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Financial fragmentation in the Euro area

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**DIRECTORATE GENERAL FOR INTERNAL POLICIES
POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICY**

Financial market fragmentation in the euro area

IN-DEPTH ANALYSIS

Abstract

Fragmentation has increased since the financial crisis. It remains, though, that differences in cross-border financial flows have been strong across Euro area member states since the creation of the Euro. We show that the transmission of ECB policies to the interest rates on loans to non-financial corporations is quite uneven in the Euro area: the pass-through is much stronger in the periphery than in the core since the Global financial crisis. Consequently, the ECB is able to reduce the spread between the periphery and the core. We also show that the monetary policy transmission to NFC rates is stronger when fragmentation is low. Limiting fragmentation is thus crucial to improve the interest-rate channel in the Euro area. We argue that TLTRO II and QE should be targeted towards peripheral countries in order to limit Euro area fragmentation. Moreover, institutional improvements to make banking systems more homogenous across Euro area should be advocated.

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DRAFT

EXECUTIVE SUMMARY

- Fragmentation has increased since the financial crisis.
- The transmission of ECB conventional and unconventional policies to interest rates on loans to non-financial corporations is uneven in the euro area: the pass-through is stronger in the periphery than in the core since the Global financial crisis.
- Consequently, the ECB is able to reduce the spread between the periphery and the core, without inducing distortions in market forces.
- The monetary policy transmission to rates on loans to non-financial corporations is stronger when fragmentation is low. Limiting fragmentation is an important objective for the ECB as it will improve the interest-rate pass-through.
- Implementation features of monetary policies (negative rates, TLTROs, QE) should thus aim at reducing euro area fragmentation.
- Institutional improvements to make banking systems more homogenous across euro area should also be advocated.

DRAFT

1. INTRODUCTION

The integration of financial markets – full mobility of capital between countries - has been a major concern for the Euro area and especially for the ECB since 1999. Two reasons can be put forward. *First*, the role of financial systems is crucial for growth in the Euro area in order to achieve the best allocation of capital among member countries. Homogeneity in financial and banking systems facilitates capital mobility and makes this optimal allocation possible.¹ *Second*, when heterogeneity in financial and banking systems remain – reliance on banks rather than markets for funding differ or the level of competition in domestic banking system differ –, cross-border financial flows may be limited and may lead to suboptimal allocation of capital. In this latter case, two institutional responses are possible: first, some structural reforms on banking and financial systems through the removal of legal barriers to cross-border capital flows, the harmonization of national regulation (e.g. with a Banking Union), improvement in the homogeneity of the level of bank competition across countries and higher internationalization of domestic banking systems; second, a monetary policy to dampen divergence in financial conditions across countries.

Financial integration has long stood at the political agenda with the aim of enforcing the single market by removing legal barriers and by harmonizing national regulation. Convergence reports have extensively assessed the state of convergence on different markets since 1999. It was generally pointed out that convergence was strong on wholesale banking markets, on sovereign bonds market and to a less extent on retail markets because the latter were retaining local features like different degrees of local competition. Since the financial and sovereign debt crises though, the European banking system has been harshly hit: financial integration has been challenged because of the halt in the process of financial convergence. This halt is usually called 'fragmentation': not only have cross-border financial flows been said to have stopped within the monetary union, but interest rates are also said to have deviated across the member states.

The aim of this policy brief is twofold. First, it highlights the degree of fragmentation in the Eurozone, with a distinction between financial flows (deposits, loans, debt securities) and interest rates. The focus is on the banking systems as banks play a crucial role in the Euro area as far as funding to households and non-financial corporations is concerned. Second, the policy brief investigates the impact of ECB policies on market rates and draws some conclusions on the ability of the ECB to limit financial fragmentation.

¹ The relationship between financialisation and GDP per head (an indicator of allocation of capital) has been shown recently to follow a bell-shape: there is an optimal level of financialisation for which the growth rate of GDP per head achieves a maximum (Arcand, Berkes and Panizza, 2012). The growth in the share of non-performing loans on total loans also impacts negatively the rate of growth of GDP per head (Creel, Hubert and Labondance, 2015).

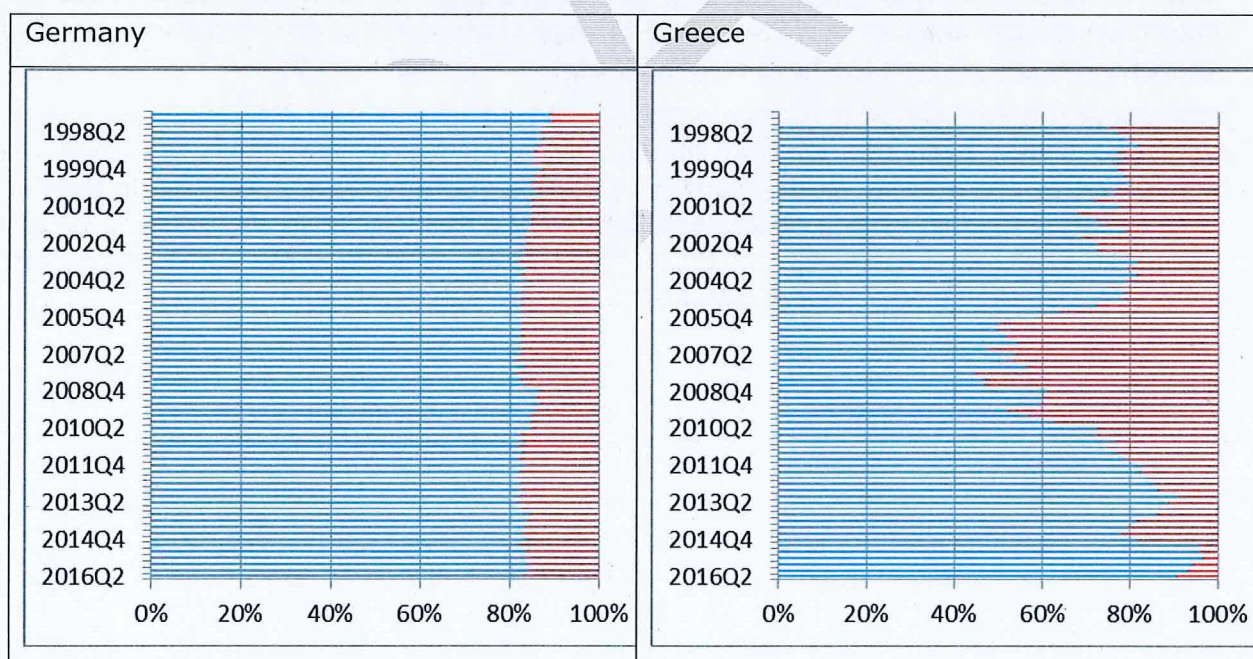
2. FRAGMENTATION OF FINANCIAL MARKETS: WHERE DO WE STAND?

There can be two ways of analysing financial fragmentation in a monetary union under so-called full capital mobility (since 1989 in the case of the EU). First, it can be analysed by the degree of heterogeneity in external funding. If banks of country A resort much less to non-domestic assets and liabilities than banks of country B, where countries A and B form a monetary union (with other countries), there can be signs that financial integration is imperfect, e.g. if banks in country A are limited in their cross-border financial activities by domestic regulations or they face disincentives to invest in banks of country B because risk in the latter banking system is different from the risk in their home country.

Drawing on data from the ECB on banks' balance sheets, on the side of cross-border financial flows, there is clear evidence that intra-Eurozone interbank flows are quite different from one country to another. Drawing on the respective shares of banks' assets and liabilities *vis-à-vis* either the origin country or other Eurozone member states, it appears that reliance on non-domestic assets and liabilities is not the same whether we study German banks or Greek banks or banks from the core and banks from the periphery.

The share of deposits by MFI in German banks has been rather stable since 1999 around 16%, whereas it peaked at above 55% in Greek banks before the crises, before it finally declined below 25% (figure 1).

Figure 1. Deposits by domestic (blue bars) or residents in other members states of the Eurozone (red bars) monetary and financial institutions (MFI)

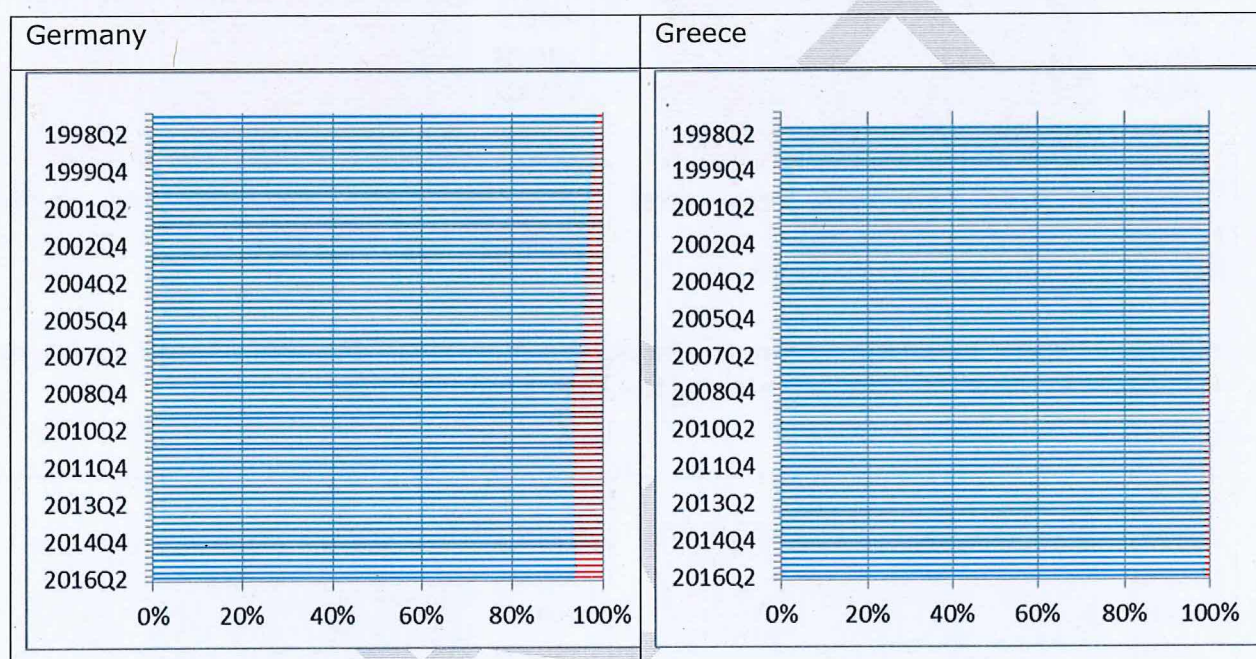


Sources: ECB, computations by the authors

On the assets' side of banks' balance sheets, loans typically represent 80% of the sum of loans and debt securities, whether in Germany or Greece. The internationalization of banks as regards loans remains very limited in Germany (with an average share of loans to other Eurozone non-MFIs of 4.5%) and inexistent in Greece (figure 2). On the contrary, the remaining part of assets – debt securities – shows larger intra-Eurozone relationships (figures 3 and 4). Debt securities held by German banks on other Eurozone MFIs grew

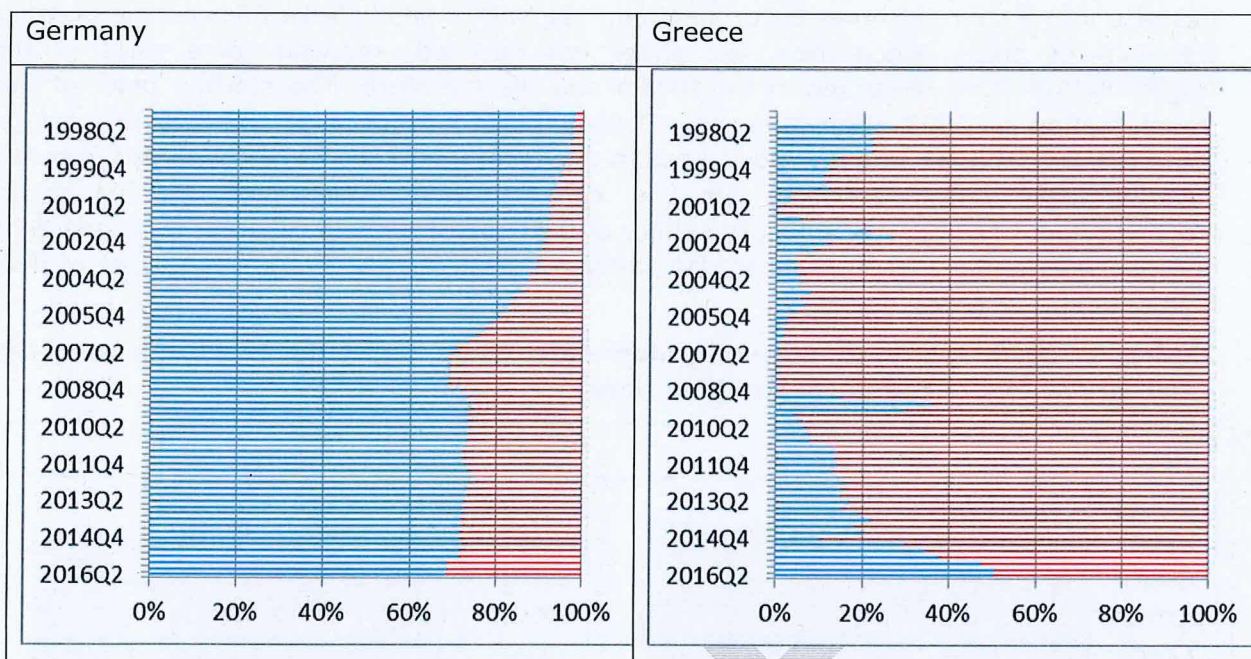
steeply between Euro's adoption and the financial crisis; it has then stabilized more or less at 30%. Regarding debt securities held on non-MFI, German banks show an even faster increase in the share of other Eurozone countries, with a peak above 55% on the onset of the financial crisis. Since then, the share has declined, showing some signs of the fragmentation often discussed in the media and the literature. The starting point of this fragmentation is 2008 (Bouvatier and Delatte (2016) argue that the overall peak of Eurozone cross-border financial flows appeared in 2007), and seems disconnected from the sovereign-debt crisis, at least for the core countries. Regarding the periphery, fragmentation has appeared later: the share of debt securities held on other Eurozone MFIs declined substantially after 2010. It was partly compensated by the growing share of debt held on other Eurozone non-MFIs.

Figure 2. Bank loans to non-MFI, domestic (blue bars) or residents in other members states of the Eurozone (red bars)



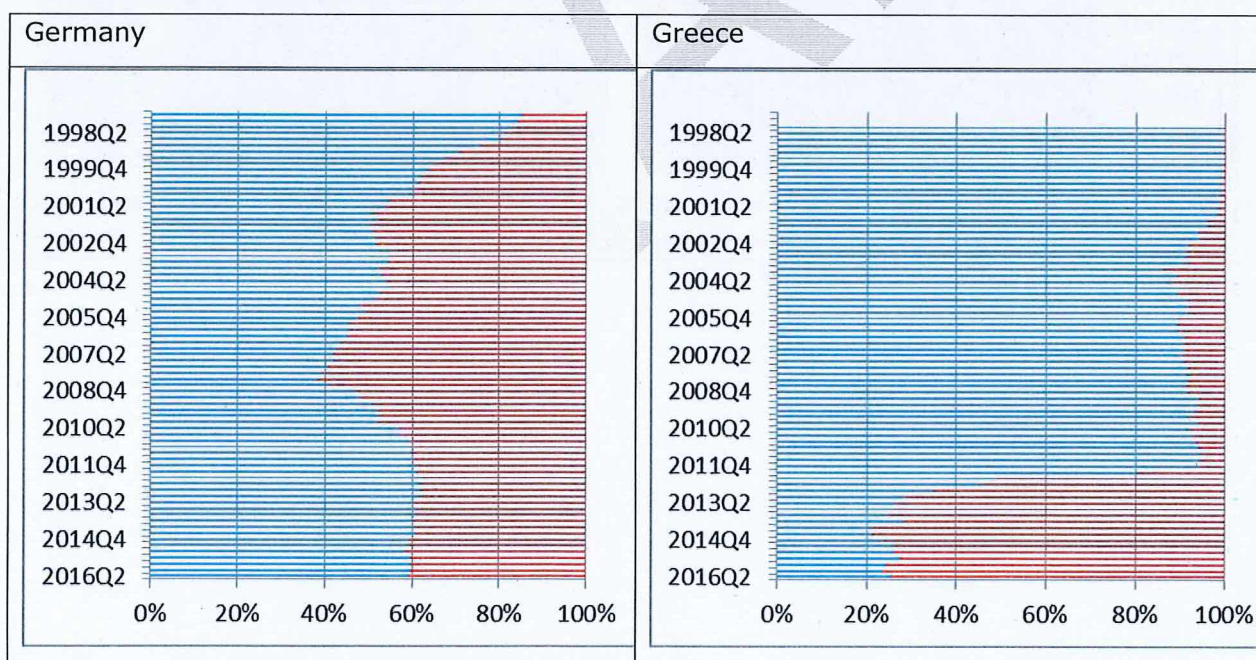
Sources: ECB, computations by the authors

Figure 3. Debt securities held by banks on MFI, domestic (blue bars) or residents in other members states of the Eurozone (red bars)



Sources: ECB, computations by the authors

Figure 4. Debt securities held by banks on non-MFI, domestic (blue bars) or residents in other members states of the Eurozone (red bars)



Sources: ECB, computations by the authors

The second way of analyzing financial fragmentation is on the side of interest rates charged on loans, debt securities or deposits. Under full financial integration, the law of one price is supposed to hold. In that case, there should be no difference in the prices of two financial assets having the same characteristics. When financial markets are not fully integrated, a convergence process may be expected, prices get closer and financial fragmentation recedes. As emphasized in much of the literature on the convergence of financial systems,

integration was soon achieved for money and public debt markets (Jappelli and Pagano, 2008). In its 2007 report on financial integration, the ECB emphasized the high degree of integration in the money markets, a convergence in bond markets since the introduction of the euro (and the removal of exchange rate risk), rising integration in the equity markets but still fragmentation in the retail banking activities.² Yet, it was stressed that integration in the wholesale markets (interbank market activities) as well as for the capital market activities was on an improving path.

Considering the European banking sector, full integration for retail markets would imply that interest rates on loans and deposits are identical across all Euro area countries. Yet, credit and deposit markets across countries do not share exactly the same characteristics as they intrinsically remain local markets subject to national regulations and practices. Besides, the level of interest rates on these markets will also depend on the main features of the domestic financial systems. Competition within the banking sector and between banks and financial markets (debt securities) also matter for the conditions under which households and non-financial corporations have access to funding. Consequently discrepancies between retail banking interest rate are expected to remain. But, with a common monetary policy and increased harmonization of the European legislations, less fragmentation should be expected.

To assess the extent of fragmentation, we apply the concept of sigma-convergence, which boils down to analysing the dynamics of the cross-sectional standard deviation for a given variable to interest rates.³ Here, we consider the interest rate applied on six retail banking markets for which the ECB provides data since 2000. These markets are: housing loans, consumption loans, loans to non-financial corporations below € 1 Million, loans to non-financial corporations over € 1 Million, deposit market for non-financial corporations and deposit market for households. Data are collected from January 2000 until November 2015 and are available for 11 Euro area countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

These indicators provide a quick and visual insight on the process on fragmentation for retail banking market since 2000 (see figures 5a, 5b and 5c). A downward trend in the indicator suggests less fragmentation while an increase indicates more fragmentation across Euro area domestic interest rates. For the six markets, the standard deviation of interest rates first decreased sharply in 2000-2001 then slowed down until 2007-2008. Since the Global financial crisis, standard-deviations have significantly increased either in 2007, for consumption loans for example, or in 2008 after the collapse of Lehman Brothers. During this crisis period, retail banking interest rates went on a diverging path across EMU countries. An empirical analysis confirms the rise in fragmentation after September 2008. It can indeed be shown that a break occurred at this date and that standard-deviations went on a rising trend in the retail banking markets for loans to non-financial corporations (see appendix I). Convergence would have ceased in deposits' markets and significantly slowed down in the markets for housing and consumption loans.

² See also Baele et al. (2004).

³ See Vajanne (2007) for an early assessment.

Figure 5a. Fragmentation indicator for retail banking interest rates to households
Standard-deviation



Sources: ECB, authors' computations.

Note: immo stands for rates on housing loans; conso stands for rates on consumption loans

Figure 5b. Fragmentation indicator for retail banking interest rates to non-financial corporations
Standard-deviation



Sources: ECB, authors' computations

Note: snfb stands for loans to NFC below €1 million; snfo stands for loans to NFC above €1 million

Figure 5c. Fragmentation indicator for retail banking interest rates on deposits
Standard-deviation



Sources: ECB, authors' computations

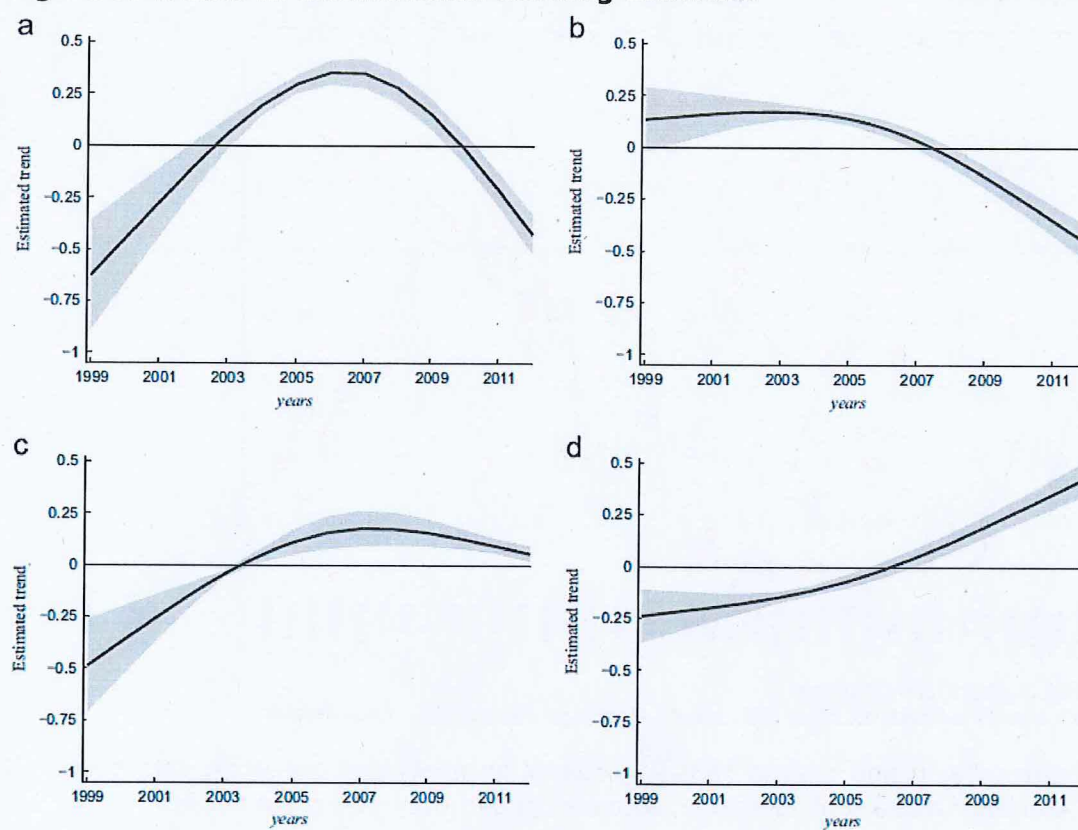
Note: *depnfc* stands for deposits from NFC; *dephh* stands for deposits from households

Overall, figures 5a, b and c show that fragmentation indicators are improving since 2011-2012 but standard deviations remain in all cases above their pre-crisis levels.

Besides, dispersion in retail banking markets partly reflects the increase in the dispersion in the sovereign bonds markets. Regressing standard-deviations for retail banking markets on standard-deviation for sovereign yields, inflation rate, industrial production and the levels of some macroeconomic indicators suggest a positive link from the dispersion of sovereign yields to the dispersion in the retail banking markets (see Appendix). An increase in the average level on the sovereign yield in the Euro area would also contribute to a rise of dispersion in the retail banking markets.

The analysis on retail banking interest rates is consistent with Bouvatier and Delatte (2016). They show that the crises – the Global financial crisis and the sovereign debt crisis – have triggered a halt in international banking activities leading to a “balkanisation of Euro area financial markets” (Reichlin, 2014). Based on international cross-border flows of the banking sector, they build a synthetic indicator of international banking integration. They suggest that integration of Euro area banks *vis-à-vis* other Euro area banks and non-Euro area banks has declined significantly since 2007 (figure 6). While claims of non-Euro area banks *vis-à-vis* Euro area banks have slowed down, they have still been increasing *vis-à-vis* other non-Euro area countries. Lucotte (2015) also finds that dissimilarities widened across banking systems of the Euro area. Such a situation questions the transmission of a common instrument of monetary policy for different countries since higher fragmentation in the retail banking interest rates may imply that the transmission of monetary policy is not homogeneous across Euro area countries.

Figure 6. Trends in international banking activities



Source: Bouvatier and Delatte (2016). Estimated trend. (a) Claims of Euro area countries vis-à-vis Euro area countries; (b) Claims of Euro area countries vis-à-vis non-Euro area countries; (c) Claims of non-Euro area countries vis-à-vis Euro area countries; (d) Claims of non-Euro area countries vis-à-vis non-Euro area countries.

3. POLICY OPTIONS FOR THE ECB

3.1 An asymmetric transmission of monetary policy?

Fragmentation is a key issue for the ECB as it threatens the transmission of common monetary policy. The interest channel has indeed been disrupted by the shocks to banking systems and on sovereign markets. Blot and Labondance (2013) and Gambacorta et al. (2015) document this point and show that the long-term pass-through of the ECB policy rate to the banks' lending rate have decreased after the bankruptcy of Lehman Brothers.

There have already been a few attempts to assess the impact of ECB unconventional measures on private interest rates, e.g. Gambacorta et al. (2015) and Creel, Hubert and Viennot (2016) who focus on the interest rate channel on a selected number of Eurozone countries: Italy and Spain in Gambacorta et al. (2015), the same plus Germany and France in Creel et al. (2016). Gambacorta et al. (2015) report that unconventional ECB policies have enhanced the interest-rate channel.⁴ Creel et al. (2016) suggest that SMP and covered bond purchase programme (CBPP) have helped to reduce retail banking interest rates in Italy and Spain.

Following this literature and in order to study whether the monetary policy transmission has been asymmetric in the Euro area since the crisis, we estimate the relationship between monetary policy rate⁵ and retail banking interest rates for two groups of countries. We classify member states that belong to the core or to the periphery of the Euro area.⁶ This classification is suggested by the differentiated impact of the sovereign debt crisis which has led to an increase in the spread of peripheral long-term interest rates *vis-à-vis* German long-term interest rate. We estimate that since October 2008, a country which encounters an average spread superior to 2 percentage points is part of the periphery. Countries in the core are thus Austria, Belgium, Germany, Finland, France and the Netherlands. Countries in the periphery are Greece, Ireland, Italy, Portugal and Spain.

The empirical model introduces sovereign bond yields and control variables (see the appendix) to capture the structural determinants of private interest rates. The monetary policy rate is assumed to impact private rates only in the short run. Hence, if the policy rate has a significant impact, it will illustrate the ability of the ECB to move private rates in the expected (positive impact) or unexpected direction (negative impact) without impairing long-run determinants of private interest rates. For instance, if there are structural reasons behind the spread in private rates between the periphery and the core, they will be captured by sovereign bond yields and the control variables; hence, ECB policy in the short run does not show any distortionary impact on market forces.

The main result regarding the short-term pass-through between ECB policy rate and private rates relates to non-financial corporations (table 1). It is twice higher in the periphery than in the core, meaning that an accommodative monetary policy has a quite stronger effect in the periphery than in the core in reducing banking interest rates. It suggests heterogeneity in the transmission mechanism, but it also suggests that the ECB unconventional monetary policy has helped to mitigate the fragmentation in non-financial corporation interest rates markets.

⁴ See also Blot and Labondance (2013) for a similar result and Belke, Beckman and Verheyen (2013) in a non-linear framework.

⁵ We use the shadow rate computed by Wu and Xia (2016) as an indicator of conventional and unconventional policy measures.

⁶ As a robustness check, we have also tested panels of the Euro area and the periphery without Greece.

Table 1. Monetary policy short term pass-through

		Euro Area	Core	Periphery
Loans to Households	Loans for consumption	-0.01	0.00	-0.07
	Lending for house purchase	0.03***	0.02***	0.04***
Loans to non financial corporation	Loans to Non-Financial corporations up to 1 million euro	0.10***	0,10***	0,20***
	Loans to Non-Financial corporations - over 1 million euro	0.15***	0,11***	0,22***
Deposit	Non financial corporations	0.07***	0.01	0.12***
	Households	0.04***	-0.00	0.07***

3.2 How does fragmentation affect the monetary policy transmission?

Finally, we also test the extent to which fragmentation may affect the monetary policy transmission. We look at the short term pass-through to the NFC according to the level of fragmentation (low fragmentation versus high fragmentation). Table 2 shows that the transmission mechanism is stronger (0.21 and 0.27 for loans to non-financial corporations up to and over € 1 million respectively) when the cross-sectional dispersion of retail banking interest rates across countries is low than when this fragmentation indicator is high (0.05 and 0.08 respectively). The monetary policy transmission is improved when the fragmentation in the euro area banking sector is low.

Table 2. Monetary policy short term interest rate pass-through to the interest rates for NFC according to the level of fragmentation

	Low Fragmentation	High Fragmentation
Loans to Non-Financial corporations up to 1 million euro	0,21	0,05
Loans to Non-Financial corporations - over 1 million euro	0,27	0,08

4. CONCLUSIONS AND POLICY IMPLICATIONS

Our empirical analysis shows that fragmentation has increased since the financial crisis. It remains, though, that differences in cross-border financial flows have been strong across Euro area member states since the creation of the Euro, at least.

Our results also show that the transmission of conventional and unconventional ECB policies to the interest rates on loans to non-financial corporations is quite uneven in the Euro area: the pass-through is much stronger in the periphery than in the core since the Global financial crisis. Consequently, the ECB is able to reduce the spread between the periphery and the core. We argue that the part of the spread that the ECB is able to reduce is not structural. The ECB does not distort market forces.

We also showed that the monetary policy transmission to NFC rates is stronger when fragmentation is low. Limiting fragmentation is thus crucial in order to improve the interest-rate channel in the Euro area.

Considering these results, we argue that the (relatively) new features of ECB policies, like negative rates, TLTRO II, and QE, should be targeted towards peripheral countries in order to limit Euro area fragmentation. Beyond monetary policymaking, we argue that institutional improvements to make banking systems more homogenous across Euro area should be advocated: in large countries, like Germany and France, bank systems remain highly auto-centric as far as cross-border financial flows within the Euro area are concerned. More Euro-area-isation of banking flows would enhance capital allocation and the effectiveness of ECB policies at impacting private rates. Euro-area-isation may accelerate with the implementation of the Single Supervisory Mechanism and the application of the Single Resolution Mechanism as part of the provisions of the Banking Union.

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APPENDIX

A1. Testing for fragmentation in the retail banking interest rates

Fragmentation may be assessed by a dispersion indicator for a given price variable. For loans and deposits, we consider interest rates applied by banks on retail banking markets, and the measure of dispersion is the cross-sectional standard-deviation, reflecting what is called σ -convergence in the literature on convergence. The indicator is also computed for public market interest rates: the sovereign yield on benchmark bonds. A significant decrease (respectively increase) in the indicator suggests lower (respectively higher) fragmentation. Then it can be tested whether this indicator is trending downwards over the all sample or over sub-samples. We highlight this effect in estimating equation (1) where the cross sectional standard deviation between interest rates of the same market ($\sigma_{b,t}$) is regressed on a linear time trend.

$$\sigma_{b,t} = \alpha + \beta_1 \text{time} + \varepsilon_t$$

In case of convergence, β_1 is significantly negative, indicating that the standard-deviation for a given retail banking market is decreasing over time. It should be noted that deviations may persist as the constant may remain significantly positive. In the extreme case of fully integrated retail banking markets, interest rates on housing loans, consumption loans, on credit to non-financial corporations and on deposits would be the same in all Euro area countries so that $\sigma_{b,t}=0$. Otherwise, for β_1 significantly positive, we would conclude that retail market interest rates are facing higher fragmentation. Finally, if β_1 is not significantly different from zero, we are neither in a process of lower nor higher fragmentation. Due to the occurrence of the crisis, a breakdown occurred in the interest rates process the month when Lehman Brothers collapsed. Formal evidence of the occurrence of such a break point is confirmed in the literature by Belke et al. (2013), Blot and Labondance (2013), Gambacorta et al. (2015). To account for this situation, we estimate equation (1) on the whole periods (January 2000 – November 2015) and on two sub-periods with a break in September 2008. Results are summarized in table A1 below.

They suggest that the trend was significantly negative for all retail banking markets from January 2000 to September 2008 and also for the sovereign bonds market. The level of β is then either significantly positive – for the sovereign bond market, and for the market of loans to non-financial corporations –, null – for deposits markets – or would have decreased for the markets for housing and consumption loans. We would then conclude that fragmentation in the retail banking markets has at least slowed down and has even reversed for some markets.

Table A1. Testing for fragmentation in the retail banking interest rates

	Sovereign	Housing loans	Consumption loans	NFC below 1M €	NFC over 1M €	Deposit rates for NFC	Deposit rates for households
All sample							
β_1	0.023***	0.000	0.002***	0.003***	0.002***	0.002***	0.001***
S-D	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Before September 2008							
β_1	-0.000***	-0.005***	-0.006***	-0.007***	-0.010***	-0.008***	-0.005***
S-D	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
After September 2008							
β_1	0.017*	-0.002***	-0.003***	0.006***	0.008***	0.001	0.001
S-D	[0.01]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Source: ECB, authors' computations. S-D stands for standard-deviation.

The determinants of standard-deviations for retail banking markets can be analysed through simple regression analysis where ($\sigma_{b,t}$) is explained by standard-deviations for sovereign bonds markets, for some macroeconomic variables (inflation rate, the quarterly growth rate of industrial production and the banking sector market capitalization). Results are shown in table A2 and suggest that standard-deviations for retail markets are mainly correlated to the standard-deviation of sovereign markets. The dispersion of inflation rates across Euro area countries is significant only for the deposit market for non-financial corporations but the level of inflation rate in the Euro area has a positive (respectively negative) impact on the dispersion in non-financial loans and deposit markets (respectively housing loans and consumption loans markets).

Table A2. The determinants of dispersion in the retail banking interest rates

	Housing loans	Consumption loans	Loans for NFC <1M	Loans for NFC >1M	Deposits by NFC	Deposits by households
Sovereign	0.040***	0.026**	0.045***	0.033**	0.040***	0.044***
Dispersion	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
IPI	-0.010*	-0.015	-0.004	0.009	-0.004	-0.005
Dispersion	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Market cap	-0.000	0.000	0.000	0.000	-0.000	-0.000
Dispersion	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
CCISS	-0.058***	-0.033	-0.042	-0.002	-0.042	-0.010
	[0.02]	[0.03]	[0.03]	[0.04]	[0.04]	[0.03]
Time	-0.008***	-0.004	0.011***	0.014***	0.006*	0.002
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Inflation	0.010	-0.117	0.117	0.145	0.234**	0.148*
Dispersion	[0.04]	[0.08]	[0.08]	[0.11]	[0.10]	[0.08]
Sovereign Level	-0.064***	0.094**	0.169***	0.163***	0.095*	-0.000
	[0.02]	[0.04]	[0.04]	[0.06]	[0.05]	[0.04]
Inflation Level	-0.062***	-0.081***	0.055**	0.064**	0.138***	0.098***
	[0.01]	[0.02]	[0.02]	[0.03]	[0.03]	[0.02]
IPI Level	0.024***	0.010	-0.018	-0.011	-0.021	-0.022
	[0.01]	[0.01]	[0.01]	[0.02]	[0.02]	[0.01]
Constant	2.033***	2.481***	-1.202**	-1.897***	-0.875	0.040
	[0.29]	[0.50]	[0.52]	[0.69]	[0.66]	[0.50]
Observations	86	86	86	86	86	86
R2	0.71	0.52	0.85	0.77	0.77	0.75

Source: ECB, authors' calculation. Standard-deviation in brackets.
 Estimation period: 2008-M10 / 2015-M11

A2. Testing for ECB monetary policy transmission

The changes in bank lending rates $\Delta ib_{i,t}$ are determined by adjustments towards long term equilibrium between bank interest rates and the long term interest rate ($LT_{i,t}$). λ' measures the long term pass-through of long term interest rates to the retail interest rates. α' reflects the speed of adjustment to the long term equilibrium. Here, we are also interested in the significativity of ϕ_j coefficients measuring the effect of monetary policy in the short-run

To account for direct and indirect effects, we estimate the following system with equations 2 and 3:

$$\left\{ \begin{array}{l} \Delta ib_{i,t} = \alpha_{ib} + \alpha'_{ib} \cdot (ib_{i,t-1} + \lambda'_{ib} \cdot LT_{t-1}) \\ + \sum_{j=1}^{p1} \theta_{j,ib} \Delta ib_{i,t-j} + \sum_{j=1}^{p2} \gamma_{j,ib} \Delta LT_{t-j} + \sum_{j=1}^{p3} \rho_{j,ib} \Delta X_{t-j} + \sum_{j=1}^{p4} \phi_{j,ib} \Delta MP_{t-j} + \varepsilon_{i,t} \quad (2) \\ \Delta LT_{i,t} = \alpha_{LT} + \alpha'_{LT} \cdot (LT_{i,t-1} + \lambda'_{LT} \cdot iBC_{t-1}) \\ + \sum_{j=1}^{p1} \theta_{j,LT} \Delta LT_{i,t-j} + \sum_{j=1}^{p2} \gamma_{j,LT} \Delta iBC_{t-j} + \sum_{j=1}^{p3} \rho_{j,LT} \Delta X_{t-j} + \sum_{j=1}^{p4} \phi_{j,LT} \Delta MP_{t-j} + \varepsilon_{i,t} \quad (3) \end{array} \right.$$

iBC_t stands for an ECB policy rate, measured by a shadow rate (see Wu and Xia, 2016).