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Aurélien Leroy – Laboratoire d'Economie d'Orléans (LEO), UMR CNRS 7322, Rue de Blois, BP 26739, 45062 Orléans Cedex 2, France. Corresponding author: aurelien.leroy@univ-orleans.fr
Yannick Lucotte – PSB Paris School of Business, Department of Economics, 59 rue Nationale, 75013 Paris, France; ylucotte@gmail.com

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Abstract

This paper empirically investigates the evolution and the sources of interest rate pass-through heterogeneity in the Eurozone for a sample of 11 euro area countries over the period 2003M1-2011M12. Considering two harmonized bank retail rates, we first estimate single equation error correction models (ECM) and find an important pass-through heterogeneity, both for household and firm rates, even if results suggest that heterogeneity is not a new phenomenon. On the basis of this result, we then extend our analysis by studying the role played by a large number of structural and cyclical factors on monetary policy transmission. Findings based on a panel ECM approach and a panel interaction VAR framework indicate that financial tensions and fragile economic activity following the crisis are not the only factors that explain the heterogeneous monetary transmission in the euro. The differences of financial market structures across countries, in terms of banking competition and financial market development, also explain a part of this heterogeneity. In terms of policy implications, this means that future reforms promoting a more efficient and homogeneous monetary policy transmission should not only focus on risk factors, but also try to consolidate financial integration.

Keywords: Interest rate pass-through; Monetary policy transmission; Eurozone; Error correction model; Interacted panel VAR

JEL Codes: C23; D40; E43; E44; E58

1 Introduction

The repricing of risks that began with the recent crisis has caused a strong reversal of the financial integration process within the euro area. Indeed, despite the use of unconventional monetary policies by the European Central Bank (ECB), financial conditions in the Eurozone remain heterogeneous, with a still sizeable gap between peripheral and core countries.[1] This financial fragmentation naturally raises the question of the effectiveness of monetary policy transmission in the Eurozone, especially in the periphery, where bank retail rates have increased relative to the core and the ECB's policy rates. According to the ECB (2012), these marked and persistent differences in bank interest rates today constitute the major challenge that faces the common monetary policy, and even more since the financial sector is the primary channel through which monetary policy impulses affect economy and ultimately prices. One could argue that this financial fragmentation phase is undoubtedly temporary, and will be reversed when peripheral economies will return to the path of growth and their sovereign risk decrease. Of course, the financial and sovereign debt crises exacerbated the macroeconomic and financial imbalances in the euro area and contributed to increase financial conditions heterogeneity, with the consequences that we know on the monetary policy transmission process.

However, if we refer to the literature on bank interest rate pass-through, we can observe that the question of the heterogeneity of pass-through among euro area countries is not new. Since the introduction of the single currency in 1999, this issue is at the heart of the debate amongst academics and policy-makers. The majority of empirical studies devoted to this question conclude that the interest rate pass-through in the euro area is sluggish in the short-term but also incomplete in the long-term (Mojon, 2000; Toolsema et al., 2002; Donnay and Degryse, 2001; Sander and Kleimeier, 2004; Kleimeier and Sander, 2006; De Bondt, 2005; De Bondt et al., 2005; Banerjee et al., 2010; Van Leuvensteijn et al., 2013; Bernhofer and van Treeck, 2013). In addition, they show strong evidence of substantial heterogeneity both across euro area countries and interest rate categories. These results suggest therefore a failure of common market policies supporting financial integration and deregulation to increase the efficiency and homogeneity of interest rate transmission. More importantly, they highlight the fact that the recent crisis certainly tells part of the story and the necessity to investigate the role played by structural factors in the ECB's monetary transmission.

We find several arguments in the literature that can explained the sluggish and imperfect monetary transmission process, such as for example the rigidity of bank costs (Enfrun and Cordier, 1994), the consumer aversion to pay variable interest rates (Borio and Fritz, 1995), the competition from direct finance (Mojon, 2000), or the lack

[1] Peripheral countries refer here to Greece, Ireland, Italy, Portugal, and Spain, while core is defined as Germany, France, Belgium, and the Netherlands.

of competition in the banking sector (Borio and Fritz, 1995). However, the empirical literature on determinants of bank interest rate pass-through is relatively scarce and has mainly focused on the role played by banking competition in the transmission of monetary policy (see, e.g., Sørensen and Werner, 2006; Van Leuvensteijn et al., 2013; Leroy and Lucotte, 2014).

To the best of our knowledge, only two papers (Gigineishvili, 2011; Saborowski and Weber, 2013) have tried to empirically investigate this issue, by considering a large number of factors potentially explaining the heterogeneity in the degree of pass-through from market rates to bank interest rates. Nevertheless, by considering a large and heterogeneous sample of industrialized and emerging economies, these studies do not give a clear picture of factors driving the retail banks' price-setting behavior and market responses to monetary policy impulses in developed countries, especially in the euro area.

Knowing the drivers of monetary transmission and the reasons behind the cross-country heterogeneity in the interest rate pass-through has valuable policy implications for strengthening monetary policy efficiency. In particular, as argued by Gigineishvili (2011), this knowledge could provide important directions for the choice of a monetary policy framework, including intermediate targets and policy instruments. Nonetheless, despite the relevance of the studies of Gigineishvili (2011) and Saborowski and Weber (2013), we believe that this question of monetary policy transmission and pass-through heterogeneity is even more important in the case of a single currency area. Indeed, contrary to countries with monetary sovereignty, one can hardly imagine a common central bank conducting a more aggressive monetary policy (in terms of policy rates) to compensate an incomplete and sluggish interest rate pass-through in some countries of the monetary union, since such a policy will induce high economic costs in other member countries.

Therefore, identifying the factors that constitute an obstacle to the pass-through will help promoting a more homogeneous transmission of monetary policy across the monetary union, and reducing the trade-off faced by the central bank. In the case of the European Monetary Union, several measures and reforms have been introduced to increase financial integration (such as the Financial Services Action Plan for example), and alleviate financial tensions following the economic and debt crisis. But, as shown by Bernhofer and van Treeck (2013) and as the ECB (2013) itself recognized, these measures did not have the expected effect, with bank lending conditions that remained heterogeneous, and policy interest rates that passed through with difficulty to bank rates in several member countries.

Against this background, our paper tries to fill this gap in the literature by investigating the role of several cyclical and structural variables in determining the strength of bank interest rate pass-through in the euro area. As stated above, our first objective in this paper is to identify the factors that could explain the cross-country heterogene-

ity in the ECB's monetary transmission. For this purpose, our empirical analysis, that covers the period from January 2003 to December 2011, proceeds in two steps. The first step consists of assessing the degree of heterogeneity in the ECB's monetary policy transmission mechanism, and of analyzing whether and to what extent this heterogeneity has changed since the financial crisis.

Thus, by considering two harmonized bank interest rates to households and firms, we estimate single-equation error correction models (ECM) for eleven euro area countries over two sub-periods: the "pre-crisis" and the "crisis" periods. Results that we obtain are in line with findings of recent papers that investigated the impact of the crisis on monetary transmission for the Eurozone (see, e.g., Aristei and Gallo, 2014; Al-Eyd and Berkmen, 2013; Blot and Labondance, 2013; Karagiannis et al., 2010). Indeed, we find that the pass-through of monetary policy to rates on bank loans to households and non-financial firms has been impaired in the aftermath of the Great Recession. More important, our results reveal a substantial heterogeneity in the interest rate pass-through across euro area countries over the two sub-periods, both for household and firm lending rates. This last result confirms therefore the fact that the recent crisis, and more largely the economic and financial climate, is not the only factor that can explain heterogeneity in the ECB's monetary policy transmission. A number of structural factors also probably explain this heterogeneity in the pass-through from money market rate to bank retail rates.

Consequently, in a second step, we examine this issue by considering a large number of potential cyclical and structural determinants of interest rate pass-through. More precisely, we group the cyclical and structural variables considered in four categories: (i) macroeconomic environment (industrial production, inflation rate); (ii) macro-financial environment (stock price index, money market rate volatility, spread between swaps 6-month Euribor and 10-year government bond rates, country risk-premium); (iii) financial structure (Lerner index, Herfindahl-Hirschman index, market capitalization); (iv) bank risks (non-performing loans ratio, distance to default). Then, we reparameterize our baseline ECM into a panel framework and interact each potential determinant considered with the money market rate. This model is estimated using the pooled mean group estimator (PMGE) developed by Pesaran et al. (1999). Except for Herfindahl-Hirschman index in the case of households, distance to default in the case of firms, and money market rate volatility for both households and firms, our results indicate a significant effect of each variable considered individually on the interest rate pass-through in the Eurozone. For instance, we find that the lack of banking competition, and not well developed financial markets impair the monetary policy transmission mechanism and are an important source of pass-through heterogeneity across euro area countries. Above all, these findings support the fact that the recent financial crisis and the resulting context of financial fragmentation only tell part of the story. Structural factors and financial market structures also seem to be at play.

Finally, we make the choice to extend our previous empirical analysis by considering a multivariate VAR approach. Beyond testing the robustness of our results, two main reasons have motivated this choice. First, contrary to a univariate approach, such a framework allows for endogeneity of money market rate. Indeed, as argued by Rocha (2012), even if the interbank rate is closely controlled by the monetary authority, one would also imagine that it is endogenous to bank lending rates since the central bank is expected to respond to the market, and therefore possibly reacting to banks' actions[2]. Second, by considering a trivariate VAR framework including bank rate, money market rate, but also the industrial production, we control for asymmetric shocks and to some extent for differences in risk premium across euro area countries. Therefore, such an approach allows us to provide a more accurate representation of the euro area economy, in particular in time of financial crisis. To assess to what extent the structural and cyclical factors that we consider in our study affect the response of bank lending rates to a monetary policy shock, we rely on the panel VAR interaction framework recently developed by Towbin and Weber (2013). As stressed by Saborowski and Weber (2013), such a framework can be viewed as a generalized panel VAR regression in which two-way interactions between policy rate and bank interest rate can vary deterministically with country characteristics. Results that we obtain corroborate previous findings.

The remainder of the paper is structured as follows. Section 2 is devoted to the analysis of interest rate pass-through heterogeneity in the Eurozone. Section 3 describes data and methodology used to identify the structural and cyclical drivers of ECB's monetary policy transmission. Section 4 discusses in detail our empirical findings, while section 5 concludes and gives possible recommendations to policy makers.

[2]This point is also mentioned by Saborowski and Weber (2013), that find feedback from the policy rate to movements in the retail lending rate.

2 Assessing heterogeneity in Eurozone pass-through

2.1 Methodology

Our preliminary analysis consists in assessing heterogeneity in interest rate pass-through in the Eurozone. In this respect, we consider a single equation error correction model (ECM), that we derive from an ARDL model. The time-series model that we estimate for each of the euro area countries considered is specified as follows:

$$\Delta br_t = \phi(br_{t-1} - \beta mr_{t-1}) + \sum_{j=1}^{p-1} \lambda_j \Delta br_{t-j} + \sum_{j=0}^{q-1} \delta_j \Delta mr_{t-j} + \mu + \varepsilon_t \qquad (1)$$

where the portion in parentheses is the error correction mechanism, with br_t the selected bank lending rate and mr_{t-j} the money market rate. In this study, we make the choice to consider two harmonized bank lending rates, labeled by the ECB: "Total cost of borrowing to households for house purchase" and "Total cost of borrowing to non-financial corporations", that we respectively synthesize into the motions "household rates" and "firm rates". Furthermore, we employ 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. Due to the availability of harmonized bank rates and potential determinants of pass-through (see section 3.1), our study covers the period from January 2003 to December 2011 (i.e., there are 108 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.

From (1), we follow Pesaran et al. (2001) and apply a bounds test to ensure that money market and bank rates are well characterized by a long-run relationship.[3] If they are, the long run pass-through between mr_t and br_t is given by: β.[4] Furthermore $\sum_{j=0}^{q-1} \delta_j$ and ϕ denote respectively, the short-run pass-through and the error correction term, that is the speed of adjustment to the long-run equilibrium.[5]

We estimate equation (1) for the 11 countries of our sample and for two sub-periods. The first sub-period covers 2003:1-2008:9 and corresponds to the boom period, stopped by the collapse of Lehman Brothers. The second sub-period spreads over 2007:8 and

[3] In contrast to traditional cointegration test, ARDL approach, as well as in time-series and panel data framework, allows testing cointegration with variables of mixed order of integration. However in our case mr_t and br_t are both I(1).

[4] The ARDL can also be written in the following form: $\Delta br_t = \phi br_{t-1} + \theta mr_{t-1} + \sum_{j=1}^{p-1} \lambda_j \Delta br_{t-j} + \sum_{j=0}^{q-1} \delta_j \Delta mr_{t-j} + \mu + \varepsilon_t$, with $-(\theta/\phi) = \beta$ the size of the long-run pass-through.

[5] The choice of lag structure is based on Akaike's Information Criterion (AIC).

2011:12 and includes all the crisis period. Thus, our approach allows observing whether bank interest rate pass-through is heterogeneous over time and across countries.

2.2 Heterogeneity

Tables 1 and 2 show the estimation results from equation (1) for household and firm lending rates, respectively. The F-test columns report the statistics for the bound tests. In the majority of cases the latter indicates, according to the critical values, given by Pesaran et al. (2001), that we can reject the null hypothesis of absence of cointegration between mr_t and br_t. These results justify the relevance of an error correction model and allow to interpret the long-run pass-through coefficient $\hat{\beta}$. We report these estimated coefficients in the two tables.[6]

Table 1: Household rate pass-through in Eurozone

	2003:1-2008:9		2007:8-2011:12	
	Pass-through	**F-stat**	**Pass-through**	**F-stat**
AT	0.922	5.823	0.817	9.715
BE	0.690	3.572	0.424	2.426
GE	0.426	4.323	0.377	1.468
ES	1.111	2.418	0.790	4.551
FIN	0.960	5.166	0.806	11.633
FR	0.9418	3.731	0.407	5.764
GR	0.251	3.718	0.252	5.069
IE	0.908	3.837	0.584	4.233
IT	0.922	5.823	0.647	2.11
NL	0.656	3.102	0.269	1.883
PT	0.996	6.852	0.201	0.027
Mean	0.799		0.507	
St.dev	0.263		0.232	
Min	0.25		0.201	
Max	1.111		0.817	

Note: F-stat is the statistic of the bound-test proposed by Pesaran et al. (2001). The "I(1) bound" (upper-bound) critical values tabuled by Pesaran et al. (2001; pp.303-304) are 3.51, 4.16 and 6.44 for, respectively, the 10%, 5%, and 1% significance levels for k = 1,where k is the number of regressors. Pass-trough corresponds to the long term coefficient of Eonia, that is β. All β are statistically significant at least at the 10% level.

Three main comments can be drawn from these estimations. Firstly, it appears that the Eurozone is well characterized by different pass-through across the countries irrespective of the period or the rate considered. Cross-sectional standard deviations are indeed equal to 0.127 for firm bank rate and approximately 0.25 for household rate during the boom period. An illustration of this heterogeneity is Spain. Table 1 indicates that on average a one percent change of Eonia has led to a change of household bank rate of 1.111 per cent compared to 0.799 per cent for the entire Eurozone. Thus, common monetary shocks imply different magnitudes of effective interest rate channel.

[6] In this study, we only focus on long-run estimations. Consequently we have not reported the other coefficient estimates of the ARDL, but we have checked that they have the right signs and the error correction terms are well significant. Complete estimations are available upon request.

Secondly, our estimations underline temporal heterogeneity. As shown for instance by Blot and Labondance (2013), the time of economic downturn has lead to a severe decrease of monetary policy effectiveness. The average transmission of rate is passed to 0.799 by point of change of Eonia to 0.507 between the boom and the crisis period for household rates. Comparable results are also observed for firm rates. However, it is important to note that heterogeneity is not a crisis phenomenon (consequence). Standard deviations reveal that pass-through were also very disparate before the crisis. Nevertheless, the countries contributing to the heterogeneity are not necessary the same. For instance, Portugal pass-through was superior to the mean before the crisis, whereas since the cointegration relationship has been broken.

Table 2: Firm rate pass-through in Eurozone

	2003:1-2008:9		2007:8-2011:12	
	Pass-through	**F-stat**	**Pass-through**	**F-stat**
AT	0.905	7.58	0.837	11.863
BE	1.035	3.736	0.873	3.647
GE	0.849	5.119	0.699	8.993
ES	1.221	3.972	0.627	1.179
FIN	1.003	6.224	0.848	6.778
FR	1.071	5.8	0.769	4.275
GR	0.765	2.372	1.042	2.009
IE	1.055	13.741	0.805	3.603
IT	0.905	7.581	0.836	1.02
NL	0.896	7.124	0.756	9.274
PT	1.052	3.737	0.573	0.305
Mean	0.978		0.788	
St.dev	0.127		0.127	
Min	0.765		0.573	
Max	1.221		1.042	

Note: F-stat is the statistic of the bound-test proposed by Pesaran et al. (2001). The "I(1) bound" (upper-bound) critical values tabuled by Pesaran et al. (2001; pp.303-304) are 3.51, 4.16 and 6.44 for, respectively, the 10%, 5%, and 1% significance levels for k = 1,where k is the number of regressors. Pass-trough corresponds to the long term coefficient of Eonia, that is β. All β are statistically significant at least at the 10% level.

Lastly, another type of heterogeneity is between the two bank retail rates considered. It clearly appears that monetary transmission is more effective for firm than household bank rates. These results are in line with many previous studies (see, e.g., Mojon, 2000; Sørensen and Werner, 2006).

This multidimensional heterogeneity implies that the implementation of a common monetary policy is an ardent task in Eurozone. First, because the euro area countries can be striken by asymmetric shocks and also because the interest rate channel have not the same scale between the countries. The issues related to heterogeneity raise questions as the factors behind this heterogeneity.

3 Explaining heterogeneity: Empirical strategy

3.1 Data

We aim to estimate to what extent some economic factors influence the transmission of monetary policy shocks to bank rates. Therefore in addition to the money market rate and the two bank lending rates defined in section 2.1, we furthermore consider in this study 11 variables as potential determinants of the effectiveness of interest rate pass-through in the Eurozone. Our main hypothesis is that two types of factors can explain pass-through heterogeneity and lead to different incentives to report a policy rate shock. The first refers to cyclical factors, the second to structural factors. Since some variables can be both considered as cyclical and structural factors, we use the following typology to classify variables: macroeconomic conditions, macro-financial environment, bank risks and financial structure.[7]

The first category comprises the industrial production index and the inflation rate. Industrial production is an indicator of the position of the economy in the business cycle. Thus an increase (decrease) of industrial production would encourage banks to modify the allocation of their portfolios towards riskier (low-risk) projects. De Bondt (2002) indicates that this effect positively influences the size of the pass-through.[8] However, since perceived credit risk of borrowers is pro-cyclical a reverse effect would also be possible. Thus, an increase of Eonia in boom (burst) period leads to a moderate (an important) increase of rates because the risk is under-(over-)estimated. In addition, we could add that industrial production is a proxy for loans demand.
Concerning inflation, theoretical macroeconomic literature shows that nominal prices adjust more frequently when inflation is high. Then we can expect that a higher inflation rate increases the size of pass-through. Cottarelli and Kourelis (1994) highlight such an effect.

We include the following macro-financial variables in our analysis: stock price index, money market rate volatility, a spread between swaps 6-month Euribor and 10-year government bond rates[9], and last a country risk premium measure defined as the spread between specific government bond rate and Eonia.[10] These four variables impact the banking sector since banks are connected to financial market, especially in Europe, due to the dominance of universal banking system and since marginal cost of bank funding is not independent of country risk premium. Therefore, we expect that a higher stock price index increases the pass-through and opposite effects for the

[7] Definitions and sources of the variables are presented in the table 6 in appendix.
[8] According to De Bondt (2002), that explains why pass-through can be superior to 1.
[9] A decrease of the indicator indicates an increase of the liquidity risk.
[10] We have also tested the spread between Government bond rate and US government bond rate.

country risk premium.
Concerning the volatility of the money market rate, theory suggests that monetary transmission will be more important whether the bank are confident that the change is permanent, and not temporary (Borio and Fritz, 1995). This last argument refers to the "menu cost" (Cottarelli and Kourelis, 1994; Mester and Saunders, 1995). The confidence about the future evolution of market rates is also very important as bank rates have a longer maturity than market rates. Therefore, money market rate volatility is expected to have a negative effect on bank interest pass-through.

Beyond macro-environment, bank risks, both internal and perceived bank risks, can influence the pass-through. We use the non-performing-loans ratio (NPL) as an indicator of internal bank risks, or in other words of bank credit quality. As the crisis underlined, balance-sheet strength affects the effectiveness of monetary policy. Banks with bad assets in their balance-sheets would benefit from an expansive monetary policy to strengthen their liquidity and their financial health rather than cut interest rates (Saborowski and Weber, 2013). Therefore higher NPL ratios are expected to reduce the pass-through.
For perceived bank risks, we use an aggregate measure of distances to default of listed banks by country, which is an indicator of banking stability (more its value is high more the distance to default point is important).[11] This latter gives additional information to NPL, since it reflects the risk perceived by the financial markets and consequently the bank risk premium charged by the market on interbank, repo or obligation market. In this way we take into account the fact that marginal cost for bank is not necessarily the same across the Eurozone.

The last category of variables that we consider in this paper refers to financial structure. This category includes measures of banking competition, banking sector concentration and of market capitalization to GDP. First the degree of monopoly power and the banks' markup may reduce the transmission mechanism to the extent that the effects on marginal cost are not necessarily transmitted to price(Borio and Fritz, 1995). Van Leuvensteijn et al. (2013), Sørensen and Werner (2006) and Leroy and Lucotte (2014) find that interest rate transmission tends to be higher in more competitive banking systems. As a proxy for competition we opt for the Lerner index, which is an inverse proxy of banking competition. Higher values of the Lerner index signal higher market power, and consequently less bank competition. Banking concentration could have the same impact on the pass-through. Indeed, according to the "structure-conduct-performance" paradigm, concentration index is a good proxy for the market

[11] To obtain an aggregated distance to default we proceed in two steps. First we calculate bank distance to default for Eurozone listed banks following Duan et al. (2005). Then we aggregate these bank-specific distances to default according the location of the bank's headquarters and the relative weight of the bank, to obtain a country-specific measure of banking risk.

power of banks. Thus, we add HHI provided by the ECB to measure concentration. Since Lerner Index is an indicator of market power and HHI of concentration, we expect for these two variables a negative impact on interest rate transmission.
Last, we use the stock market capitalization to GDP ratio as a measure of financial development, but also as a proxy for the market-based degree of a national financial system. Capital market development is expected to increase the efficiency of a banking system, especially in creating competition on firm loans segment. Moreover, we expect that this positive competition effect also affects household loans segment through an efficiency-enhancing.

3.2 A single equation approach: Error correction model (ECM)

The empirical specification used in this paper adapts the two standard approaches for the estimation of pass-through in such a way to isolate the determinants of heterogeneous pass-through.

Thus, first we re-parametrize our previous ARDL-ECM into a panel model, as shown by Pesaran et al. (1999):

$$\Delta br_{i,t} = \phi_i(br_{i,t-1} + \beta mr_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta br_{i,t-j} + \sum_{j=0}^{q-1} \delta_{i,j} \Delta mr_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

where i denotes the country, and μ_i are the country fixed effects. The other coefficients and variables have the same definition as in equation (1).

The latter equation is well suited to study the pass-through in a panel framework (see, Bernhofer and van Treeck, 2013). However since in this study we focus on the determinants of pass-through, we need to extend the previous equation by including variables that can affect the size of pass-through. To measure the impact of these variables on pass-through, we interact potential determinants with the money market rate ($mr_{i,t-1}$).

Therefore the model that we estimate is given by:

$$\begin{aligned} \Delta br_{i,t} = \phi_i(br_{i,t-1} + \beta mr_{i,t-1} + \gamma(mr_{i,t-1} * Z_{i,t-1}) + \rho Z_{i,t-1}) \\ + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta br_{i,t-j} + \sum_{j=0}^{q-1} \delta_{i,j} \Delta mr_{i,t-j} + \eta_i \Delta(mr_{i,t} * Z_{i,t}) + \kappa_i \Delta Z_{i,t} + \mu_i + \varepsilon_{i,t} \end{aligned} \quad (3)$$

where $Z_{i,t}$ is a country-specific variable that is expected to influence the pass-through. γ is a parameter that indicates the effect of $Z_{i,t-1}$ on pass-through. A negative value of γ implies that the factor $Z_{i,t}$ contributes to reduce the size of pass-through and

therefore the monetary policy effectiveness. ρ refers to the impact of $Z_{i,t-1}$ on the level of bank rate. η_i and κ_i define the effect of $Z_{i,t}$ on the short-run pass-through and the immediate effect of variation of $Z_{i,t}$ on the evolution of bank rate, respectively.[12]

Before the estimations of equation (3) as a whole, we follow Westerlund (2007) and test for cointegration between the variables in level included in the model to check the relevance of an ECM specification. We do not use a bound test procedure, as in the previous section, since the critical values are not available in the panel context.[13]

Thereafter, to estimate this model, we use Pooled Mean Group estimators (PMG) (Pesaran et al., 1999). The PMG estimator is commonly used for estimating non-stationary heterogeneous panels, and it both allows the intercepts, the short-run coefficients, the error correction terms and error variances to differ across countries and constrains the long-run coefficients such that they must be equal across countries.[14] However thank to our interaction variables the long-run pass-through will not be effectively homogeneous between the Eurozone countries and will vary with respect to country characteristics.

3.3 A multivariate approach

Our second empirical analysis employs a multivariate approach, that allows for the potential endogeneity of the money market rate.[15] This empirical strategy is in the spirit of De Bondt (2002) or Égert et al. (2007) for instance, who check their univariate ECM results with a VAR procedure. However, we extend their approach by using a panel-VAR framework and considering a more complex VAR.

First, we make the choice to model instead of a traditional bivariate VAR, that includes only the money market rate and the bank lending rate, a broader VAR that incorporates the industrial production index. In this way, we have a more accurate representation of the economy and control for asymmetric shocks in activity.[16]

Second, our panel-VAR also contains an interaction term between the money market rate and the potential determinants of heterogeneous pass-through in Eurozone. From a methodological viewpoint, the panel interaction VAR framework augments a traditional panel-VAR with an interaction term and therefore allows to represent different

[12] In this study, we opt for an ARDL(2 3 1 1) that ensures no serial-correlation in the error term.

[13] Nevertheless note that Westerlund cointegration test is less flexible than bound test because it constraints all the series to be non-stationary, whereas panel ARDL-ECM allows in theory long-run equilibrium relationships between variables of mixed orders of integration (see, Pesaran et al., 1999).

[14] Recently, Bernhofer and van Treeck (2013) used this estimator to estimate interest pass-through in Euro area.

[15] Although endogeneity of money market rate is often ignored, Rocha (2012) notes that can be an issue in the extent to the fluctuations of money market rates depend of central bank decisions and market forces which are not independent of the banking sector.

[16] Our results are not dependent of this specification but the inclusion of industrial production index is a way to control for different risk premiums.

underlying structures of monetary policy transmission according to country specific characteristics in a similar way to what we do in our single equation approach. Thus, the response of bank rates to shocks in money market rates will be dependent upon some determinants.

To model and estimate a panel-VAR with interaction term, we refer to Towbin and Weber (2013).[17] Thus our panel-VAR on the so-called recursive form is modeled as follows:

$$\begin{pmatrix} 1 & 0 & 0 \\ a_{0,it}^{21} & 1 & 0 \\ a_{0,it}^{31} & a_{0,it}^{32} & 1 \end{pmatrix} \begin{pmatrix} IndP \\ Eonia \\ BR \end{pmatrix} = \mu_i + \sum_{l=1}^{L} \begin{pmatrix} \alpha_l^{11} & \alpha_l^{21} & \alpha_l^{31} \\ \alpha_l^{12} & \alpha_l^{22} & \alpha_l^{32} \\ \alpha_l^{13} & \Gamma_{l,it}^{23} & \alpha_l^{33} \end{pmatrix} \begin{pmatrix} IndP \\ Eonia \\ BR \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ chi \end{pmatrix} Z_{i,t} + \varepsilon_{i,t} \tag{4}$$

The structural parameters $\Gamma_{l,it}^{23}$ distinguish the traditional panel-VAR from our framework and allow to analyse how bank rate's responses to monetary policy shocks vary according to some economic characteristics and their relative evolutions. Thus for this purpose these coefficients have the following form:

$$\Gamma_{l,it}^{23} = \alpha_l^{23} + \eta^l Z_{i,t} \tag{5}$$

where α_l^{23} and η_l are two vectors of coefficients and $Z_{i,t}$ a variable underlying individual (country) heterogeneity, which we think may impact interest pass-through. Therefore, η_l is the interaction term, and indicates the supplement of effect of the exogenous variable on pass-through.

We model our VAR in level. Indeed according to Sims et al. (1990) a VAR in level with integrated variable of order one maximizes the long-term information of the data and takes in consideration (not explicitly as in an ECM or VECM) the possibility that the variables are cointegrated. This specification provides consistent coefficient estimates and avoid the error of mis-specification of the cointegration relationships which will bias the estimations. To obtain impulse response functions (IRF), after estimation by OLS of the reduced form of the VAR model, we compute the Choleski decomposition of the variance matrix of the residuals. In this way we make the residuals orthogonal.[18] For Choleski decomposition we choose the following ordering: industrial production

[17] We are very grateful to Sebastian Weber for providing us available their matlab code for interacted Panel VAR procedure.

[18] This procedure is the same as transforming the system in a recursive VAR (see equation (4)).

index, money market rate and bank interest rate. In this way industrial production index responds to shocks in bank rates only with lags and the contemporaneous response remains zero. Conversely, we assume that bank interest rates respond contemporaneously to all the shocks.[19]

As common in VAR model, we cannot interpret the coefficients of interaction terms and therefore we compare cumulative IRF of bank rates to a shock of Eonia, at 20^{th} and 80^{th} percentiles of the distribution of the considered exogenous determinants. In other words, we compare the effect of monetary policy shocks for both low and high levels of the exogenous variables.

[19]For robustness purpose, we have checked our IRF results for different orderings and find same results in all cases.

4 Explaining heterogeneity: Results

4.1 ECM results

Tables 3 and 4 report the estimation results of Westerlund cointegration tests and error correction terms, i.e the long run relationships of equation (1) for household and firm bank rates.

We begin by focusing on Westerlund cointegration tests. Results of these tests show that the considered determinants, the money market rate, the interaction term between these two variables and the bank rate are connected to one another through a cointegrating vector in the majority of cases. Consequently we can well opt for an ECM representation. Note that for inflation rate, we cannot apply Westerlund cointegration test. Indeed, this variable is I(0). However because ARDL approach has the advantage to not require all variables to be I(1) as the Johansen cointegration framework, we consider in our estimations inflation rate. Even if the coefficient estimates have to be considered with caution, the statistical significance of error correction terms for the two bank interest rates seems to support the existence of long-run relationships.

Table 3: Determinants of household bank rate pass-through

	Westerlund		**ECT**	**Eonia**	**Z**	**Eonia*Z**
Macroeconomic environment:						
Industrial production	-1.336	-2.526	-0.048**	-0.597*	-0.020*	**0.013*** **
Inflation	No	No	-0.043*	0.699***	0.039	**0.034***
Macro-financial environment:						
Stock price index	-1.029	-4.094	-0.059**	0.179**	-0.018***	**0.005*** **
Vol MMR	3.939	2.264	-0.037***	1.236***	33.106***	**-8.463*** **
Spread	-2.675	-3.584	-0.036***	0.941***	-0.945***	**0.229**
Risk premium	-6.287	-19.3	-0.042***	1.446***	0.717***	**-0.150*** **
Bank risks:						
Npl	-3.626	-9.066	-0.085***	0.900***	0.105***	**-0.033*** **
Distance to default	0.397	-1.961	-0.042***	0.538***	-.350***	**0.077****
Financial structures:						
Lerner	-4.019	-8.202	-0.040***	1.706***	12.832***	**-3.675*** **
HHI	1.036	-1.305	-0.053***	1.134***	41.271***	**-3.531*** **
Market capitalization to GDP	-0.032***	1.266***	-0.032***	1.266***	-0.058***	**-0.001**

Note: This table shows the results of Westerlund tests and estimates of (3) for household bank rates. The values in the two first columns correspond to the z-value of Pa and Pt Westerlund tests (critical values are 1.28, 1.65 and 2.33 respectively for the 10%, 5%, and 1% significance levels). To save space we report only estimates of the error correction term (ECT) and the long-run relationship part. The column Eonia corresponds to the estimates of β. Z refers to the determinants and corresponds to the estimates of ρ. Z*Eonia corresponds to the estimates of γ and is our main interest variable in the extend to it indicates the effect of Z on pass-through. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Looking at the estimation results, we first observe that there is a significant impact of macroeconomic environment on interest rate pass-through. As expected, a decline

of industrial production alters significantly the scale of pass-through. These results are essentially due to the crisis and confirm our previous findings that have highlighted in a time-series framework a decrease of pass-through during the crisis. The latter also confirms the fact that industrial production is a proxy of firm risk premium.[20] Whether the risk increases, banks could reduce the pass-through to take into account the risk evolution and pass a less important part of policy rate decreasing. As can be seen in the table 5, the economic effect is relatively high. Thus, when we consider the first quintile of industrial production, namely the 20% worst months, the estimated pass-through for firm rates is equal to 66% against 84% for the fourth quintile of the distribution. On another side, it turns out that inflation constraints banks to pass faster and in a greater proportion the changes in Eonia, despite potential menu costs or disagreements for consumers. As for industrial products, the nominal prices of financial products adjust more frequently and more completely when the inflation is high (Mojon, 2000).

Table 4: Determinants of firm bank rate pass-through

	Westerlund		**ECT**	**Eonia**	**Z**	**Eonia*Z**
Macroeconomic environment:						
Industrial production	-0.739	-3.625	-0.145***	-0.083	-0.003	**0.008*** **
Inflation	No	No	-0.127***	0.705***	0.016	**0.039*** **
Macro-financial environment:						
Stock price index	-4.376	-5.722	-0.111***	0.330***	-0.014***	**0.004*** **
Vol MMR	-1.765	-2.474	-0.132***	0.891***	12.687**	**-2.289*** **
Spread	-7.230	-16.183	-0.092***	0.920***	-0.917***	**0.321*** **
Risk premium	-4.288	-6.566	-0.094***	1.449***	0.743***	**-0.160*** **
Bank risks:						
Npl	-4.456	-5.713	-0.133***	0.957***	0.115***	**-0.084*** **
Distance to default	-2.962	-4.29	-0.159***	0.848***	-.055***	**-0.008**
Financial structures:						
Lerner	-2.547	-3.775	-0.155***	0.919***	0.838	**-0.511****
HHI	-3.204	-3.436	-0.011***	0.750***	10.466***	**0.264**
Market capitalization to GDP	-4.104	-7.15	-0.107**	0.765***	-0.103***	**0.002*** **

Note: This table shows the results of Westerlund tests and estimates of (3) for firm bank rates. The values in the two first columns correspond to the z-value of Pa and Pt Westerlund tests (critical values are 1.28, 1.65 and 2.33 respectively for the 10%, 5%, and 1% significance levels). To save space we report estimates of the error correction term (ECT) and the long-run relationship part. The column Eonia corresponds to the estimates of β. Z refers to the determinants and corresponds to the estimates of ρ. Z*Eonia corresponds to the estimates of γ and is our main interest variable in the extend to it indicates the effect of Z on pass-through. *Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

The worsening of macro-financial environment has every reasons to significantly influence the interest rate pass-through, because there is no dichotomy between real

[20]The relevance of the proxy seems good since industrial production has a significant negative impact on the level of rates.

and financial sectors. However, macro-financial variables can specify our findings and isolate the channels that influence the monetary transmission. Results in tables 3 and 4 show a positive effect of stock price index on pass-through. There are two ways to explain this result. First, a high financial market value would be associated, and even the consequence, with low money market rates and a weak volatility. Thus a stable financial environment could encourage banks to move their portfolio towards riskier borrowers. This result is confirmed by the negative impact of the money market rate volatility on pass-through. Finally we observe that country risk premium alters the pass-through. An increase of risk premium would downgrade the relative bank funding conditions as well as on interbank, repo or security markets. Moreover country risk premium would also be a proxy of agent credit-worthiness, with the negative impact discussed above. As for industrial production, the economic effect (see, table 5) is very important. The variable spread has a positive impact on firm bank rate pass-through. This is consistent with risk-premium results, since the variable spread is an inverse proxy of country risk premium.

Banking stability measures allow focusing our analysis on banking sector, exclusively. In this respect, we note that non performing loans reduce the bank interest rate pass-through. Banking difficulties lead to a fall of monetary policy efficiency. This point tends to justify the Federal Reserve (FED) prerogative in terms of banking regulation since 1913 and the creation of a banking union in Eurozone headed by the ECB. Note however, that the variable distance to default (proxy of banking stability) has a more unclear impact on pass-through, since it is only statistically significant for household bank rates.

The fourth type of factors that we test, refers to the financial structures. First, it appears that Lerner index has a negative impact on pass-through. This means that banking competition reinforces the transmission of monetary policy as shown by previous studies (Van Leuvensteijn et al., 2013; Leroy and Lucotte, 2014). In the same vein, we find that banking concentration (HHI) decreases the household bank rate pass-through. Indeed, concentration is usually viewed in the literature as an inverse proxy for banking competition. Last beyond banking structure and competition, we observe that market capitalization increases the firm bank rate pass-through. This finding can be explained by the fact that market capitalization to GDP is a proxy for competition from market on financial intermediation. The economic effect of these structural variables, in particular the Lerner Index and market capitalization, are not marginal. Thus, if the competition is fierce, the household bank rate pass-through is equal to 1.14 against 0.83 in a weakly competitive market. The effects are also important for market capitalization.

Table 5: Pass-through estimates for two different states

	Household PT		Firm PT	
	p20 - Low level	p80 - High level	p20 - Low level	p80 - High level
Macroeconomic environment:				
Industrial production	0.618	0.907	0.665	0.842
Inflation	0.743	0.807	0.755	0.829
Macro-financial environment:				
Stock price index	0.536	0.797	0.616	0.824
Vol MMR	1.034	0.645	0.836	0.731
Spread	0.877	0.980	0.830	0.980
Risk premium	1.346	0.983	1.346	0.952
Bank risks:				
Npl	0.859	0.703	0.854	0.455
Distance to default	0.686	0.963	0.832	0.803
Financial structures:				
Lerner	1.145	0.835	0.841	0.797
HHI	0.974	0.469	0.761	0.799
Market capitalization to GDP	1.228	1.181	0.839	0.933

Note: This table reports pass-through when we consider the interaction term at two different levels. We calculate first pass-through at the first quantile of the distribution ("p20") and then at the fourth quantile of the distribution ("p80") of the determinant considered.

4.2 PVAR results

The second part of our analysis discusses the results of panel-var with interactions. As discussed above, this framework is not only a robustness check, but also an extension part, because it allows to control for endogeneity of Eonia and for different macroeconomic environments across euro area countries.

Figures 1 and 2 present the cumulative IRF for all the tested determinants of household interest rate pass-through. Figures 3 and 4 show, the cumulative IRF for firm rates. On these figures the cumulative IRF at the left refer to response to bank rates to a shock in Eonia when the considered determinant is at its 80^{th} percentile, i.e when it is high. The figure at the center shows cumulative IRF when the value of the determinant is low, namely at the 20^{th} percentile. The third graphic indicates the difference between the IRF. 95% confidence intervals are in the three cases computed.

As we can see, the impact of money market rate shock is long. In many cases, cumulative IRF continue to growth after 24 months. However we arbitrarily consider that 24 months after the shock correspond to the long term impact. We report results of 10 different determinants against 11 in the previous section. Indeed we do not considered industrial production as exogenous variable since it is an endogenous variable in the VAR.

Regarding the other variables, we observe that the multivariate approach corroborates previous results.[21] Thus for instance, NPL ratio has a significant impact on pass-through. A banking system with a low NPL ratio has a household rate pass-through of 64% against only 50% when NPL ratio is at its 20^{th} percentile. Lerner Index and risk premium have the same negative impact. By contrast, a high market capitalization to GDP ratio is associated with a significant more important pass-through. The pass-through is indeed 15 percentage points higher when the ratio is high and not low. Banking concentration (HHI), stock-price index, inflation, and our spread variable have a same positive effect on pass-through. Furthermore as expected, here the distance to default has a significant impact on firm interest pass-through, that we were unable to observe in our ARDL-model. An explanation of this difference is that the significant impact occurs only many months after the initial Eonia shock, as can be seen in figure 3.

Concerning the money market rate volatility, the median of the cumulative IRF is negative. However the large confidence intervals do not permit to conclude on an effect on the pass-through, which is in line with the results obtained in the previous section. To a lesser extent it is also the case for banking concentration, since the IRF flirt with the x-axis.

Last, whether we focus on the two other structural determinants, the Lerner Index and the market capitalization to GDP, we can note that, once we control for macroeconomic environment with our trivariate VAR, the effect on the pass-through highlighted in the previous section remains. Consequently on the same basis of conjectural factors, structural factors should be taken in consideration.

[21] Table 7 in appendix provides a synthetic view of our results.

5 Conclusion

This paper empirically investigates the role played by several structural and cyclical factors on the interest rate pass-through in the Eurozone, and therefore, to what extent these factors can explain the pass-through heterogeneity across euro area countries. This issue has not been examined in a rigorous way as far as we know. To do this, our study proceeds in two steps. First, we assess the degree of pass-through heterogeneity across countries, and analyse whether heterogeneity has evolved following the financial crisis. Then, considering a single equation ECM specification derived from an ARDL model, we estimate for each of the 11 euro area countries of our sample the long run pass-through by distinguishing two periods: a pre-crisis and a crisis period. Results show strong evidence of substantial heterogeneity both across countries and bank lending rates, and confirm recent empirical findings in the literature (see, e.g., Bernhofer and van Treeck, 2013). In addition, as expected, we find that ECB's monetary policy transmission has been impaired in the aftermath of the financial crisis, due to an environment of persistent sovereign debt tensions, fragile economic activity, weak capital positions and high levels of uncertainty (ECB, 2013).

More importantly, we find that interest rate pass-through heterogeneity is not only due to the crisis. As stated in introduction, this latter result means that the economic and macro-financial environment are certainly not the only sources of pass-through and lending rate heterogeneity in the euro area. As argued by the ECB (2013), a number of structural and institutional factors may also explain these cross-country divergences. Consequently, in a second step, we extend our study to examine the relative importance of several structural and cyclical factors to interest rate pass-through and their role inside the "black box" of monetary policy transmission. For this purpose, we use two complementary panel data approaches: an extended ARDL-ECM in which each cyclical and structural variable considered is interacted with money market rate, and the panel interaction VAR framework recently developed by Towbin and Weber (2013).

Results indicate that, among the structural and cyclical factors, a number of them has constituted an obstacle to a homogeneous monetary policy transmission across the euro area. In particular, we find that financial tensions following the crisis have negatively affected the transmission from money market rate to bank lending rates and contributed to the pass-through heterogeneity in the Eurozone, even if results also suggest that financial market structures have played a significant role in this phenomenon. Thus, we find for example that higher risk premiums and banking instability contribute to the weakening of ECB's monetary policy transmission. These results confirm the preliminary analysis conducted by the ECB (2013). Also, in line with findings of Van Leuvensteijn et al. (2013) and Leroy and Lucotte (2014), our results indicate that the level of banking competition is a powerful driver of monetary transmission. Interest rate pass-through tends to be lower in economies where bank competition is

low and conversely, higher in countries with highly market-based financial systems.

In terms of policy implications, our findings suggest at least two recommendations. First, despite the conventional and unconventional measures taken by the ECB in the aftermath of the crisis, it appears that the stance of monetary policy has not appropriately been transmitted across countries. Even if, as shown by Cihák et al. (2009), it seems that policy rate cuts and enhancement of credit support have allowed to some extent to contain financial tensions on stressed markets and to reduce money market term spreads, facilitating the interest pass-through in some peripheral euro area countries. But financial markets are still fragmented, and weak growth has intensified balance sheet stresses and credit risks, undermining the transmission of monetary policy in the periphery. In this regard, it is necessary that the ECB takes additional measures to try to alleviate persistent financial fragmentation and reduce bank balance sheet stresses. As suggested by Al-Eyd and Berkmen (2013), the ECB could for instance take further actions to support liquidity to weak banks, by notably conducting additional long-term refinancing operations (LTROs) and extending their maturity.[22] Moreover, in addition to the recent measures aiming to target liquidity to small and mid-size firms, the ECB could also take further steps in the same direction with an eye to increasing banks' lending to small and medium enterprises. Indeed, as shown by Al-Eyd and Berkmen (2013), the broken monetary transmission impacts smaller businesses disproportionately. The current work of the ECB on the asset-backed securities (ABS) programme is moving in that direction.

However, as our results also suggest, measures and reforms need to be implemented for promoting a more efficient and homogeneous monetary transmission in the euro area should not just focus on risk factors. They should also take into consideration the lack of financial integration within the euro area and try to mitigate differences of financial market structures across countries. Indeed, it seems that the financial deregulation process failed to reduce the observed cross-country heterogeneity in the interest rate pass-through. Consequently, at the medium-term, further steps are required to homogenize financial and banking markets in the euro area, and strengthen bank competition in some countries, by taking care that these reforms will not increase financial instability. Against this background, European Banking Union is a step in this process.

[22] Note nonetheless that this option is the object of intense debate among academics and practitioners. For instance, Mancini et al. (2013) recently argued that liquidity provided by the ECB through LTROs had no significant effects on interbank activity or rates which they interpret as a type of liquidity trap.

Appendix

Table 6: Variable definition and source

Variable	Frequency	Source/Explanations
Pass-through:		
Eonia	Monthly	ECB
Real estate rates for households	Monthly	ECB
Bank rates for firms	Monthly	ECB
Macroeconomic environment:		
Industrial production index	Monthly	ECB
Inflation	Monthly	ECB
Macro-financial environment:		
Stock price index	Monthly	OECD
Money market rate volatility	Monthly	ECB
Spread	Monthly	ECB, authors' calculation
Risk premium	Monthly	ECB
Financial structures:		
Lerner	Annual	GFD database, World Bank
HHI	Annual	ECB
Market capitalization to GDP	Annual	GFD database, World Bank
Bank risks:		
Npl	Annual	GFD database, World Bank
Distance to default	Monthly	Datastream, authors' calculation

Table 7: Summary table of the results

	ARDL		**Panel VAR**	
	Households	**Firms**	**Households**	**Firms**
Macroeconomic environment:				
Industrial production	+	+	/	/
Inflation	+	+	+	+
Macro-financial environment:				
Stock price index	+	+	+	+
Money market rate volatility	-	-	N.s	N.s
Spread	N.s	+	+	+
Risk premium	-	-	-	-
Bank risks:				
Npl	-	-	-	-
Distance to default	+	N.s	N.s	+
Financial structures:				
Lerner	-	-	-	-
HHI	-	N.s	+	+
Market capitalization to GDP	N.s	+	+	+

Note: N.s means non significant results.

References

Al-Eyd, A. and Berkmen, P. (2013). Fragmentation and monetary policy in the euro area. IMF WP 13/208.

Aristei, D. and Gallo, M. (2014). Interest rate pass-through in the Euro area during the financial crisis: A multivariate regime-switching approach. *Journal of Policy Modeling*, 36(2):273–295.

Banerjee, A., Bystrov, V., and Mizen, P. (2010). Interest rate pass-through in the major european economies-the role of expectations. Discussion Papers 10-07, Department of Economics, University of Birmingham.

Bernhofer, D. and van Treeck, T. (2013). New evidence of heterogeneous bank interest rate pass-through in the euro area. *Economic Modelling*, 35:418–429.

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

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

Cihák, M., Harjes, T., and Stavrev, E. (2009). Euro area monetary policy in uncharted waters. IMF WP 09/185.

Cottarelli, C. and Kourelis, A. (1994). Financial structure, bank lending rates, and the transmission mechanism of monetary policy. IMF WP 94/39.

De Bondt, G. (2002). Retail bank interest rate pass-through: New evidence at the euro area level. European Central Bank Working Paper No.136.

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

De Bondt, G., Mojon, B., and Valla, N. (2005). Term structure and the sluggishness of retail bank interest rates in euro area countries. European Central Bank Working Paper No.518.

Donnay, M. and Degryse, H. (2001). Bank lending rate pass-through and differences in the transmission of a single EMU monetary policy. Center for Economic Studies – Discussion Paper Series 01.17, University of Leuven.

Duan, J.-C., Gauthier, G., and Simonato, J.-G. (2005). On the equivalence of the kmv and maximum likelihood methods for structural credit risk models. Groupe d'études et de recherche en analyse des décisions.

ECB (2012). Heterogeneity in euro area financial conditions and policy implications. ECB Monthly Bulletin, August 2012:63–75.

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

Égert, B., Crespo-Cuaresma, J., and Reininger, T. (2007). Interest rate pass-through in central and eastern europe: Reborn from ashes merely to pass away? *Journal of Policy Modeling*, 29(2):209–225.

Enfrun, B. and Cordier, J. (1994). Factors affecting the process of transmission of changes in interest rates in France. National Differences in Interest Rate Transmission, BIS.

Gigineishvili, N. (2011). Determinants of interest rate pass-through: Do macroeconomic conditions and financial market structure matter? IMF WP 11/176.

Karagiannis, S., Panagopoulos, Y., and Vlamis, P. (2010). Interest rate pass-through in Europe and the US: Monetary policy after the financial crisis. *Journal of Policy Modeling*, 32(3):323–338.

Kleimeier, S. and Sander, H. (2006). Expected versus unexpected monetary policy impulses and interest rate pass-through in euro-zone retail banking markets. *Journal of Banking & Finance*, 30(7):1839–1870.

Leroy, A. and Lucotte, Y. (2014). Heterogeneous monetary transmission process in the eurozone: Does banking competition matter? National Bank of Poland Working Papers 171.

Mancini, L., Ranaldo, A., and Wrampelmeyer, J. (2013). The euro interbank repo market. Research Paper No. 2013/16, University of St. Gallen, School of Finance.

Mester, L. J. and Saunders, A. (1995). When does the prime rate change? *Journal of Banking & Finance*, 19(5):743–764.

Mojon, B. (2000). Financial structure and the interest rate channel of ecb monetary policy. European Central Bank Working Paper No.40.

Pesaran, M. H., Shin, Y., and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3):289–326.

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.

Rocha, M. D. (2012). Interest rate pass-through in Portugal: Interactions, asymmetries and heterogeneities. *Journal of Policy Modeling*, 34(1):64–80.

Saborowski, C. and Weber, M. S. (2013). Assessing the determinants of interest rate transmission through conditional impulse response functions. IMF WP 13/23.

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.

Sims, C. A., Stock, J. H., and Watson, M. W. (1990). Inference in linear time series models with some unit roots. *Econometrica*, 58(1):113–144.

Sørensen, C. K. and Werner, T. (2006). Bank interest rate pass-through in the euro area: a cross country comparison. European Central Bank Working Paper No.580.

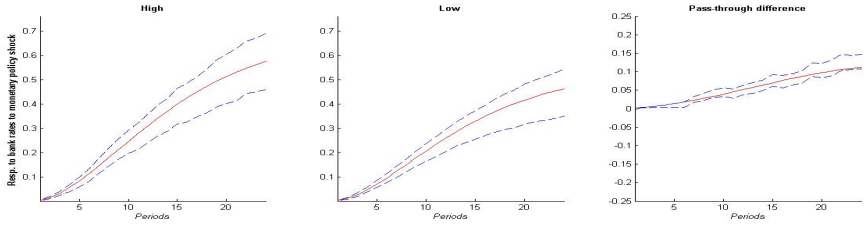
Toolsema, L. A., Sturm, J.-E., and Haan, J. (2002). Convergence of pass-through from money market to lending rates in EMU countries: New evidence. CCSO Centre for Economic Research Working Papers 200206, University of Groningen.

Towbin, P. and Weber, S. (2013). Limits of floating exchange rates: The role of foreign currency debt and import structure. *Journal of Development Economics*, 101:179–194.

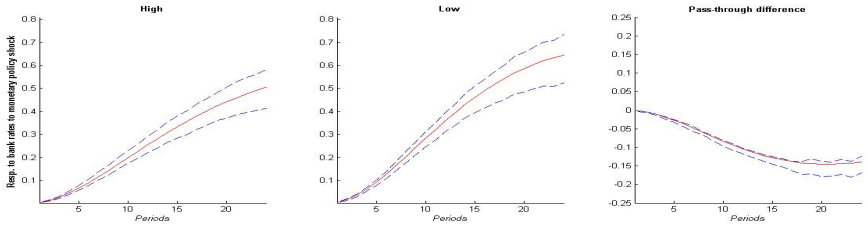
Van Leuvensteijn, M., Sørensen, C. K., Bikker, J. A., and Van Rixtel, A. A. (2013). Impact of bank competition on the interest rate pass-through in the euro area. *Applied Economics*, 45(11):1359–1380.

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

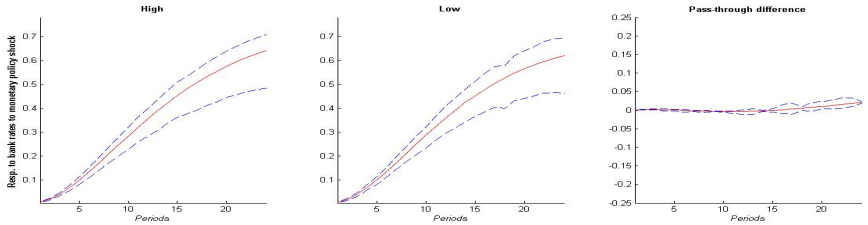
Figure 1: Cumulative Impulse Response Functions of Household rates following a shock of 1 p.p change in EONIA(1)



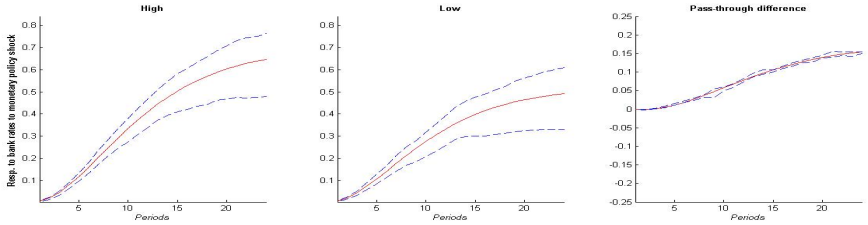
(a) Inflation



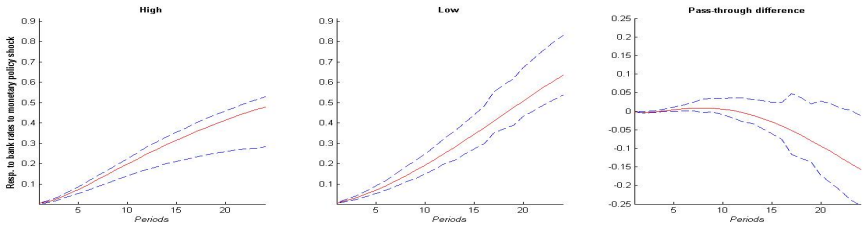
(b) Non performing loans (NPL)



(c) Bank distance to default



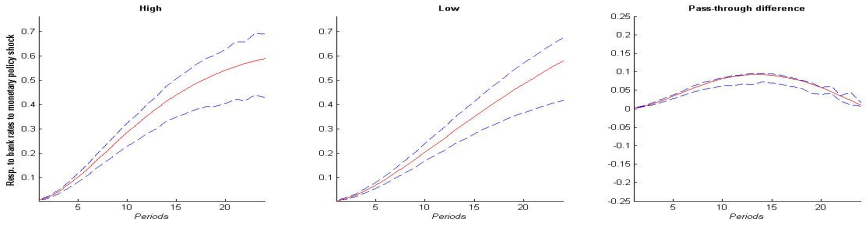
(d) Stock price index



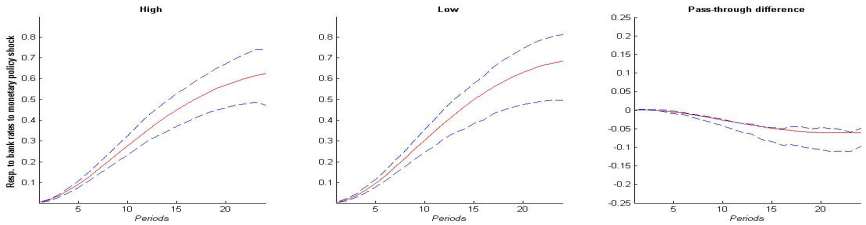
(e) Money market rate volatility

Note: The figure shows cumulative impulse responses of bank rate to a one percentage point increase in the money market rate under the 20^{th}("low") and 80^{th}("high") percentile level of the interaction variable. The figures on the right represent the difference between the two. The solid lines correspond to the median (50^{th}) cumulative impulse response. The two dotted lines represent the 5% error bands (two standard deviations)generated by bootstrap.

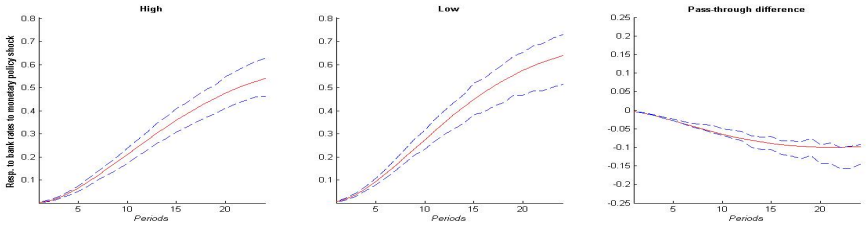
Figure 2: Cumulative Impulse Response Functions of Household rates following a shock of 1 p.p change in EONIA(2)



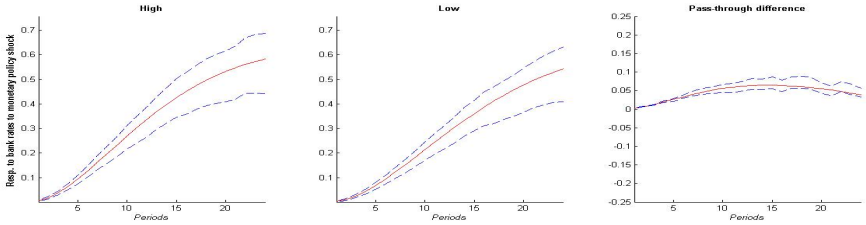
(a) Spread - swaps 6 month Euribor - government bond rate



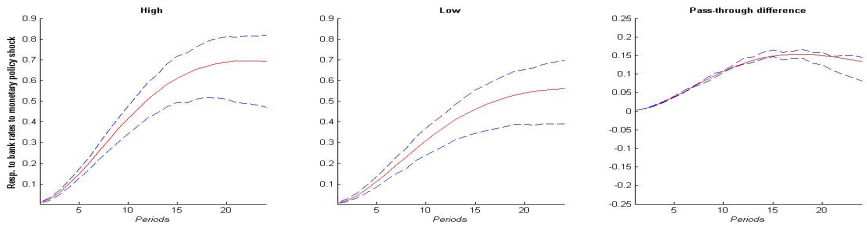
(b) Risk premium



(c) Competition



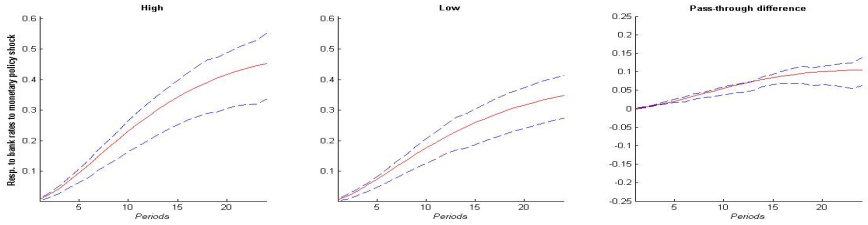
(d) Concentration



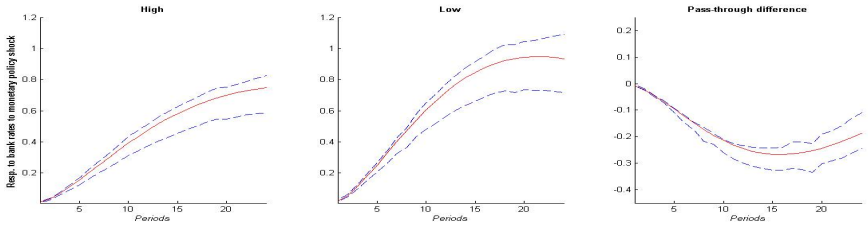
(e) Market capitalization

Note: The figure shows cumulative impulse responses of bank rate to a one percentage point increase in the money market rate under the 20^{th}("low") and 80^{th}("high") percentile level of the interaction variable. The figures on the right represent the difference between the two. The solid lines correspond to the median (50^{th}) cumulative impulse response. The two dotted lines represent the 5% error bands (two standard deviations)generated by bootstrap.

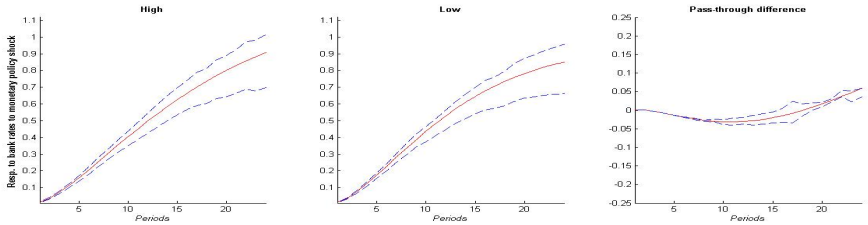
Figure 3: Cumulative Impulse Response Functions of Firm rates following a shock of 1 p.p change in EONIA(1)



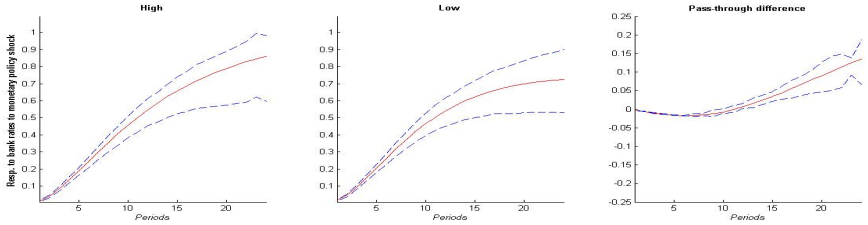
(a) Inflation



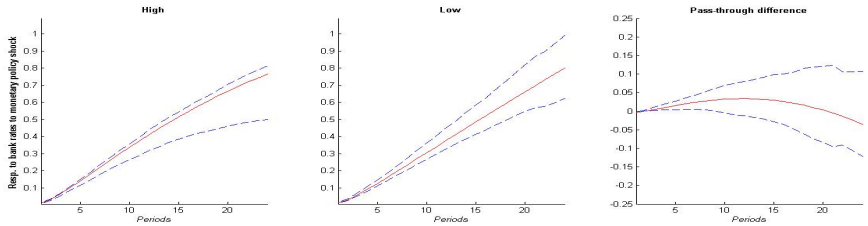
(b) Non performing loans (NPL)



(c) Bank distance to default



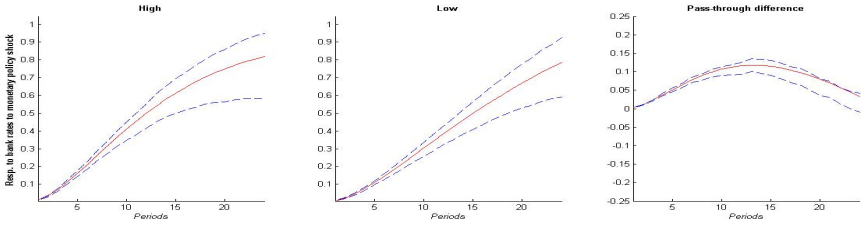
(d) Stock price index



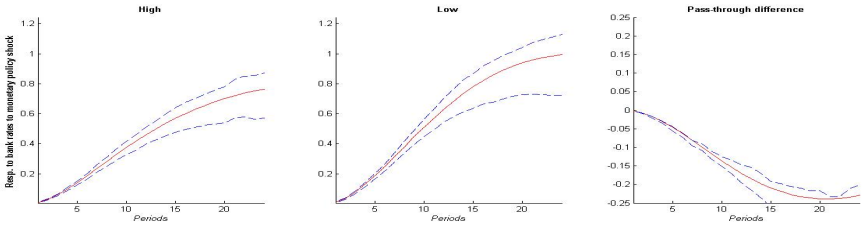
(e) Money market rate volatility

Note: The figure shows cumulative impulse responses of bank rate to a one percentage point increase in the money market rate under the 20^{th}("low") and 80^{th}("high") percentile level of the interaction variable. The figures on the right represent the difference between the two. The solid lines correspond to the median (50^{th}) cumulative impulse response. The two dotted lines represent the 5% error bands (two standard deviations)generated by bootstrap.

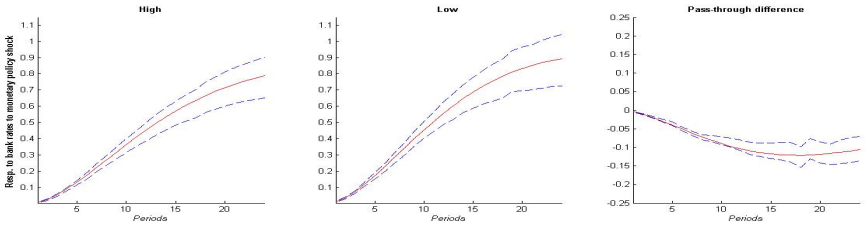
Figure 4: Cumulative Impulse Response Functions of Firm rates following a shock of 1 p.p change in EONIA(2)



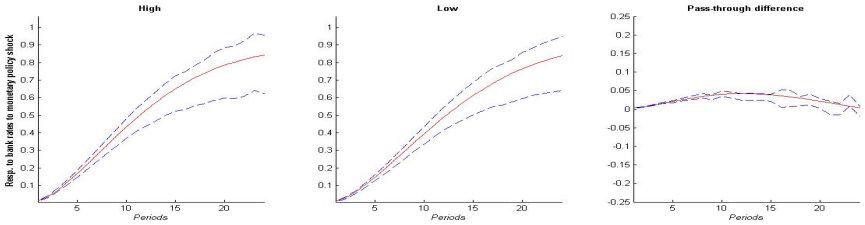
(a) Spread - swaps 6 month Euribor - government bond rate



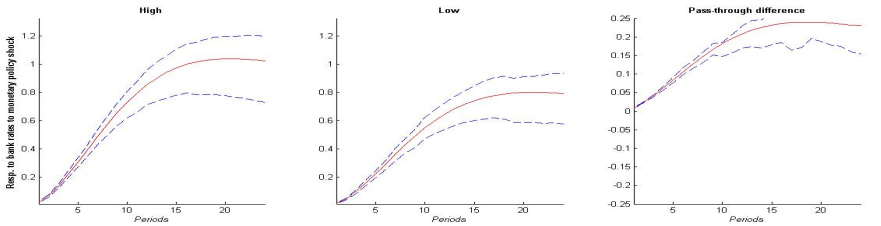
(b) Risk premium



(c) Competition



(d) Concentration



(e) Market capitalization

Note: The figure shows cumulative impulse responses of bank rate to a one percentage point increase in the money market rate under the 20^{th}("low") and 80^{th}("high") percentile level of the interaction variable. The figures on the right represent the difference between the two. The solid lines correspond to the median (50^{th}) cumulative impulse response. The two dotted lines represent the 5% error bands (two standard deviations)generated by bootstrap.

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