The 2007/2009 turmoil: a challenge for the integration of the euro area money market?*

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Abstract

This paper studies the impact of the ongoing financial turmoil on cross-country lending patterns in the euro money market, using data on overnight transactions on the e-MID money market trading system. The paper finds that the structure of cross-border transactions in money markets has fundamentally changed in two phases: From the onset of the turmoil in August 2007, it changed from a truly integrated marekt with frequent cross border trading to a two-tier market structure in which predominantly large banks were active in the international money market. After September 2008, the data provides evidence of a quasi breakdown of international trading activity. These changes in market structure are attributed to the emergence of a higher degree of asymmetric information.

1   Introduction

Money markets were among the most affected segments of the financial markets during the financial crisis of 2007-2009. The day when concerns about European banks' exposures to the US sub-prime market led to a near-breakdown of the European money market, August 9, 2007, marks for many the beginning of the

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turmoil period. Similar effects could be witnessed in many countries around the globe. Banks started to hoard liquidity and refrained from lending in the interbank market, presumably both because of heightened concerns about the solvency of their peers in the market, as well as the increased uncertainty about own future liquidity needs.

In this paper, we focus on consequences for the integration of money markets in the European context. The integration of this market constitutes a very important element for the conduct of the single monetary policy: a condition for achieving equal financing conditions throughout the euro area is that short-term interest rates are equalized across countries, and for this, a precondition is the possibility for short-term funds to flow smoothly across throughout the entire euro area.

Our first key finding is that the volume of cross-border trades declined significantly after August 2007. At first glance, this finding seems to indicate a breakdown of the cross-border market with a possible segmentation of money markets across the euro area. However, our second finding is that the price for these transactions declined in comparison with domestic trades. Thus, a more likely interpretation seems to be that, as a result of the turmoil, cross-border interbank trades are now conducted mainly by banks with a relatively high credit standing, who act as money centers in the different countries of the euro area. The higher average quality of cross-country borrowers is reflected in the lower interest rates. Other, most likely smaller or less known banks are mainly trading in domestic markets, where interests are higher, because the average credit risk is perceived to be higher. Thus, in the cross-border context, the events seem to have enforced a two-tier system of the money market, in which smaller banks rely on liquidity provision by internationally active money center banks. The results change after the failure of Lehman in September 2008: the data indicate that the two-tier system is replaced by a situation with near-segmentation of the money market.

Our paper is mainly related to two strands of literature. The first is the theoretical literature on interbank markets. Bhattacharya and Gale (1987) were among the first to study this market. The authors show that an interbank market is beneficial because it is an insurance mechanism against idiosyncratic liquidity shocks. However, they argue that banks try to free-ride on other banks' liquidity provision, and thus there is an underprovision of aggregate liquidity by the banking

sector. Rochet and Tirole (1996) argue that the benefit of having a decentralized interbank market is the one of having most effective peer monitoring in the presence of moral hazard, while Allen and Gale (2000) study an interbank market with a focus on the possibility of contagion across banks. The above papers are concerned mainly with efficiency or solvency of banks in a system with interbank linkages; they do not focus on the formation of interest rates in this market, nor, more generally on adverse selection. Flannery (1996) is, to our knowledge, the first paper to address the impact of private information on interest rates in the interbank market. In his model, a financial crisis increases the degree of uncertainty of banks about their peers. As a result, loan rates increase and good borrowers may be driven out of the market as in the classical 'lemon's problem' by Akerlof (1970). Adverse selection in interbank markets is more rigorously addressed in Freixas and Holthausen (2004). Because banks in their model have information about other banks' probability of failure, prices in the interbank market reflect mutual credit concerns. The authors argue that noisier signals imply a higher markup on prices and study the possible breakdown of an international interbank market if cross-border information is of lower quality than domestic one.

The second is the recently emerging literature on the behaviour of interbank markets during the financial turmoil. Several papers have documented the failure of the interbank markt to redistribute liquidity, for instance Allen and Carletti (2008) or Brunnermeier (2008). One line of reasoning for this is that the turmoil increased solvency risk of many financial market players. Thus, credit risk in interbank lending transactions rose, especially because information about the individual exposures of banks was extremely scarce. Heider et al (2009) argue that this increased level of counterparty risk led to adverse selection in the interbank market, and to liqudity hoarding by banks. Eisenschmidt and Tapking (2009) provide an alternative theory, arguing that in an environment of increased uncertainty about the general market situation and market sentiment, banks try to hoard liquidity with an insurance motive, since they want to make they sure that they possess sufficient liquidity in all circumstances . This leads banks to hoard liqudity instead of lending it out to those in need of short-term funds. On the empirical side, Angelini et al (2009) also study e-MID data to document developments in mainly longer maturity segments of the money market during the financial turmoil, and to link trading behaviour to bank characteristics, while

Acharya and Merrouche (2008) study interest rates in the UK money market.

The remainder of the paper is organised as follows. In section 2, we describe the euro area money market and report the impact of the financial market turmoil on money markets. Section 3 reviews the theoretical model that the analysis is built on. Section 4 deals with the empirical analysis of the turmoil's implication for cross-border interbank trades, and section 5 concludes.

2 The Euro overnight interbank market

Prior to the introduction of the euro as single currency in the euro area in 1999, money markets in this area were segmented along currencies, that is, along national borders. In each country, deposits were traded among banks at the money market interest rates prevailing in that country, which was linked to the monetary policy decisions of each central bank. Only the single currency paved the way for an integrated market. From one day to the other, banks could trade deposits denoted in euro, and they could do so with a much larger set of banks, located across the entire euro area.

Several articles have documented the rapid pace of integration of such markets. Ciampolini and Rhode (2000) as well as the European Central Bank (2000) have documented how a big step towards integration of this market has been achieved very quickly in the first days of January 1999. On the one hand, this integration took place in terms of quantities traded: according to ECB (2000), after the first year of monetary union, more than 50% of unsecured lending activity in the euro area took place across borders. At the same time, this market increased in liquidity, especially for shorter maturities. Reference rates such as the EONIA and EURIBOR were adopted quickly and served as benchmarks for the market prices. On the other hand, the degree of integration was visible in terms of prices: shortly after the introduction of the single currency, risk-adjusted short term rates were almost identical across participants from various euro area countries.

The evidence thus points to the euro money market being a liquid, integrated market prior to the financial market turmoil starting in 2007. However, money markets were among the most affected markets by the financial turmoil. On 9 August 2007, when rumors about some European banks' exposures spread, liquidity

in the euro money market very quickly dried up and interest rates soared, until the ECB announced the provision of an unusually large amount of liquidity overnight. The situation remained very tense for the next year, and short-term interest rates were only kept at adequately low levels because of an adjustment in the time path of supply of liquidity to the banking sector.[1] When markets were again and even more fiercely affected after the failure of Lehman Brothers in September 2008 (and several subsequent bank failures or bail-outs), the Eurosystem introduced some changes to its auction design in switching from a variable rate tender with fixed allotment amount to a fixed-rate tender without rationing. As a consequence, from that point on the amount of liquidity provision from the central bank to the banking sector was determined by aggregate private demand rather than by the central bank.[2]

In the following, we argue that the element of increased uncertainty about borrower's credit quality may have played a role in the context of euro area money market integration.

3 A theoretical foundation

As a basis for the empirical tests on possible segmentation of the money market, we use the model by Freixas and Holthausen (2004), which studies possible cross-border integration of interbank markets in the presence of asymmetric information about bank solvency. The basis features of this model, in the following FH, are briefly recapitulated in the following: a banking sector is modelled in which banks face individual liquidity shocks as in Diamond and Dybvig (1983), where depositors are ex-ante uncertain at which point in time they need to consume. These liquidity shocks differ across banks: for each bank, the fraction of depositors withdrawing funds early may be high or low. This justifies the existence of an interbank market where banks can insure themselves against liquidity shocks: banks with low liquidity needs (π_L) lend their excess cash to banks with high

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[1]Between August 2007 and September 2008, the ECB did not change the aggregated supply of liquidity to banks on average - instead it shifted the time path of liquidity supply to the banking sector. This allowed banks to build up temporary liquidity buffers, which were then periodically used up for the fulfillment of reserve requirements. With this policy, the ECB was able to broadly stabilize short-term interest rates. See ECB (2009).

[2]Fixed-rate tenders with full allotment remained in place throughout 2009.

liquidity needs (π_H) against an interest rate. Essentially, the interbank market helps avoiding inefficient liquidation of banks' longer-term projects.

Moreover, it is assumed that the aggregate liquidity needs of two countries differ: country A is liquidity rich because it has a high fraction of π_L-banks, while country B is short in liquidity, as the fraction of banks with high liquidity needs π_H is large. As a consequence, a cross-border market for liquidity may emerge, which is welfare-improving.

Banks invest both in riskless reserves (which are always liquid) and in an illiquid risky technology. For managing, their liquidity at an interim period, banks have several options: they can use the funds invested in riskless reserves, they can liquidate (at a cost) parts of their risky techology, and they can borrow or lend in the interbank market. Before the interbank market takes place, however, banks receive signals $\bar{s}$ (good) or $\underline{s}$ (bad) about each others' solvency and thus ability to repay an interbank loan. It is assumed that the signal received about domestic banks is rather precise - here, we assume for simplicity that it is a perfectly revealing signal. One crucial assumption of the model is that in the other country, this signal it is observed with some noise β, where $0 \leq \beta < \frac{1}{2}$. Under these assumptions, one can characterize each bank by a signal pair (s_D, s_F), consisting of the signals that are observed about this bank in the domestic and the foreign market. Thus, there are four different types of banks, characterised by the four possible signal pairs $(\bar{s}, \bar{s})$, $(\bar{s}, \underline{s})$, $(\underline{s}, \bar{s})$ and $(\underline{s}, \underline{s})$. FH show that, as is intuitive, banks can only borrow in the country in which the good signal $\bar{s}$ has been observed.

Because only banks of type $(\bar{s}, \bar{s})$ have an actual choice in their decision where to borrow (all other types can either borrow only in one country or not at all), it is the fraction of these banks that choose to borrow in either country which determine the equilibrium. More precisely, an equilibrium is characterized by the set of variables $(\psi, r_A, r_B, r_F, p_F)$, where ψ denotes the fraction of $(\bar{s}, \bar{s})$-banks of the liquidity-short country that choose to borrow abroad, r_A and r_B are the interest rates charged to domestic borrowers in each country, r_F is the interest rate charged to borrowers from country B by lenders from country A, and p_F denotes the updated probability of solvency of foreign borrowers, given a certain level of cross-border borrowing ψ.

In order to characterize the equilibrium, it is useful to express all these variables

as functions of ψ. In particular, an increasing ψ implies that more liquidity is borrowed across borders, and this affects the aggregate liquidity situation in each country: in country A, the net provider of liquidity, liquidity becomes tighter when the intensity of cross border borrowing increases, thus $\frac{\partial r_A}{\partial \psi} > 0$. In country B, on the contrary, a higher cross-border borrowing implies an easing of liquidity conditions, thus $\frac{\partial r_B}{\partial \psi} < 0$.

Liquidity-rich banks from country A can choose whether to lend to domestic or foreign banks. The interest rate charged will, however, be different. This is because it is different populations of banks that are in each pool of borrowers: domestic borrowers are those with a good domestic signal $\bar{s}$, of the types $(\bar{s}, \bar{s})$ or $(\bar{s}, \underline{s})$. Foreign borrowers may be of types $(\bar{s}, \bar{s})$ or $(\underline{s}, \bar{s})$. The lower precision of the signal observed in the foreign country implies that foreign loan applicants are of their worse average quality. Consequently, foreign borrowers are charged an interest rate premium on top of the domestic rate, which results in an interest rate r_F where $r_F \geq r_A$.

This also implies that the effect of ψ on the rate charged by country A-banks to foreign borrowers is more involved, because it is influenced by two factors. On the one hand, r_F (just as r_A) reflects the available liquidity in country A, which is reduced with a higher ψ (i.e. with more foreign lending) On the other hand, with ψ the composition of banks that borrow across borders changes: the more of the good banks with a $(\bar{s}, \bar{s})$ -signal are in the pool of borrowers (i.e. the higher ψ), the higher the average credit worthiness of foreign borrowing banks. Thus, an increase in ψ also has a negative effect on r_F. It is because of this adjustment of the quality of foreign borrowers that an equilibrium with an integrated market, in which at least some of the $(\bar{s}, \bar{s})$ -banks borrow abroad, does not always exist.

The equilibrium value of ψ will be determined by the relationship between r_B and r_F, as $(\bar{s}, \bar{s})$-banks will choose the loan contract with the lower interest rate. Both rates are displayed as functions of ψ in figure 1. In the first case, r_F lies above r_B for all values of ψ. Therefore, borrowers always prefer to borrow domestically, and $\psi^* = 0$ (segmented market). This case happens if either the difference in liquidity needs across countries is small, or when the cross-border signal carries a lot of noise (high β). In the second case, parameters are such that both curves intersect.

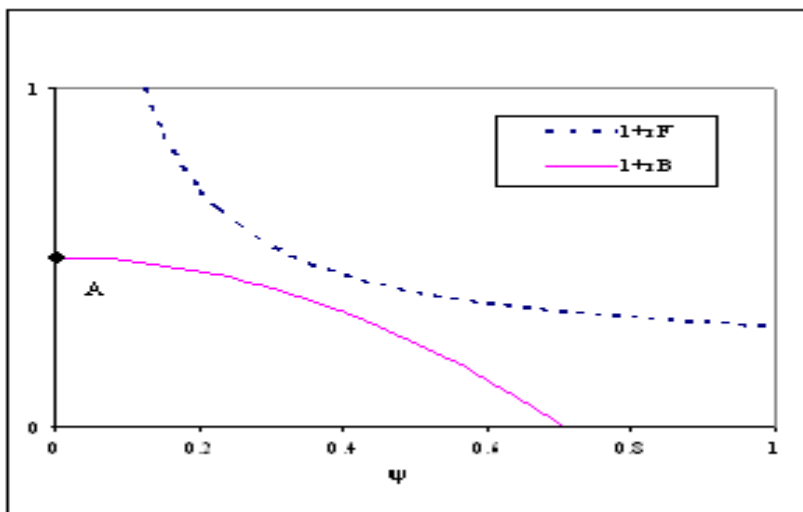The FH-model has the following predictions:

Figure 1: *Only a segmented equilibrium exists (case 1)*

- A (Nash-) equilibrium with segmented interbank markets always exists.

- There may be an integrated equilibrium in which some country-B-banks borrow from country A-banks. Because of the adverse selection problem in the international market, this equilibrium does not always exist. In particular, if the informational asymmetry across boders is high (high β), or when liquidity differences are too small, there will be no integrated equilibrium.

Figures 1 and 2 illustrate possible cases for equilibria. The two downward-sloping curves depict the interest rates faced by borrowers from the liquidity-short country (country B) when borrowing domestically (at rate $1+r_B$) and abroad (at rate $1+r_F$), as a function of ψ. In figure 1, these two curves do not intersect. In this case, there is no integration of money markets, as all banks prefer to borrow domestically. This can happen when the premium charged to foreign borrowers is very high. Figure 2 illustrates a parameter constellation for which there is in an integrated market, where both curves intersect (point B). Here, banks are indifferent in which country to borrow, and the equilibrium value of ψ is determined.

FH also consider the case of heterogeneous banks. They focus on sound large banks, that are well known also across borders, and possibly even considered as too-big-to-fail. These banks would be characterized by the signal pair $(\bar{s}, \bar{s})$, thus being able to borrow in either country. This enables them to take an intermediation role in the money market: large banks could channel liquidity across borders
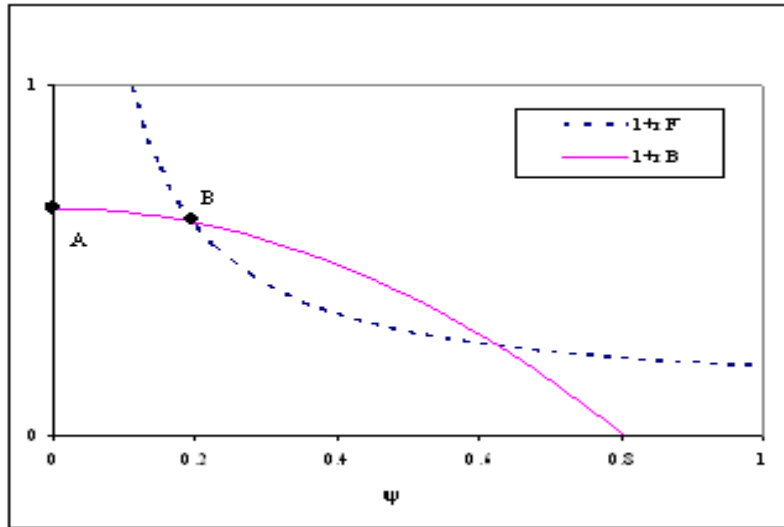
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Figure 2: *Existence of equilibria with segmentation and integration (case 2)*

and thus achieve a levelling out of liquidity needs, even if for smaller banks, there was no money market integration.

The FH-model shows that asymmetric information across borders may hamper the integration of money markets because foreign banks would need to pay a premium, which reflects the higher degree of uncertainty about their solvency and thus ability to repay an interbank loan. If this premium is very high, it might be the case that there is no equilibrium in which banks can borrow abroad, but only a segmented equilibrium. Moreover, Freixas and Holthausen argue that even if an integrated equilibrium exists, it coexists with the equilibrium with segmentation. Thus, it is possible that an external shock, without changing the fundamentals of the economy, might lead to a breakdown of the integrated equilibrium.

Freixas and Holthausen also consider the case in which larger, well known banks exist, which are equally well known across borders and which can thus act as local banks in all economies.[3] Even if other, smaller banks may not be able to engage in cross-border borrowing, these banks could play the role of money centers which can channel liquidity across borders and thus lead to an levelling out of money market rates in all countries involved. The banking system in this case is characterized by a two-tier structure.

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[3]One can also consider these banks as being perceived as too-big-too-fail.

3.1 Testable hypotheses

Before the turmoil, the money market appears to have been integrated, as interest rates were on very similar levels. The model by Freixas and Holthausen argues that this could be the result of one of the following market characteristics:

First, it is possible that the market was fully integrated in the sense that all banks of a good international standing were able to borrow in the foreign country. In this case, cross-border interest rates should be slightly above those rates prevailing in the liquidity-rich country (the difference corresponds to the premium due to asymmetric information). The overall volume of cross-border trades should be rather large.

Second, it may be the case that interest rate convergence is achieved because of the activity of large money-center banks. In this case, smaller banks are constrained to borrowing in the domestic market, but the cross-border lending activity of larger banks is sufficient to bring about convergence in money market rates.

Third, it is possible that markets were fully integrated because no problems of asymmetric information existed and there was effectively one large money market.

Our testable hypotheses are the following:

H1 The turmoil has had no impact on money market integration

In this case, the equilibrium type should remain unaffected from the one prevailing before the turmoil. Volumes of cross-border trades should remain unaffected, and the relative price of cross-border transactions relative to domestic ones should remain constant.

H2 The equilibrium has switched from one where also smaller banks could borrow on the international market to one in which they cannot.

This case corresponds to the move from an integrated equilibrium to a segmented one in the terminology of Freixas and Holthausen (2004) [18]. The main consequence is a drastic decline in the volume of cross-border trades. Two subcases need to be distinguished:

H2a A complete breakdown of international money market transactions

H2b Two-tier system in which large, international banks channel liquidity across borders and ensure (near) equality of money market rates across countries.

Under hypothesis H2b, cross-border trades would be concentrated among a few banks. Because these banks are well known across countries, or indeed perceived to be very safe, they should be able to borrow at lower rates than the average population of borrowing banks. Therefore, H2b goes along with a *decline* in the relative price of cross-border trades relative to domestic ones.

4 An empirical test of market segmentation

4.1 The data

We use high quality data on euro overnight interbank borrowing and lending rates and volumes, which was kindly provided by e-MID. This is an electronic market for unsecured interbank deposits. It served as domestic market for Italian Lira transactions during the 1990s. With the advent of the euro, money market traders could conduct any euro money market transaction across the euro area via e-MID. The number of international counterparties increased over time and even surpassed the number of Italian banks. As a result, both domestic and cross-border trades are represented in the sample. In e-MID, unsecured money markets deals for different maturities are done, from overnight to very long term maturities.[4]

According to the "Euro Money Market Study 2004", the e-MID market accounted for 17% of total turnover in unsecured money market in the Euro Area. In 2007, the average daily turnover for the overnight maturity was around 20 billion euro, about 55% of it due to transactions involving at least a non-Italian counterparty. One important feature of the trading in the e-MID is that it is fully transparent. "Buy" and "Sell" proposals (prices and volumes), appear on the screens of the trading platform along with the identity of the bank posting them. Furthermore, all the parameters of a trade are recorded, which means that the full information on the conditions of each trade and the counterparties involved can be traced.

To this point, there is no database for euro money market trades which is more comprehensive than e-MID. One other source of information is the EONIA

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[4]For more details on the e-MID system, see Angelini et al (2009)

panel. The EONIA (euro area overnight index average) is computed as a weighted average of all overnight unsecured lending transactions in the interbank market, initiated within the euro area by a panel of selected banks. The panel, which is the same that is used to compute EURIBOR rates, is composed by forty five large banks all headquartered in the euro area, with first class credit standards. In 2007, the average daily turnover of the EONIA panel banks was around 50 billions euro. While EONIA is an important index that serves as a benchmark for money market trades, for our purposes it is not an optimal soucre of data, given that it comprises only the very largest and most active banks, but does not allow to study the behaviour of a cross-sample of all banks.

Prima facie evidence of the emergence of asymmetric information in the euro overnight interbank market is provided by comparing the evolution of volumes in the EONIA panel with the volumes in e-MID. Prior to the turmoil (in the first half of 2007), e-MID volumes were nearly one-half of the EONIA trading volume. During the turmoil, however, overnight trading volumes in e-MID declined compared to EONIA volumes, being closer to arond one-quarter of EONIA trading volume (in the period August 2007-December 2009). One interpretation of the loss in the share of total trading is that banks, in particular borrowers, preferred to switch from an electronic dealership market - which is characterized by a high degree of transparency - to an over-the-counter bilateral market which is more opaque. In fact, banks may prefer not to reveal that they are on the borrowing side, which could lead to credit rationing. During the turmoil, banks seem to have preferred to trade in the more anonymous market (see also Angelini et al, 2009). Still, despite its limitations, at this point in time e-MID constitutes the best source of money market data that covers the entire turmoil period.

4.2 Empirical evidence on cross-border market segmentation

The hypothesis that the turmoil has had no impact on money market integration can be easily rejected. Figure 3 displays the share of cross-border trades (that is, trades where at least one counterparty was non-Italian) among all overnight trades done via e-MID. Around mid-2007, roughly with the start of the financial turbulences, the share of cross-border trades in e-MID significantly declined. In spite of this decline, during 2007, the average share of cross-border trades among
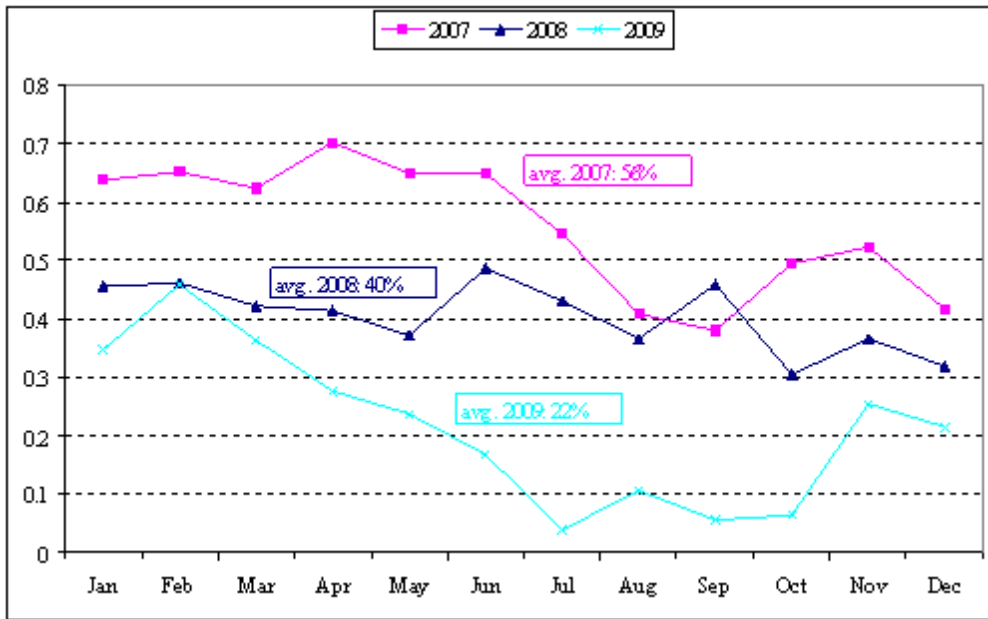
Figure 3: *Share of cross-border trading volume in e-MID*

all trades remained at 56%. During 2008, this share was only 40%, and in 2009, it declined to 22% - less than half of its earlier share. The financial turmoil has led to a severe qualitative shift from international money market activity to more domestic acticity.

This is in line with results obtained in the Euro Money Market Study (2008 and 2009), according to which the number of foreign, euro-area counterparties in unsecured trades, in relation to domestic counterparties, declined from 1.85 in 2007, to 1.44 in 2008 and a mere 1.22 in 2009. Thus, the sharp reduction in cross-border euro area trading in the money market is not specific to e-MID.

While figure 3 illustrates a near breakdown in terms of volumes on the cross-border segment in the unsecured money market, a study of volumes is not sufficient to distinguish the various equilibria in the FH model. For this, relative prices need to be analyzed as well.

Figure 4, which is based on the econometric methodology presented in the annex, displays a time series of the spread between average interest rates paid in cross-border trades and those paid in domestic trades (quarterly data). The following pattern is visible:

- Prior to the financial turmoil (i.e. up to the second quarter of 2007), the spread was hovered around zero. Banks paid the same price for a money
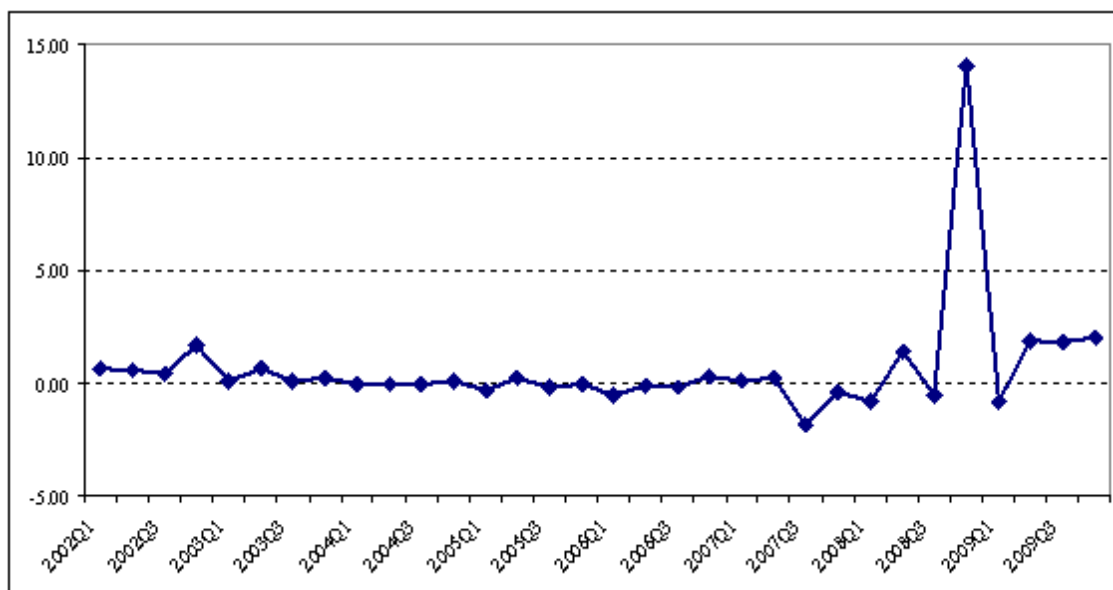
Figure 4: *Spreads between the average interest rates for cross-border trades and for domestic trades*

market transaction, irrespective of the location of either the borower or the lender.[5]

- For several quarters between the beginning of the turmoil, but prior to September 2008, the spread became negative (with one exception). This implies that a money market trade in which one counterparty was foreign was conducted at more favorable rates than one with a domestic counterparty.

- In the quarter immediately following the failure of Lehman Brothers, which exhibited most tensions, there was a sharp upward spike in the spread, implying that cross-border trades became quite expensive in relative terms. The spread of 14 basis points is even more noteworthy if one considers the extremely low level of overnight interest rates during that time period, which was around 70 basis points.

- During 2009, the spread remained positive at around 2 basis points.

Taking together the evidence on both interest rates and volumes allows us to draw conclusions on the nature of the market equibrium at different points in time,

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[5]Notice that in the first years of Eurpean Monetary Union, there was a slightly positive spread, indicating that the process of integration may still have been ongoing.

using the FH framework.

1. Between 2003 and up to July 2007, the money market was deeply integrated across member states. Cros-border lending activity was high, and there was no spread to be paid on cross-border transactions.

2. Between August 2007 and September 2008, the fully integrated equilibrium broke down. The relatively low volumes combined with the negative spread observed for cross-border trades indicates that it was replaced by a system in which only some banks operated in the euro area wide market. The fact that those banks were able to trade at a discount implies that these were banks that were either very well known, or considered as too-big-too-fail. This is in line with Freixas and Holthausen's predictions, as the risk of counterparty failure may have been perceived higher for foreign than for domestic banks, possibly due to cross-border asymmetric information. A two-tiered structure of trading activity in which some larger banks with comparatively low credit risk distribute liquidity across the euro area, thereby allowing for a continued harmonization of interest rates (Hypothesis H2b).

3. Last quarter 2008 - end 2009: In the last quarter of 2008, the further decline in volumes paired with an extreme spike in rates indicates that the role of large banks as distributors of liquidity was no longer valid. Possibly, the failure of Lehman Brothers signalled also for European banks that even large banking groups were not fully shilded from possibly bankruptcy. Instead concerns about solvency may have exacerbated asymmetric information across borders. (Hypothesis H2a)

   As spreads continued being elevated for the following quarters, albeit on a smaller level, and the share of cross-border volumes declined further, this equilibrium seems to have continued throughout all of 2009.

5   Conclusions

In this paper we explored the consequences of information asymmetry for the integration of money markets in the European context by studying transaction data from the Italian e-MID system for money market trades..

We found evidence supporting the hypothesis that during the first year of

the turmoil, a two-tier system of the money market emerged, in which smaller banks rely on liquidity provision by internationally active money center banks, and smaller banks are constrained to obtaining funds in their domestic markets. This situation marks a departure from the fully integrated money market that prevailed in the euro area before August 2007.

It is found that another equilibrium emerges in the period after the failure of Lehman Brothers: the new equilibrium is characterized by a near-breakdown of international trading activity, and foreign banks generally need to pay a premium in order to obtain funding in e-MID. All three equilibria (full integration, two-tier system, segmentation) support the findings of the model by Freixas and Holthausen, who argued that these equilibria can emerge as a result of increased informational asymmetries across borders.

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6 Annex: Econometric methodology to obtain figure 4

The econometric methodology is as follows: the regression is OLS with $t-statistics$ based on Newey-West standard errors.

Regressions underlying Table 1:

$$S_j = c + \sum_{t=2002q1}^{2009q3} \alpha_t D_t + \varepsilon_j \tag{1}$$

where S_j is the spread (or premium) for transaction j, defined as the difference between the interest rate paid in transaction j (p_j) and the prevailing interest rate on the market (P_t) at the moment transaction j takes place: $S_j = p_j - P_t$; P_t is computed as the average of the interest rate paid on the last three transactions before t and the first three transactions after t. Only transactions in a 20 minute time interval centred on t are considered; D_t are a set of quarterly dummies from the first quarter 2002 to the third quarter 2009 (for example, the dummy for the first quarter 2002 takes value 1 if S_j belongs to that quarter and 0 otherwise). Therefore, the constant captures the average spread paid by foreign banks in the forth quarter of 2009, while the coefficient of the dummies captures the marginal effect of each quarter. The average spread paid by foreign (domestic) banks in the quarter t is the sum of the constant and the coefficient of the respective dummy.

Table 1, the basis for figure 4, summarizes the results. The coefficient of the second column in Table 1 is the coefficient of the dummy in equation 1, while the spread is the sum of the coefficients plus the constant of the equation.[6]

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[6]Note: The spread is regressed on a set of quarterly dummies to capture trends. The column "Coefficient" reports the estimated coefficients for each dummy and the constant, which refers to the period October - December 2009. The column "Spread" reports the premium/discount over the prevailing interest rate paid by foreign (non Italian) banks; it is the sum of the constant plus the coefficient of the dummy for the respective semester. The analysis refers to the overnight maturity. Volumes are expressed in euro millions. Only transactions initiated by the borrower are considered (i.e. the trade is initiated by a bank posting a quote for the interest rate paid on a deposit in the e-mid trading platform). "***" ("**"/"*") indicates significance of the coefficients at 1% (5%/10%) confidence level.

Period	Coefficient	Spread
2002Q1	-1.38 ***	0.67
2002Q2	-1.48 ***	0.57
2002Q3	-1.59 ***	0.47
2002Q4	-0.39	1.67
2003Q1	-1.96 ***	0.09
2003Q2	-1.39 ***	0.67
2003Q3	-1.97 ***	0.08
2003Q4	-1.80 ***	0.26
2004Q1	-2.06 ***	-0.01
2004Q2	-2.08 ***	-0.02
2004Q3	-2.09 ***	-0.03
2004Q4	-1.94 ***	0.11
2005Q1	-2.36 ***	-0.31
2005Q2	-1.81 ***	0.24
2005Q3	-2.25 ***	-0.19
2005Q4	-2.09 ***	-0.04
2006Q1	-2.59 ***	-0.53
2006Q2	-2.14 ***	-0.09
2006Q3	-2.25 ***	-0.20
2006Q4	-1.73 ***	0.33
2007Q1	-1.92 ***	0.13
2007Q2	-1.82 ***	0.24
2007Q3	-3.90 ***	-1.85
2007Q4	-2.45 ***	-0.40
2008Q1	-2.82 ***	-0.77
2008Q2	-0.64	1.41
2008Q3	-2.54 ***	-0.48
2008Q4	11.96 ***	14.01
2009Q1	-2.83 ***	-0.78
2009Q2	-0.15	1.91
2009Q3	-0.26	1.80
2009Q4	2.05 ***	2.05

Table 1: Average spread paid by foreign (non Italian) banks when borrowing in the e-mid market.