-country correlation between the Lerner and Boone indexes over 2003-2010 is equal to 0.79 and statistically significant at the 1% level.

[7] See Berger et al. (2009), Carbó et al. (2009), and Beck et al. (2013) for more practical details concerning the computation of the Lerner index.

disaggregated these data using a linear interpolation to match the monthly frequency of our study. Over the period 2003-2010, the average Lerner index for the eleven euro area countries considered was 17.2%, but it varied across countries from -12.4% in Finland to 26.9% in Portugal on average.

4.2. The econometric methodology

Two econometric approaches predominate in the literature to estimate the pass-through from market rates to bank interest rates. The first, traditional approach is based on Vector Auto Regressive (VAR) models and aims to analyze the effects of monetary policy shocks on bank rates through the impulse response functions (see, e.g., Cottarelli and Kourelis, 1994; De Bondt, 2005). The second, widely used approach by most recent studies consists of estimating either an error correction model (ECM) or its multivariate version, namely, the VECM. In comparison to a VAR model, an ECM has two main benefits for analyzing the interest rate pass-through: first, from a technical point of view, an ECM requires that the data are non-stationary and cointegrated. This property of ECMs is particularly important when we study the monetary policy transmission process because time series for interest rates are typically integrated of order one ($I(1)$). Second, from an economic analysis point of view, an ECM is appropriate because it allows one to determine the long-run and short-run structures of the relationships among the variables considered. Indeed, in our case using an ECM allows testing for both the long-run equilibrium pass-through of bank retail rates to changes in the market rates (i.e., analyzing if the pass-through is complete or incomplete) and the speed of adjustment towards the equilibrium.

Hence, our empirical pass-through analysis follows the recent literature and considers an ECM framework, which is specified as follows for each of the six considered bank retail rates:

$$br_{i,t} = \alpha_i + \theta mr_t + \delta D_t + \mu_{i,t} \qquad (1a)$$

$$\Delta br_{i,t} = \xi_i + \rho_i \Delta mr_t + \gamma_i ECT_{i,t-1} + \varepsilon_{i,t} \qquad (1b)$$

where $ECT_{i,t-1} = \hat{\mu}_{i,t-1}$, $br_{i,t}$ and mr_t are the national bank loan and deposit rates and the short-term money market rate (EONIA), respectively. In addition, α_i and ξ_i are constant terms that are allowed to differ across countries, i refers to countries and t refers to months. Equation $(1a)$ represents the long-run cointegration relationship between the two interest rates, whereas equation $(1b)$ reflects the short-term adjustments of bank interest rates to their long-run equilibrium. As can be seen, equation $(1b)$ is augmented by a lagged error correction term $(ECT_{i,t-1})$ that is obtained by estimating equation $(1a)$, which represents the deviation from the cointegration relationship. Therefore, γ_i denotes the adjustment coefficient with respect to the deviations from the long-run relationship in the previous period $(\hat{\mu}_{i,t-1})$, and ρ_i captures the effects of the monthly change in the money market rate on the bank interest rates, i.e., the short-term pass-through. One would expect γ_i to be negative if the variables exhibit a return to their long-run equilibrium. The long-term pass-through is captured by the parameter θ, and $(1-\rho_i)/\gamma_i$ equals the mean adjustment lag at which the money market rate is fully passed through to the bank interest rates (Hendry, 1995). More importantly, this two-equation system assumes that the long-run relationship between the money market rate and the bank retail rate should be unique $(\hat{\theta})$ due to a common monetary policy, the short-run relationship between these two interest rates may vary across countries $(\hat{\rho}_i)$. Such a framework allows us to quantify and compare the degree of cross-country heterogeneity in the speed of the adjustment to the long-run equilibrium. Finally, following Belke *et al.* (2013), we introduce in equation $(1a)$ a shift dummy variable D_t that takes the value of one from October 2008 to account for the break in the interest rate pass-through caused by the financial crisis (Blot and Labondance, 2013).

In a perfect competitive environment, one would expect a perfect pass-through of market interest rates to bank interest rates in the long-run, i.e., an estimated coefficient $\hat{\theta}$ equal to unity. In the short-run, the degree of competition in the banking sector is expected to impact the speed of the adjustment of bank interest rates to their long-run equilibrium, and theoretically, there should be a higher speed of adjustment in more competitive markets. To study this effect of the banking

competition on both long-run and short-run pass-through, we extend equations $(1a)$ and $(1b)$ by including an interaction term that is the product of the money market rate and the Lerner index:

$$br_{i,t} = \alpha_i + \theta mr_t + \varphi Lerner_{i,t} + \beta\left(mr_t \times Lerner_{i,t}\right) + \delta D_t + \mu_{i,t} \qquad (2a)$$

$$\Delta br_{i,t} = \xi_i + \omega_i \Delta Lerner_{i,t} + \rho_i(\Delta mr_t \times \Delta Lerner_{it}) + \gamma_i ECT_{i,t-1} + \varepsilon_{i,t} \qquad (2b)$$

where $Lerner_{it}$ is the indicator of banking competition that is considered in our study. Because an increase of the Lerner index indicates less competition, the estimated coefficients $\hat{\beta}$ and $\widehat{\rho_i}$ are expected to be negative. This two-equation system is estimated using the Pooled Mean Group (PMG) estimator developed by Pesaran *et al.* (1999). The PMG estimator is commonly used for estimating non-stationary heterogeneous panels, as it both allows the short-run coefficients and error variances to differ across countries and constrains the long-run coefficients such that they must be equal across countries. Furthermore, unlike the Dynamic OLS (DOLS) and Fully Modified OLS (FMOLS) estimators, the PMG estimator highlights the adjustment dynamic between the short-run and the long-run.

5. Empirical results

This section reports our results on the impact of banking competition on pass-though. We start with the results of our panel unit root and cointegration tests. Subsequently, we report the findings from the examination of our ECM by distinguishing the long-run and short-run effects.

5.1. The panel unit root and cointegration tests

Table 2. Westerlund cointegration tests

	Consumer loans			Real estate loans		
Statistics	Value	Z-value	p-value	Value	Z-value	p-value
Pt	-11.5	-3.942	0	-12.481	-4.58	0
Pa	-20.793	-3.582	0	-30.994	-8.199	0
	Household deposits			Firm deposits		
Statistics	Value	Z-value	p-value	Value	Z-value	p-value
Pt	-14.729	-6.97	0	-9.628	-1.549	0.061
Pa	-42.822	-13.35	0	-24.142	-5.215	0
	Loans to firms < 1 million €			Loans to firms beyond > 1 million €		
Statistics	Value	Z-value	p-value	Value	Z-value	p-value
Pt	-13.187	-6.16	0	-17.038	-10.252	0
Pa	-39.685	-10.84	0	-73.796	-24.277	0

Note: We do not report the results of the two group-mean tests of Westerlund (2007).

We first check for the presence of unit roots in our panel from the panel unit root tests proposed by Im *et al.* (2003) and Hadri (2000). We find that all the variables are integrated of order one. Therefore, we test for cointegration between our non-stationary variables using the panel cointegration tests developed by Westerlund (2007). The results of these tests, reported in table 2, indicate that we can reject the null hypothesis of the absence of cointegration. Consequently, there exists a long-run equilibrium relationship between these variables, which justifies the use of a panel ECM.

5.2. The effects of banking competition on the interest rate pass-through

Tables 3, 4 and 5 present the effects of banking competition on the interest rate pass-through. Table 3a focuses on the interest rate transmission in the long-run, and tables 4 and 5 report the short-term pass-through results. More precisely, for each considered bank interest rate we present the estimation results of equations 1(a) and 1(b) and of equations 2(a) and 2(b) with the objective of observing the influence of competition on the traditional interest rate pass-through framework.

5.2.1. The effect of bank competition on the long-run equilibrium

The estimations of the effect of bank competition on the long-run relationship are reported in table 3a.

Table 3a. Banking competition and long-term pass through for households and firms

Long-term ECM	**Consumer loans**		**Real estate loans**		**Household deposits**	
Eonia	0.755*** (0.049)	1.151*** (0.178)	1.067*** (0.022)	1.498*** (0.152)	1.128*** (0.021)	1.559*** (0.109)
Lerner		-0.051 (1.705)		7.182*** (1.628)		7.710*** (1.519)
Lerner*Eonia		-3.255*** (0.761)		-2.111*** (0.651)		-3.772*** (0.533)
Crisis dummy	0.702*** (0.142)	0.372*** (0.092)	0.862*** (0.063)	0.693*** (0.074)	1.019*** (0.060)	0.849*** (0.045)
Long-term ECM	**Loans to firms < 1 million €**		**Loans to firms > 1 million €**		**Firm deposits**	
Eonia	0.948*** (0.019)	0.996*** (0.041)	1.018*** (0.012)	1.045*** (0.023)	1.086*** (0.009)	1.373*** (0.041)
Lerner		1.243*** (0.464)		0.413 (0.279)		4.916*** (0.620)
Lerner*Eonia		-0.672*** (0.196)		-0.264* (0.125)		-1.643*** (0.230)
Crisis dummy	0.621*** (0.055)	0.412 (0.045)	0.622*** (0.035)	0.605*** (0.032)	0.273*** (0.03)	0.306*** (0.031)

Note: Constant terms are included but not reported. Full results are available upon request. Standard errors reported between brackets. *, **, *** refer to statistical significance at the 10%, 5% and 1% respectively.

Results concerning the long-term pass-through lead to several striking findings. First, we note that the estimated coefficients of the market rate increase significantly for the majority of selected bank rates when we take the level of competition into account (with the exception of the interest rates of loans to firms beyond €1 million). Consequently, the size of the pass-through increases when competition is integrated.

Thus, a change of one point of the money market rate will have a greater impact on bank interest rates once we have controlled for the heterogeneous competitive environment. Furthermore, in all the cases a change of market rate leads to a complete long-run pass-through (which means that the coefficient becomes significantly greater than 1). Therefore, market structures have an impact on monetary transmission. However, beyond this interaction's effect on the monetary policy, which we will discuss later, the competition can also act directly on the level of bank interest rates.

Although the estimated coefficients of competition are significant and positive, the coefficients do not reflect the main effect of competition on bank rates. Indeed, the main effect of competition is given by $\varphi + mr\beta$. We report the results in table 3b, and they are mixed. Only three bank rates are significantly impacted by competition: consumer loans, house loans and firm deposit rates. The other rates seem to be independent of bank competition, which suggests that competition is not a determining factor of the level of interest rates. The price-competition could be irrelevant for the banking industry, or the banks' market power could be consistently unexercised on bank rates. Our preliminary findings are consistent with van Leuvensteijn *et al.* (2013). However, a potential bias of these early estimations is that we calculate the main effect of competition by discriminating the crisis period with a dummy variable.

Table 3b. Global effect of banking competition

	Consumer loans	**Real estate loans**	**Household deposits**
Estimation with dummy crisis	-0.632*** (0.197)	2.212*** (0.652)	-0.769 (0.564)
Estimation without dummy crisis	6.217*** (0.842)	9.24*** (0.917)	27.553*** (4.267)
	Loans to firms < 1 million €	**Loans to firms > 1 million €**	**Firm deposits**
Estimation with dummy crisis	-2.667 (0.199)	-0.181 (0.115)	1.22*** (0.458)
Estimation without dummy crisis	2.516*** (0.719)	-0.199 (0.219)	2.673*** (0.686)

Note: Standard errors are reported between brackets and are given by the following equation: $SE = [Var(\varphi) + mr^2 Var(\beta) + 2\, cov(\varphi, \beta)]^{1/2}$. *, **, *** refer to statistical significance at the 10%, 5% and 1% respectively.

To obtain the true main effect of competition, we re-estimate our baseline model by ignoring the structural break (i.e., by excluding the crisis dummy) and calculate $\varphi + mr\beta$. The results are displayed in table 3b, and they are less mixed than in the previous case. First, three in four lending rates highlight the positive effect of competition on the levels of the rates, which supports the "Structure-Conduct-Performance" hypothesis and is in line with many studies that show that a lack of bank competition leads banks to charge higher rates (see, e.g., the models of Freixas and Rochet (2008) or Ho and Saunders (1981)). One lending rate (the interest rate of loans to firms that are greater than 1 million euros) is not affected by the level of bank competition. The rationale is as follows: these products are in competition with financial markets (with direct debt financing)[8]. Consequently, regardless of the level of banking competition, banks are constrained to cut their margins (see, e.g., Mojon, 2001; Corvoisier and Gropp, 2002).

In contrast to previous arguments, for deposit rates (to firms and households) we find that greater competition reduces the offered rates, whereas competition according to the Cournot model should increase these rates. Some elements can plausibly explain these contradictory results. First, in a competitive market, the pressure on the loan rates forces banks to decrease their deposit rates to ensure a non-negative margin. Furthermore, our measure of competition reflects only the banking competition, which seems more appropriate for loans than deposits. The substitutability between bank deposits and direct or indirect investment in the financial markets is certainly stronger. The access to money market funds, for instance, is easier and does not result in entry costs. In addition, other non-bank devices also drain savings (life insurance, for instance). Lastly, our results could support the efficient structure hypothesis: lower competition could result in a decrease in managerial costs due to increasing efficiency (Gropp and Corvoisier, 2002). The banks should use their cost-effectiveness to offer higher deposit rates. Gropp and Corvoisier (2002), and more recently van Leuvensteijn *et al.* (2013), find these same contradictory results.

[8] The access to financial markets is greater for loans beyond 1 million € because: (1) these firms will have on average a larger size, and therefore, fewer informational asymmetries, and (2) the entry costs (which are fixed costs) in financial markets are spread over a larger basis.

Finally, most importantly for our purpose, is that significant interactions exist between interbank rates and competition. Thus, on table 3a we note that competition indirectly affects banks' interest rates through the monetary transmission. In every case and at a very high significance level, stronger competition implies the long-run impact of the interbank rate on banks' interest rates is more important. Competition will reinforce the effectiveness of monetary policy transmission. By comparing the different coefficients, we observe that competition seems to improve more the effectiveness of the monetary policy for households. The main reasons are that the pass-through is initially weaker for this category of agents, and they have more difficulty using competition to their advantage because they are more "bank-dependent". In addition, their demand could be less elastic. Consequently, the banks' market power over consumers should be higher than it is over firms.

Our period of study includes the recent financial turmoil, which has undoubtedly affected the bank rates and the transmission process because banks faced solvency and liquidity problems, client creditworthiness downgrades occurred with the onset of the recession, and furthermore, the ECB implemented unconventional monetary policies. Our crisis variable dummy, which is first used for October 2008, is positive and highly significant. As expected, the difficulties encountered by banks led them to increase lending rates. However, the positive sign for the deposit rates is surprising; we explain this finding by the need of banks to have stable funding due to the crisis[9], but it is also due to the implementation of Basel III.

Beyond this overall result, it is interesting to compare the size of the pass-through between the bank rates. As prior studies have shown, the pass-through of firm loans and large loans (beyond one million euros) are both more important than consumer loans and loans to firms that are smaller than one million euros (see, e.g., Kok Sørensen and Werner, 2006).

[9] Berlin and Mester (1999) argue that deposits are a cheap and stable funding base.

5.2.2. The effect of bank competition on the short-run adjustment

In this subsection, we analyze the implication of competition on bank rates' short-run adjustment. Tables 4 and 5 report the results, and in these tables, we distinguish two types of results: pooled and specific to each country, on which we comment successively. First, the very significant negative sign for the error-correction term for all bank rates supports the use of an ECM model. This sign indicates an adjustment towards the equilibrium relationship after a shock occurs, which is given by our long-run equation. In addition, we find that in most cases, the bank rates react very significantly in the short-term to the market rate. Therefore, there is an immediate response to market rates' evolutions.

The estimated coefficients of market rates allow us to proxy the short-term transmission mechanism. More important the coefficient is, more the market rate will immediately affect the bank rate offered to customers. Consequently, the interaction term between the Lerner index and the money market rate would indicate the additional effect of competition evolution on the short-term transmission process. Our assumption is that whenever the level of competition is increasing, the short-term monetary transmission should also increase. Our results confirm this idea, as we observe that the interaction term is statistically very significant and negative. The increase of collusive behaviors reduces the immediate monetary policy transmission. Thus, increasing competition allows bank rates to adjust to a greater extent and more quickly to monetary policy shocks. We consider that the reaction will be faster because a greater part of the adjustment will be realized immediately.

Note that unlike van Leuvensteijn *et al.* (2013), we have not considered the competition level but the dynamic of competition to interact with the first difference of the market rate in the short-term equation[10]. In our view, the level of competition essentially affects our long-term equation. In the short-term, the crucial factor would be the change of competition, which can be explained at a microeconomic level. For

[10] Our ECM framework implies that all long-term variables are first differentiated in the short-term equation.

a bank, rate changes will be more important in the short-term if the pressure on its market share increases, that is, if the environment becomes more competitive. Nevertheless, as a robustness requirement, we have checked our conclusion for the competition level in place of its first difference, and we do not find any major discrepancy[11].

[11] These results are available upon request.

Table 4. Banking competition and short-term interest rate pass-through for households

		Consumer loans				Real estate loans				Household deposits			
		Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.
Pool short-term ECM	ECT	-0.135***	0.03	-0.218***	0.076	-0.122***	0.03	-0.118***	0.031	-0.149***	0.034	-0.2***	0.06
	Eonia	0.141	0.089	0.463	0.392	0.257***	0.059	0.702***	0.17	0.525***	0.051	1.26***	0.194
	Lerner*Eonia			-2.309	2.011			-2.51***	0.795			-4.326***	1.115
Austria	ECT	-0.202***	0.045	-0.239***	0.05	-0.145***	0.023	-0.193***	0.037	-0.393***	0.056	-0.201***	0.043
	Eonia	0.182**	0.078	1.103**	0.444	0.09	0.083	1.024*	0.584	0.348***	0.08	1.79***	0.47
	Lerner*Eonia			-5.029**	2.405			-5.678*	3.148			-6.808***	2.476
Belgium	ECT	-0.148***	0.047	-0.182***	0.057	-0.057***	0.01	-0.056***	0.011	-0.208***	0.075	-0.085**	0.043
	Eonia	0.035	0.167	0.372	0.751	0.245***	0.041	0.465***	0.181	0.734***	0.077	1.036***	0.312
	Lerner*Eonia			-2.629	5.769			-1.822	1.389			-2.427	2.328
Germany	ECT	-0.078**	0.038	-0.105**	0.047	-0.031***	0.01	-0.039***	0.013	-0.306***	0.063	-0.288***	0.067
	Eonia	0.101	0.155	1.037	0.85	0.249***	0.044	0.909***	0.244	0.499***	0.083	0.479	0.39
	Lerner*Eonia			-6.118	5.578			-4.52***	1.629			0.172	2.443
Spain	ECT	-0.124***	0.046	-0.14***	0.052	-0.321***	0.036	-0.235***	0.029	-0.044*	0.023	-0.138***	0.033
	Eonia	0.019	0.298	2.498	1.875	0.048	0.077	0.982***	0.295	0.52***	0.078	1.926***	0.418
	Lerner*Eonia			-12.38	9.556			-4.489***	1.463			-7.874***	2.136
Finland	ECT	-0.067**	0.032	-0.008	0.011	-0.194***	0.054	-0.032*	0.016	-0.148**	0.065	-0.06	0.039
	Eonia	0.613***	0.082	0.709***	0.082	0.624***	0.076	0.783***	0.07	0.79***	0.084	0.865***	0.088
	Lerner*Eonia			-1.605*	0.922			-1.672**	0.724			-1.462	0.929
France	ECT	-0.092***	0.022	-0.27***	0.06	-0.059***	0.006	-0.036***	0.013	-0.156***	0.051	-0.56***	0.081
	Eonia	-0.025	0.084	0.813*	0.489	0.034	0.032	0.131	0.197	0.622***	0.08	1.608***	0.385
	Lerner*Eonia			-5.858*	3.089			-0.577	1.22			-8.002***	2.373
Greece	ECT	-0.039**	0.02	-0.079***	0.027	-0.042***	0.012	-0.045***	0.013	-0.047**	0.023	-0.083***	0.031
	Eonia	-0.192	0.143	-0.183	0.427	0.19***	0.061	-0.16	0.181	0.401***	0.108	0.024	0.287
	Lerner*Eonia			0.089	2.14			1.759**	0.899			1.613	1.438
Ireland	ECT	-0.368***	0.08	-0.868***	0.098	-0.045	0.031	-0.128***	0.047	-0.06*	0.033	-0.013	0.02
	Eonia	0.67**	0.273	-2.024	1.595	0.561***	0.064	1.074**	0.435	0.697***	0.056	1.701***	0.346
	Lerner*Eonia			10.807	7.118			-2.751	1.893			-4.404***	1.556
Italy	ECT	-0.072***	0.028	-0.12**	0.049	-0.207***	0.024	-0.206***	0.023	-0.104***	0.024	-0.579***	0.053
	Eonia	0.047	0.125	-0.841	1.509	0.227***	0.048	0.676	0.45	0.282***	0.077	2.014***	0.588
	Lerner*Eonia			4.319	7.387			-2.42	2.207			-10.388***	2.883
Netherlands	ECT					-0.03***	0.008	-0.02***	0.008	-0.108***	0.031	-0.182***	0.044
	Eonia					0.173***	0.045	0.028	0.298	0.356***	0.099	0.923	0.598
	Lerner*Eonia							1.033	1.894			-4.342	3.786
Portugal	ECT	-0.158***	0.041	-0.17***	0.052	-0.216***	0.048	-0.31***	0.061	-0.07**	0.032	-0.011	0.031
	Eonia	-0.041	0.158	1.142	1.835	0.387***	0.092	1.812**	0.893	0.523***	0.082	1.497*	0.904
	Lerner*Eonia			-4.679	7.548			-6.475*	3.555			-3.669	3.704

Note: Constant terms and the Lerner index are included but not reported. Full results are available upon request. *, **, *** refer to statistical significance at the 10%, 5% and 1% respectively.

Table 5. Banking competition and short-term interest rate pass-through for firms

		Loans to firms < 1 million €				Loans to firms > 1 million €				Firm deposits			
		Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.	Coef.	St.err.
Pool short-term ECM	EC T	-0.204***	0.042	-0.246***	0.049	-0.46***	0.073	-0.529***	0.065	-0.245***	0.068	-0.282***	0.082
	Eonia	0.349***	0.051	1.317***	0.158	0.293***	0.063	1.689***	0.32	0.579***	0.072	1.394***	0.355
	Lerner*Eonia			-5.774***	1.04			-8.286***	2.073			-4.579**	1.935
Austria	EC T	-0.266***	0.049	-0.274***	0.049	-0.696***	0.082	-0.764***	0.078	-0.226***	0.06	-0.347***	0.062
	Eonia	0.325***	0.092	1.907***	0.532	-0.082	0.124	1.933***	0.534	0.558***	0.103	2.77***	0.522
	Lerner*Eonia			-8.916***	2.798			-11.291***	2.856			-12.82***	2.851
Belgium	EC T									-0.111*	0.066	-0.048	0.036
	Eonia									0.874***	0.059	1.337***	0.169
	Lerner*Eonia											-3.406***	1.257
Germany	EC T	-0.188***	0.053	-0.384***	0.064	-0.267***	0.066	-0.648***	0.082	-0.368***	0.085	-0.466***	0.087
	Eonia	0.435***	0.074	1.78***	0.304	0.417***	0.103	2.823***	0.421	0.572***	0.09	0.996***	0.233
	Lerner*Eonia			-10.171***	2.042			-18.087***	2.974			-3.581**	1.42
Spain	EC T	-0.074***	0.023	-0.079***	0.021	-0.228***	0.065	-0.351***	0.069	-0.03	0.024	-0.057**	0.028
	Eonia	0.45***	0.068	1.592***	0.332	0.562***	0.102	2.04***	0.469	0.743***	0.077	1.081**	0.437
	Lerner*Eonia			-6.011***	1.674			-8.255***	2.431			-2.052	2.169
Finland	EC T	-0.354***	0.078	-0.314***	0.078	-0.724***	0.099	-0.747***	0.116	-0.415***	0.101	-0.012	0.017
	Eonia	0.462***	0.101	0.472***	0.11	0.208	0.132	0.216	0.145	0.606***	0.097	0.982***	0.043
	Lerner*Eonia			-1.21	0.858			-0.128	1.107			-0.128	0.422
France	EC T	-0.145***	0.029	-0.244***	0.051	-0.384***	0.083	-0.483***	0.08	-0.339***	0.071	-0.586***	0.078
	Eonia	0.188**	0.082	1.252***	0.43	0.451***	0.13	2.722***	0.599	0.453***	0.113	1.652***	0.398
	Lerner*Eonia			-7.581***	2.738			-14.968***	3.796			-9.512***	2.496
Greece	EC T	-0.047	0.041	-0.054	0.043					-0.012	0.031	-0.028	0.034
	Eonia	0.646***	0.102	0.89***	0.302					0.71***	0.137	0.202	0.382
	Lerner*Eonia			-1.366	1.503							2.455	1.879
Ireland	EC T	-0.371***	0.076	-0.363***	0.069	-0.657***	0.099	-0.514***	0.097	-0.049**	0.025	-0.19***	0.051
	Eonia	0.207	0.14	1.688***	0.648	0.153	0.134	1.143*	0.677	0.724***	0.058	1.165***	0.312
	Lerner*Eonia			-7.167**	2.89			-3.932	3.019			-2.851**	1.397
Italy	EC T	-0.381***	0.05	-0.512***	0.052	-0.434***	0.084	-0.466***	0.084	-0.426***	0.084	-0.617***	0.095
	Eonia	0.153*	0.083	1.773***	0.516	0.283	0.128	2.675**	1.135	0.305**	0.149	3.594***	1.16
	Lerner*Eonia			-8.814***	2.516			-11.85**	5.603			-16.894***	5.854
Netherlands	EC T	-0.051**	0.024	-0.053**	0.025	-0.608***	0.108	-0.639***	0.107	-0.706***	0.087	-0.716***	0.088
	Eonia	0.424***	0.072	1.007**	0.454	0.371***	0.123	1.092*	0.64	0.043	0.124	-0.712	0.475
	Lerner*Eonia			-3.809	2.903			-4.824	4.077			4.603*	2.715
Portugal	EC T	-0.163***	0.039	-0.183***	0.045	-0.139***	0.051	-0.152***	0.054	-0.011	0.063	-0.031	0.071
	Eonia	0.204**	0.104	0.807	1.047	0.279	0.174	0.558	1.899	0.786***	0.165	2.264	1.736
	Lerner*Eonia			-2.696	4.249			-1.244	7.722			-6.18	7.054

Note: Constant terms and the Lerner index are included but not reported. Full results are available upon request. *, **, *** refer to statistical significance at the 10%, 5% and 1% respectively.

To better understand what drive these findings, we present the individual results in the lower blocks of Tables 4 and 5. Our results underline the significant heterogeneity in the short-run adjustment of the different Eurozone banking sectors. One way to synthesize this observation is to compute the number of months required to go to equilibrium from the baseline model without competition measures (equations $(1a)$ and $(1b)$). For that purpose, we follow Hendry (1995) and obtain the speed of adjustment with the expression $(1-\widehat{\rho_i})/\widehat{\gamma_i}$. Table 6 indicates the different speeds of adjustment for the Eurozone by countries and rates. The number of months to reach the equilibrium varies from country to country and from bank rate to bank rate. In particular, we note that the adjustment period towards the equilibrium is longer for household rates than enterprise rates. Furthermore, Greece does not seem to adjust some of its rates in the short-term (i.e., its firm deposits and loans to firms that are smaller than 1 million €).

Table 6. Speed of adjustment (in months)

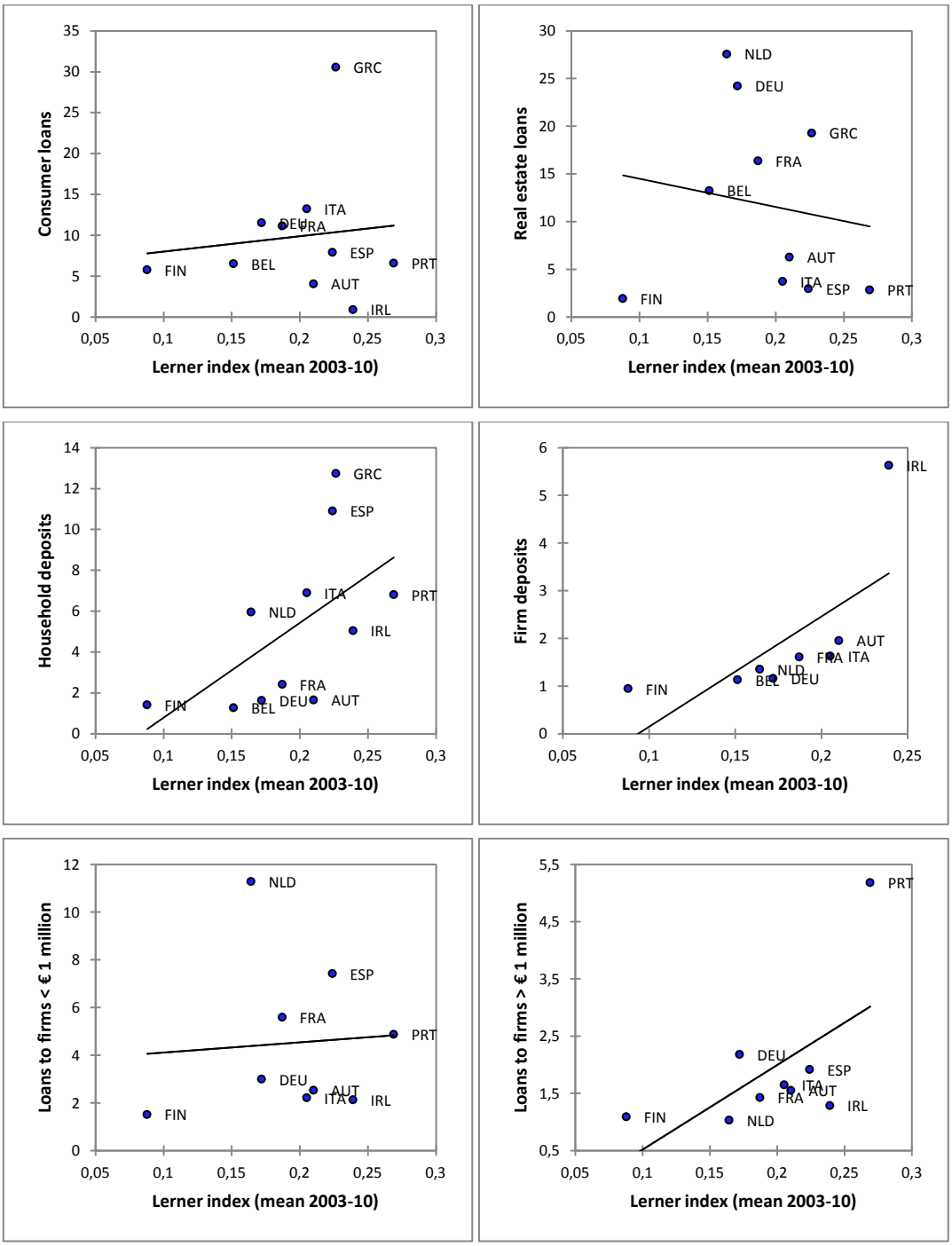
	Consumer loans	Real estate loans	Household deposits	Loans to firms < 1 million €	Loans to firms > 1 million €	Firm deposits
Pool	6.36	6.09	3.19	1.53	1.72	3.19
Austria	4.05	6.28	1.66	2.54	1.55	1.96
Belgium	6.52	13.25	1.28	-	-	1.14
Germany	11.53	24.23	1.64	3.01	2.18	1.16
Spain	7.91	2.97	10.91	7.43	1.92	-
Finland	5.78	1.94	1.42	1.52	1.09	0.95
France	11.14	16.37	2.42	5.60	1.43	1.61
Greece	30.56	19.29	12.74	-	-	-
Ireland	0.90	-	5.05	2.14	1.29	5.63
Italy	13.24	3.73	6.90	2.22	1.65	1.63
Netherlands	-	27.57	5.96	11.29	1.03	1.36
Portugal	6.59	2.84	6.81	4.88	5.19	-

Note: We report only speeds of adjustment for which the coefficient associated with the error correction term is statistically significant.

Here, we restrict our comments exclusively to the effect of competition on the immediate transmission mechanism. We find that a change of competition affects the transmission of money market rates to bank rates for the majority of rates and the majority of countries. The country-specific effects are interesting, as national competition varies across time. As we discussed in section 3, whereas the

competition has increased in some southern European economies (Spain, Portugal and Greece), it has become lower in other euro area economies.

Figure 4. Banking competition and speed of adjustment



Note: Speeds of adjustment are obtained from baseline model without competition index. Countries for which the coefficient associated with the error correction term is not statistically significant are not reported. Concerning Finland, for readability reasons, the Lerner index is computed by dropping the first year of the period study, because the index is equal to -1.61 in 2003.

Finally, in the same vein of Kok Sørensen and Werner (2006), to assess the robustness of our findings we plot in figure 4 the speed of adjustment presented in table 6 with the averages by country of the Lerner index. This analysis reveals a positive relationship for five out of six of the bank rates. Moreover, this cross-section approach confirms our results except for house loans. The more competitive the system is, the faster the speed of adjustment is. Therefore, the immediate adjustment will be more important when the competition is fierce.

5.3. Robustness checks

We check the robustness of our results in two ways[12]. First, we test the sensibility of our results by considering an alternative money market rate: the six-month EURIBOR rate. Indeed, as previously mentioned, bank rates are often priced against the corresponding EURIBOR rates. Consequently, the six-month EURIBOR rate is expected to coincide closely with the bank interest rates in terms of the rate-fixation period. The results do not change significantly when we consider the six-month EURIBOR. This is consistent with the fact that in normal times, the EONIA and EURIBOR rates are highly correlated.

Second, we relax our first hypothesis that the long-run relationship between the money market rate and bank interest rates is unique by using the mean group (MG) estimator proposed by Pesaran and Smith (1995). Compared to the PMG estimator, the MG estimator allows the long-run coefficients to differ across countries, as the model is fitted separately for each country and a simple arithmetic average of the coefficients is calculated. By providing the individual long-run parameters, this approach allows us to study the heterogeneity in the long-term pass-through between euro area countries. Our results are robust to this alternative econometric approach. Particularly, we note that considering heterogeneous long-run dynamics does not change our results on the effect of bank competition on the short-term adjustment. Therefore, the stability of our results supports our initial choice of considering a unique long-run relationship and can be explained by the fact that euro area countries are characterized by the relative homogeneity of their long-run dynamics.

[12] Results are not reported but are available upon request.

6. Controlling for risk factors: does competition still matter?

The empirical findings presented in the previous subsection provide evidence that banking competition matters in the transmission of the ECB's monetary policy both in the short-term and in the long-term. More importantly, our results show that the observed cross-country divergences in bank lending rates and the monetary policy's effectiveness are not only the result of the financial crisis that began in 2008 but also reflect the fact that financial market structures differ across countries. However, some other country-specific factors linked to the crisis may also explain the heterogeneity in the lending behavior. Among these factors, we find in particular the increasing credit risk and the banks' risk aversion (ECB, 2013; Al-Eyd and Pelin Berkmen, 2013). Therefore, in this subsection we extend our baseline empirical framework by including many risk measures in equations 2(a) and 2(b) to capture the crisis's influence. The results, reported in table 7, confirm the important role played by bank competition in driving lending rates.

Controlling for the risk premium.

The first way to control the heterogeneity of EMU countries and the divergent effects of the crisis is to insert government bond rates into our regression as risk-free assets. This insertion is relevant because these bonds explain an important part of the offered rates and must indicate the structural economic health of the different countries. In the pre-crisis context, government bond rates controlled only for temporal fluctuations because the rates in this period were very close across countries. Indeed, there was no substantial difference between the rates of EMU countries. However, since the beginning of the financial crisis, the government bond rates reflect cross-country heterogeneity. For instance, the spread between German and Greek government bond yields only consisted of 5 basis points in January 2003, but it was 910 basis points (9.1%) in December 2010. By introducing this new variable, we specify our previous dummy "crisis" and take into account the different

crisis intensities between the euro area countries. Furthermore, this variable also transcribes the evolution of the banking funding cost (e.g., the cost of bond issuance), which depends on government bond rates. As expected, the results displayed in table 7 underline the positive relation between government bond rates and bank rates in the long-run. Moreover, the more the government rate rises in a country, the more important short-run increases of the bank rates are. Overall, we can see that our results are robust to the inclusion of sovereign bond yields in our empirical model. To this point, we have controlled for temporal and cross-country economic divergences, and we note no change in the effect of bank competition on the monetary transmission. However, some other banking or financial characteristics could directly alter the monetary transmission, such as systemic risk, bank fragility and capital.

Controlling for systemic risk.

While central bankers had supported the dichotomy between monetary policy and financial stability policy, the crisis called this view into question (Mishkin, 2011). Central banks are now aware that systemic risk could alter monetary policy. To measure the systemic risk, we use the Composite Indicator of Systemic Stress (CISS) in the financial system developed by Hollo *et al.* (2012) and made available by the ECB. This Eurozone financial indicator of stress is an aggregation of five market-specific subindices created from fifteen individual financial stress measures. These subindices represent the most important segments of an economy's system: the securities markets, the sector of bank and non-bank financial intermediaries, FX markets and money markets. Thus, the composite indicator uses, for instance, the volatility of money market rates. We insert the systemic risk and the interaction term of the latter and the EONIA into our baseline model, respectively, to capture the direct effect of systemic risk on bank rates and the effect on the pass-through. Our results show that cyclical factors such as systemic risk do not alter the effect of the structural factors such as competition on monetary transmission. Furthermore, we note that these cyclical factors also act on monetary transmission. As shown by Hristov *et al.* (2012), systemic shocks and crises worsen the interest rate channel.

However, this effect appears to occur only in the short-term; from a long-term perspective, systemic risk increases the transmission channel. This finding can be explained by the fact that systemic risk constrains central banks to put in place additional measures following a crisis, such as unconventional monetary policies, to increase monetary transmission.

Controlling for bank stability.

Beyond systemic risk, the stability of banking systems could also affect the pass-through. To measure bank stability, we opt for the conventional Z-score[13]. We expect that the bank stability greatly influences the transmission of interest rates. Bank stability is obviously critical to monetary policy. According to Mersch (2013), "a stable financial system with sound and solvent banks supports the smooth transmission of monetary policy". Beside the Federal Reserve has combined monetary and supervisory functions since one century and the European Council agreement in December 2012[14], has assigned to the ECB the banking supervisory task in the context of a banking union for the euro area (Brooks *et al.*, 2013). In table 7, we report the effect of banking stability on the pass-through (*Z-score*Eonia*). We obtain mixed results: while banking stability reinforces the pass-through for household rates as expected, it reduces the pass-through for firms' interest rates. We cannot conclusively state the effect of bank stability on monetary transmission. However, considering the banking stability is important for checking our main results because it measures not only temporal banking unbalances, but also structural cross-country divergences, which could be linked with the market structures. Indeed, many studies have associated competition and stability (see, e.g., Uhde and Heimeshoff, 2009). Here, we observe that our main results remain the same. The positive effect of banking competition on the interest pass-though is direct and is not due to indirect effects through banking fragilities.

[13] The Z-score is obtained from the Global Financial Development Database of the World Bank. It is a commonly used indicator for risk in the banking sector (see, e.g., Boyd *et al.*, 2009; Laeven and Levine, 2009).
[14] The European Parliament approved the European Council agreement on 12 September 2013.

Bank capital's effect on bank rates.

Apart from these results, we now focus on bank capital to measure its effect on bank rates. It has been well known since Kashyap and Stein (2000) that bank capital is a determinant of lending behavior; that is, a well-capitalized bank could continue to lend during a tightening monetary policy. We expect that bank lending rates react less to bank capital in general. Our principal finding is that bank capital significantly affects both the lending and deposit rates. First, low-capital banking systems tend to charge higher loan rates (except for loans to firms beyond 1 million €) than well-capitalized banks, which is consistent with Hubbard et *al.* (2002). Second, well-capitalized banks tend to increase their deposit rates more than low-capitalized banks, which may be to capture additional money for loans. Last, the scale of the interest rate pass-through is influenced by the banking capitalization: the pass-through is more important when the banking system is well capitalized.

Table 7. Competition and interest rate pass-through: control for various risk factors

		Consumer loans	Real estate loans	Household deposits	Loans to firms < 1 million €	Loans to firms > 1 million €	Firm deposits
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Long-term ECM	Eonia	+	+	+	+	+	+
	Lerner*Eonia	-	-	-	-	-	-
	Government bonds	0.11**	0.495***	0.24***	0.207***	0.065***	0.112***
	Systemic risk (SR)	-0.462	-2.324***	-0.52**	-0.416**	-0.293**	-0.182
	SR*Eonia	0.058	0.559***	0.142**	0.135**	0.152***	0.121***
	Z-score	-0.012	-0.028***	-0.009***	-0.004	0.007***	0.012***
	Z-score*Eonia	0.008***	0.007***	0.007***	-0.005***	-0.004***	-0.006***
	Capital	-5.118	-12.849***	17.393***	-9.271***	4.093***	7.683***
	Capital*Eonia	4.153**	4.005***	-10.992***	0.288	-2.34***	0.766
Pool short-term ECM	ECT	-	-	-	-	-	-
	Eonia	+	+	+	+	+	+
	Lerner*Eonia	-	-	-	-	-	-
	Government bonds	-0.079	-0.014	0.051***	0.031	0.102***	0.075***
	Systemic risk (SR)	0.404***	0.139**	0.029	-0.058	-0.243**	-0.258**
	SR*Eonia	-0.037**	-0.047**	-0.023*	0.007	0.019	0.021
	Z-score	0.367	-0.032	0.006	0.03	0.092	-0.022
	Z-score*Eonia	-0.074	-0.008	-0.039***	-0.014	-0.035	-0.025
	Capital	-0.708	6.069**	6.347	1.113	7.857	4.358
	Capital*Eonia	1.746	-2.143*	-3.308	-1.401	-3.108	-4.478

Note: Full results are available upon request. *, **, *** refer to statistical significance at the 10%, 5% and 1% respectively. This table presents the estimated coefficients for 24 regressions. The upper panel shows long-term results whereas the lower panel shows short-run results. The dependent variable name is on top of each column. We use 4 different groups of control variables: (1) Government bonds, (2) SR and SR*Eonia, (3) Z-score and Z-score*Eonia, (4) Capital and Capital*Eonia that we add one by one to common variable group in the grey bloc (ECT, Eonia and Lerner*Eonia).

7. Conclusion and policy implications

This paper provides new empirical evidence on the effects of bank competition on the monetary policy pass-through for eleven euro area countries by taking into account the recent financial. This event, which was characterized by sovereign debt tensions, fragile economic activity, weak capital positions and high levels of uncertainty, has exacerbated the financial fragmentation of the European Monetary Union and increased the levels of heterogeneity in bank lending rates. Furthermore, as recognized by the ECB (2013), a number of structural factors may also explain the observed heterogeneity of bank lending rates within the Eurozone. Among these factors, we must highlight banking competition, whose levels appear relatively disparate among euro area countries despite policy initiatives to foster financial integration.

Against this background, the purpose of the present study was to analyze whether competition in the banking industry has remained a powerful driver of retail banks' price-setting behavior in a context of financial heterogeneity. For this purpose, we extended the standard pass-through models in two ways: first, we considered a model that includes an index of bank competition, namely, the Lerner index, and a dummy variable capturing the breakdown in pass-through implied by the crisis. Second, following the preliminary results of the ECB (2013), we extended our baseline model by controlling for a number of country-specific factors that may have explained the divergences between euro area countries in their interest-rate-setting behavior during the financial and sovereign debt crisis. To the best of our knowledge, our paper constitutes the first empirical study that investigates the role played by competition in the ECB's monetary transmission in times of crisis.

We considered six bank interest rates for a sample of eleven euro area countries, and our empirical findings, which are based on an ECM framework, tend to confirm the important role played by bank competition in explaining the pass-through from money market rates to bank interest rates. Three main conclusions emerge from our analysis: first, our results indicate that competition acts directly on the level of bank

retail rates, as bank interest rate spreads are lower in more competitive markets. Second, from a monetary policy viewpoint, empirical evidence suggests that stronger bank competition reinforces the long-term interest pass-through. In other words, competition improves a monetary policy's effectiveness. Finally, we found that strengthening competition increases the immediate response of bank interest rates to changes in money market rates even if the results indicate heterogeneity between euro area countries. Consequently, heterogeneous market structures and competition evolution in the euro area explain the divergent transmission's intensity and speed.

The empirical investigations conducted in the section 5 confirm the robustness of our results. Beyond robustness checks, we extended our empirical framework by introducing cyclical and other structural factors that may have affected the interest rate pass-though. We found that economic divergences between the EMU economies, which have been amplified by the recent financial crisis, influenced the interest rate pass-through. Then, our results showed that the financial sector's health (the systemic risk, banking stability and bank capitalization) has also played a significant role in determining the interest pass-through. However, competition's effects on this pass-through are not affected by these new factors.

Our results are particularly relevant for economic policy for at least two reasons. First, because the level of bank competition affects the interest rate pass-through, and therefore, the monetary policy transmission, monetary policy authorities have incentives to foster competition in the Eurozone. To date, the ECB cannot directly influence competition in the Eurozone. However, in the coming months the ECB will gain supervisory powers over individual banks in the context of a banking union. These supervisory powers could allow it to influence bank competition, which is why it is important that there are no trade-offs between bank competition and monetary policy transmission. In this context, we note no contradictory objectives. Second, our results underline the necessity of market structures' convergence in the Eurozone to insure homogeneous monetary transmission between the different EMU countries. Reinforcing financial integration within euro area countries is able to harmonize the level of bank competition in the Eurozone.

References

Al-Eyd, A. J., and Pelin Berkmen, S. (2013). Fragmentation and Monetary Policy in the Euro Area. IMF Working Paper 13/208. , International Monetary Fund.

Beck, T., De Jonghe, O. and Schepens, G. (2013). Bank competition and stability: cross-country heterogeneity. *Journal of Financial Intermediation* 22(2), 218-244.

Belke, A., Beckmann, J. and Verheyen, F. (2013). Interest rate pass-through in the EMU – New evidence from nonlinear cointegration techniques for fully harmonized data. *Journal of International Money and Finance* 37, 1-24.

Berger, A.N. (1995). The profit-structure relationship in banking – tests of market-power and efficient-structures hypotheses. *Journal of Money, Credit and Banking* 27(2), 404-431.

Berger, A.N., Klapper, L.F., Turk Arris, R. (2009). Bank competition and financial stability. *Journal of Financial Services Research* 35(2), 99-118.

Berlin, M. and Mester, L.J. (1999). Deposits and relationship lending. *Review of Financial Studies* 12(3), 579-607.

Blot, C. and Labondance, F. (2013). Business lending rate pass-through in the Eurozone: monetary policy transmission before and after the financial crash. *Economics Bulletin* 33(2), 973-985.

Boone, J. (2008). A new way to measure competition. *Economic Journal* 118(531), 1245-1261.

Borio, C. and Fritz, W. (1995). The response of short-term bank lending rates to policy rates: a cross-country perspective. BIS Working Papers No. 27, Bank for International Settlements.

Boyd, J. H., De Nicolò, G., and Jalal, A. M. (2009). Bank competition, risk and asset allocations. IMF Working Papers 09/143, International Monetary Fund.

Brooks, P. K., Pradhan, M., Tressel, T., Dell'Ariccia, G., and Pazarbasioglu, C. (2013). *A Banking Union for the Euro Area*. International Monetary Fund, European Department, in collaboration with the Legal, Monetary and Capital Markets, and Research Departments.

Carbó, S., Humphrey, D., Maudos, J. and Molyneux, P. (2009). Cross-country comparisons of competition and pricing power in European banking. *Journal of International Money and Finance* 28(1), 115-134.

Cecchetti, S.G. (1999). Legal structure, financial structure, and the monetary policy transmission process. NBER Working Papers 7151, National Bureau of Economic Research, Cambridge.

Ciccarelli, M., Maddaloni, A. and Peydró, J-L. (2013). Heterogeneous transmission mechanism: monetary policy and financial fragility in the eurozone. *Economic Policy* 28(75), 459-512.

Cottarelli, C. and Kourelis, A. (1994). Financial structure, bank lending rates and the transmission of monetary policy. *IMF Staff Papers* 41(4), 587-623.

Corvoisier, S. and Gropp, R. (2002). Bank concentration and retail interest rates. *Journal of Banking & Finance* 26(11), 2155-2189.

De Bondt, G.J. (2005). Interest rate pass-through: empirical results for the euro area. *German Economic Review* 6(1), 37-78.

Delis, M.D. (2012). Bank competition, financial reform, and institutions: the importance of being developed. *Journal of Development Economics* 97(2), 450-465.

ECB (2013). Assessing the retail bank interest rate pass-through in the euro area at times of financial fragmentation. ECC Monthly Bulletin, August 2013, European Central Bank, pp. 75-91.

ECB. (2012). Heterogeneity in euro area financial conditions and policy implications. ECB Monthly Bulletin, August 2012. European Central Bank, pp. 63-75.

Evanoff, D. and Fortier, D. (1988). Re-evaluation of the structure-conduct-performance paradigm in banking. *Journal of Financial Services Research* 1(3), 2777-294.

Fernández de Guevara, J., Maudos, J. and Pérez, F. (2007). Integration and competition in the European financial markets. *Journal of International Money and Finance* 26(1), 26-45.

Fernández de Guevara, J., Maudos, J. and Pérez, F. (2005). Market power in European banking sectors. *Journal of Financial Services Research* 27(2), 109-137.

Freixas, X. and Rochet, J.C. (2008). *Microeconomics of Banking*, 2nd edition. MIT Press.

Gropp, R., Kok Sørensen, C. and Lichtenberger, J. (2007). The dynamics of bank spreads and financial structure. ECB Working Paper Series 714, European Central Bank.

Güntner, J.H.F. (2011). Competition among banks and the pass-through of monetary policy. *Economic Modelling* 28(4), 1891-1901.

Hadri, K. (2000). Testing for stationary in heterogeneous panel data. *Econometrics Journal* 3(2), 148-161.

Hannan, T.H. and Berger, A.N. (1991). The rigidity of prices: evidence from the banking industry. *American Economic Review* 81(4), 938-945.

Hendry, D.F. (1995). Dynamic Econometrics. Oxford University Press, Oxford.

Ho, T.S. and Saunders, A. (1981). The determinants of bank interest margins: theory and empirical evidence. *The Journal of Financial and Quantitative Analysis* 16(4), 581-600.

Hollo, D., Kremer, M. and Lo Duca, M. (2012). CISS – a composite indicator of systemic stress in the financial system. ECB Working Paper Series 1426, European Central Bank.

Hristov, N., Hülsewig, O. and Wollmershäuser, T. (2012). The interest rate pass-through in the Euro Area during the global financial crisis. CESifo Working Paper Series No. 3964, Center for Economic Studies & Ifo Institute for Economic Research.

Hubbard, R.G., Kuttner, K.N. and Palia, D.N. (2002). Are there bank effects in borrowers' costs of funds? Evidence from a matched sample of borrowers and banks. *Journal of Business* 75(4), 559-581.

Im, K.S., Pesaran, M.H. and Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115(1), 53-74.

Kashyap, A. K., and Stein, J. C. (2000). What do a million observations on banks say about the transmission of monetary policy?. *American Economic Review* 90(3), 407-428.

Klein, M.A. (1971). A theory of the banking firm. *Journal of Money, Credit and Banking* 3(2), 205-218.

Kok Sørensen, C. and Werner, T. (2006). Bank interest rate pass-through in the euro area: a cross country comparison. ECB Working Paper Series 580, European Central Bank.

Laeven, L. and Levine, R. (2009). Bank governance, regulation and risk taking. *Journal of Financial Economics* 93(2), 259-275.

Lerner, A.P. (1934). The concept of monopoly and the measurement of monopoly power. *The Review of Economic Studies* 1(3), 157-175.

Maudos, J. and Fernández de Guevara, J. (2004). Factors explaining the interest margin in the banking sectors of the European Union. *Journal of Banking & Finance* 28(9), 2259-2281.

Mersch, Y. (2013). *The future of global policy coordination*. Keynote Speech at the 6th Policy Roundtable of the European Central Bank.

Mishkin, F. S. (2011). Monetary policy strategy: lessons from the crisis. NBER Working Papers 16755, National Bureau of Economic Research, Cambridge.

Mojon, B. (2001). Financial structure and the interest rate channel of ECB monetary policy. *Economie et Prévision* 147(1), 89-115.

Monti, M. (1972). Deposit, credit, and interest rate determination under alternative bank objectives, in: Szego, G.P. and Shell, K. (Eds.), Mathematical Methods in Investment and Finance, North-Holland Publishing Co, Amsterdam, pp. 430-454.

Northcott, C.A. (2004). Competition in banking: a review of the literature. Bank of Canada Working Paper 2004-24, Bank of Canada.

Panzar, J. and Rosse, J. (1987). Testing for "monopoly" equilibrium. *The Journal of Industrial Economics* 35(4), 443-456.

Pesaran, M.H., Shin, Y. and Smith, R.P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association* 94(446), 621-634.

Pesaran, M.H. and Smith, R.P. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics* 68(1), 79-113.

Sander, H. and Kleimeier, S. (2004). Convergence in euro-zone retail banking? What interest rate pass-through tells us about monetary policy transmission, competition and integration. *Journal of International Money and Finance* 23(3), 461-492.

Schiersch, A. and Schmidt-Ehmcke, J. (2011). Is the Boone-indicator applicable? Evidence from a combined data set of German manufacturing enterprises. *Journal of Economics and Statistics* 231(3), 336-357.

Smirlock, M. (1985). Evidence on the (non) relationship between concentration and profitability in banking. *Journal of Money, Credit and Banking* 17(1), 69-83.

Uhde, A. and Heimeshoff, U. (2009). Consolidation in banking and financial stability in Europe : empirical evidence. *Journal of Banking & Finance* 33(7), 1299-1311.

van Leuvensteijn, M. (2008). The Boone-indicator: identifying different regimes of competition for the American Sugar Refining Company 1890-1914. Discussion Paper Series 08-37, Utrecht School of Economics, Tjalling C. Koopmans Institute.

van Leuvensteijn, M., Kok Sørensen, C., Bikker, J.A. and van Rixtel, A. (2013). Impact of banking competition on the interest pass-through in the euro area. *Applied Economics* 45(11), 1359-1380.

van Leuvensteijn, M., Kok Sørensen, C., Bikker, J.A. and van Rixtel, A. (2011). Anew approach to measuring competition in the loan markets of the euro area. *Applied Economics* 43(23), 3155-3167.

Weill, L. (2013). Bank competition in the EU: how has it evolved? *Journal of International Financial Markets, Institutions and Money* 26, 100-112.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics* 69(6), 709-748.

www.nbp.pl