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Interest rate pass-through in Europe and the US: Monetary policy after the financial crisis

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Abstract

We examine the interest rate transmission mechanism for the Eurozone and the USA and discuss this issue in the light of the recent financial market tensions. For an efficient monetary policy, any change in the central bank policy rate is meant to be transmitted to retail interest rates, ultimately influencing consumer and business lending rates and therefore aggregate domestic demand and output. The disaggregated GETS methodology is employed, which allows us to reveal the relative importance of the central bank and money market rates as policy vehicle variables in the two banking systems. Our empirical results for the two banking systems are rather mixed as far as it concerns the pass-through transmission and completeness. We also refer to the lessons learned prior to and after the collapse of the monetary and financial system on both sides of the Atlantic. We believe that this study has interesting policy insights and provides certain policy suggestions, which might be useful for the regulatory authorities in their attempt to monitor and reinforce monetary policy effectiveness.

JEL classification: E52; E43; C22

Keywords: Interest rate pass-through; Disaggregated general-to-specific model

1. Introduction

Standard economic theory includes monetary policy as one of the two main tools that governments can use to influence output, investment, prices and employment in any economy. Monetary

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policy can affect key macroeconomic variables through the functioning of three distinct channels, namely the interest rate channel, the bank lending channel and the broad credit channel.[1] Angeloni, Mojon, Kashyap, and Terlizzese (2002) find that the interest rate channel is the most important for monetary policy transmission in the Euro area. The adjustment of retail bank interest rates (deposit and lending rates) in response to changes in wholesale rates (central bank and interbank money market rates)[2] is a fundamental element of the interest rate transmission mechanism. For an efficient monetary policy, any change in the central bank policy rate is meant to be transmitted to retail interest rates, ultimately influencing consumer and business lending rates and therefore aggregate domestic demand and output. In effect, if the interest rate transmission is not efficient, then the required policy reaction by the monetary authorities will have to be stronger in order to achieve the same end result. The efficiency of the interest rate transmission channel has become particularly important in the context of the recent financial crisis which was erupted in August 2007 and intensified in the second half of 2008. Moreover, as money and other credit markets has been getting further intertwined over the past two decades, disruptions to the money and funding markets can have adverse macroeconomic consequences (Čihák, Harjes, and Stavrev, 2009). For all these reasons, the regular monitoring and assessment of the interest rate pass-through (PT hereafter) is critical for policymaking.

The main aim of this paper is to provide empirical evidence on the interest rate pass-through process in the Euro area and USA (the locomotives of the world economy) and to discuss this issue in the light of the recent financial market tensions. We address the question of how the monetary transmission process works in these two economies and whether their responses to interest rate dynamics are symmetric or asymmetric. We also show how rapidly and extensively changes in policy rates and market interest rates are passed on to retail bank interest rates. To the best of our knowledge it is the first attempt to make a comparative study of the efficiency of the monetary policy between the Eurozone and the USA regarding the symmetric or asymmetric responses of retail rates to wholesale rates changes. In an attempt to unveil the existence and importance of a pass-through behaviour, the disaggregated general-to-specific model (hereafter GETS) is employed. This model, which has not been used before in the relevant literature, allows us to estimate and make inferences not only about the short and long run interest rate elasticities but, as well as, for the upward/downward stickiness of the interest rate transmission mechanism. Any upward or downward change in the central bank policy rate is meant to be transmitted to retail interest rates for the monetary authorities to be able to affect consumer and business lending rates and therefore aggregate domestic demand and output. Moreover, it is important for both central bankers and Treasury Secretaries to have a precise understanding of the upward and downward degree of the interest rate pass-through in order to be able to design the appropriate monetary policy along the different phases of the business cycle.

The empirical results for the two banking systems are rather mixed as far as it concerns the wholesale rates PT transmission and completeness. In the Eurozone it is mainly the money market rate that is transmitted more effectively to the retail rates (and in particular the lending rates). Also, the interest rate PT is complete in the long run, only when the wholesale rate is the money market rate and the retail rate is the deposit rate. For the US case, it is the central bank rate rather than the money market rate that works more effectively as a policy vehicle variable. Also the interest rate PT is nearly complete in the long run only between the central bank rate and the

[1] See Mishkin (1995) and Bean, Larsen, and Nikolov (2002) for a detailed discussion of the transmission channels.

[2] The money market rate can be considered as a policy controlled variable since central bank can influence it through short-term interest rate policy.

deposit rate. Regarding the effect of an upward or downward change (symmetry hypothesis) in the policy-controlled variables to the retail rates, our results for the Eurozone indicate that banks tend to pass to depositors only the decreases of the original money market rate change and to borrowers more of its increases rather than its decreases. In contrast, in the US case banks tend to pass to depositors only the decreases of the original central bank rate change, while they pass to borrowers more of its decreases rather than its increases.

The paper is structured as follows. Section 2 offers a discussion of the importance of the interest rate policy transmission mechanism, particularly in the light of the recent financial crisis. In Section 3, a brief review of the literature on interest rate PT is presented. In Section 4, the econometric approach regarding the interest rate PT model is analysed and the empirical results are given in Section 5. Section 6 provides our final remarks and draws policy conclusions.

2. Financial crisis and the interest rate pass-through

The transmission of policy rate changes to retail bank loan and deposit rates is of utmost importance since it acts as a conduit for monetary policy. The interest rate transmission channel has become particularly important in the context of the recent financial crisis. This financial market turmoil which was generated by a drop in the value of US sub-prime loans, it was soon transferred into the US and EU banking sector (massive write-downs, losses and defaults of financial intermediaries) and jeopardised confidence among banks. One of the consequences of this development was the disturbance in the functioning of the money market, which was mirrored in a widening of the spreads between the central bank policy rates and the money market rates and between the former and the retail rates. This disturbance potentially impaired the monetary policy PT to retail rates, since many bank loan and deposit rates are linked to money market ones. As a result, the cost of credit to both firms and households declined much less than the policy rates during the crisis; credit spreads initially widened, although very recently have narrowed to some extent (see Fig. 1).

The severity of the financial crisis had repercussions to the US and EU real estate markets and eventually contributed to a marked slowdown in economic growth. The downturn in property markets was also due to the oversupply of new developments, primarily caused by the preceding speculative boom in land markets (Malpezzi & Wachter, 2005). Simultaneously, demand for new space levelled off because of the contraction in economic activity. These two facts led to decelerated property prices and refinancing of companies and households became more difficult. This was the case because banks altered their risk assessments, became more cautious, switched to tighter credit standards and more conservative lending rules (Panagopoulos & Vlamis, 2009). As a result, banks become less willing to provide loans (credit rationing) since capital values of real estate, used as collateral, started to decline after the burst of the real estate bubble (primarily in the USA, Ireland, Spain and the UK). Moreover, bank funding markets have struggled to provide liquidity across the banking sector. This was another reason that “. . .may have led many banks to increase their credit risk premia and tighten their standards for providing loans” (ECB, 2009). Consequently, the decreases in central bank rates since October 2008 hindered the transmission to bank lending rates.

ECB and the US Federal Reserve responded to pressures in credit markets by injecting liquidity in their banking systems and decreasing policy rates. They also responded to the interbank money market tensions by relaxing collateral requirements for funding from the lender of last resort. Moreover, European and US governments responded to the crisis by using public money

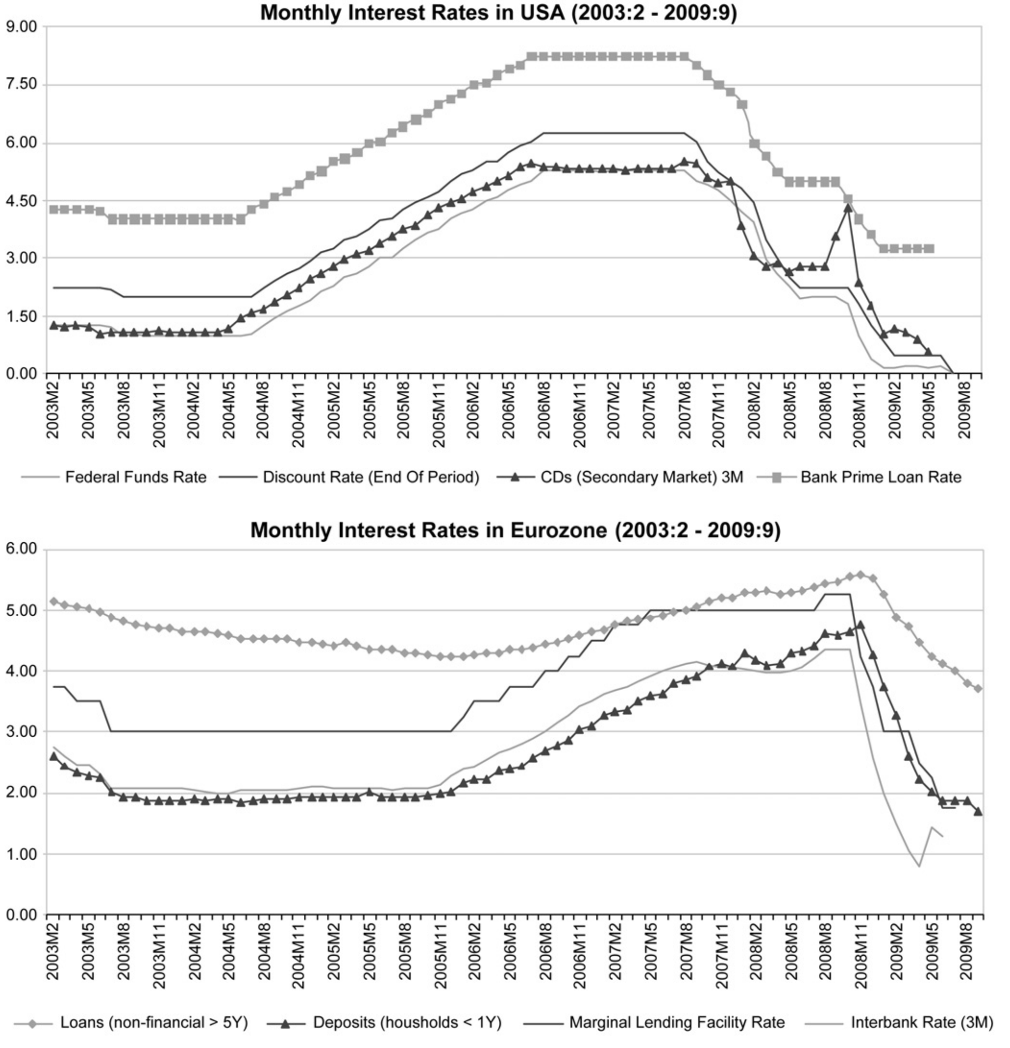

Fig. 1. Interest Rates in the US and Eurozone.

to support and recapitalise the banking sector. In October 2008, the US Congress approved a bailout programme of $700bn to purchase troubled assets from US financial institutions. The agreed Emergency Economic Stabilisation Act set out “troubled asset relief programme”, which was directed to the recapitalisation of the financial system. European Union member-states have taken certain actions to alleviate pressures on SMEs by enhancing access to credit and to support banks by purchasing preferred stocks, which were issued for this purpose. The ECB and the Federal Reserve’s liquidity management and EU and US governments’ policy measures taken throughout the crisis, seems that facilitated the functioning of the money markets as indicated by declining liquidity premia in term Euro and US money market spreads (IMF, 2008).

3. Review of the literature on interest rate pass-through

Very few studies have analysed the impact of the present crisis on monetary transmission in the Euro area and the USA. One such study by IMF (2008) reports that the PT of policy rates to market rates has been disrupted, although that affected differently the Euro area and the USA. They argue that the interest rate PT to the short-term rates has been less affected in the Euro area, while interest rate PT to the long-term ones, was much more disrupted in both the United States and the Euro area. Another study by Čihák et al. (2009), which analyses the effectiveness of ECB monetary policy in the context of the financial crisis, shows evidence that policy rate changes have still been transmitted to market rates but interest rate transmission has been less efficient. In effect, the necessary policy reaction by the monetary authorities to stabilize the economy would have to be stronger to achieve the same end result. Finally, a study by ECB (2009) points out that during the financial crisis, the bank retail interest rate PT in the Euro area has been responding relatively satisfactorily to the volatility of the Euro Interbank Offered Rate (EURIBOR) and other longer-term market rates, although less well to the volatility of the Euro Overnight Index Average (EONIA).

Although, very few studies have analysed the impact of the present crisis on monetary transmission, there is a wealth of empirical literature that deals with the transmission from the policy-controlled interest rate to the retail rates, before the eruption of the crisis (Angeloni & Ehrmann, 2003; Atesoglou, 2003; Bredin, Fitzpatrick, & O'Reilly, 2001; Burgstaller, 2003; Chionis & Leon, 2006; De Bondt, 2002; Égert, Crespo-Cuaresma, & Reininger, 2007; Fourcans & Vranceanu, 2007; Hofmann, 2006; Mojon, 2000; Petturson, 2001; Sander & Kleimeier, 2004; Toolsema, Sturm, & De Haan, 2001). It is evident from these studies that rigidities in the transmission process, significant variations across countries and non-completeness at least in some cases, exist. Regarding the degree of stickiness in different economies, recent empirics do not reach any conclusive evidence (Borio & Fritz, 1995; Cottareli & Kourelis, 1994; Donnay & Degryse, 2001; Kleimeier & Sander, 2000; Toolsema et al., 2001).

The existence of an interest rate sluggishness can be explained by the *agency costs* theory (Berger & Udell, 1992; Fried & Howitt, 1980; Stiglitz & Weiss, 1981) and the *customer switching costs* theory (Calem, Gordy, & Mester, 2006; Klemperer, 1987). Furthermore, there may be fixed *adjustment costs*, the so-called "menu costs", whenever banks decide to change retail rates (Cottareli & Kourelis, 1994; Hannan & Berger, 1991; Hofmann & Mizen, 2004). Such "menu costs" might depend on the temporal or permanent nature of policy rate changes. Additionally, interest rate sluggishness might depend on the degree of competition among banks and specifically on the concentration level of the retail market (Sander & Kleimeier, 2004; Van Leuvensteijn, Kok Sørensen, Bikker, & Van Rixtel, 2008). This is related to the so-called *bank's collusive hypothesis* (Berger & Hannan, 1989; Hannan & Berger, 1991; Neuwark & Sharpe, 1992). Finally, another explanation is provided by Hannan and Berger (1991), namely the *customer reaction hypothesis*, that is borrowers react strongly to policy rates changes if they have the bargaining power to do so.

The empirical literature on PT transmission models[3] focuses on the Error Correction Model (hereafter ECM) and the Threshold Autoregressive model.[4] Balke and Fomby (1997), Enders and

[3] For a complete survey on econometric models of asymmetric price transmission see Frey and Manera (2007).

[4] Enders and Granger (1998) and Enders and Siklos (2001) introduced the TAR models. A number of scholars applied the aforementioned methodology in interest rate PT transmission literature (see Fuertes, Heffernan & Kalotychou, 2006; Payne, 2007; Sander & Kleimeier, 2002, 2006). However, TAR models have computational difficulties and often impose *ex-ante* atheoretical restrictions.

Granger (1998) and Cramon-Taubadel (Von) and Meyer (2000), show that in the standard ECM models, tests for unit roots and co-integration have low power in the presence of asymmetric adjustment. This happens because such tests implicitly assume symmetric and linear adjustment processes. Bachmeier and Griffin (2003) and Rao and Rao (2008) presented an alternative dynamic approach originating from the LSE-Hendry general to specific methodology (Hendry, Pagan, & Sargan, 1984; Hendry, 1987; Hendry and Krolzig, 2005). The two main advantages of this approach are: (i) it can jointly and simultaneously test for short-run and long-run rigidities within the same PT dynamic model (Rao and Singh, 2006) and (ii) it can be used to test the existence of symmetric or asymmetric transmission behaviour (disaggregated GETS) between the examined variables.

4. Econometric methodology:the LSE-Hendry general-to-specific model

The interest rate PT literature is mainly related to the way central bank rate (CB hereafter) and/or interbank money market rate (MM hereafter) are transmitted to the retail rates (deposit and lending). Such PT interest rate equations usually take the following simple algebraic form:

$$i_{R,t} = c + \sum_{j=1}^{k} k \times i_{R,t-j} + \sum_{i=1}^{n} \phi \times i_{W,t-i} + e_t \tag{1}$$

where $i_{R,t}$, stands for the different kinds of loan and deposit rates and $i_{W,t}$, stands for the CB or MM rates and

$$\Delta i_{R,t} = c + \sum_{j=1}^{k} \rho \times \Delta i_{R,t-j} + \sum_{i=1}^{n} \lambda \times \Delta i_{W,t-i} - \theta \times e_{t-1} + u_t \tag{2}$$

There are two main theoretical issues which are worth examining. First, the long-run and short-run interest rate rigidities (the φ's and the λ's coefficients in Eqs. (1) and (2), respectively) from the wholesale to the retail market rates and second, the speed of retail rates adjustment initiated from the wholesale interest rate changes (the θ coefficient of the error correction term in Eq. (2)). However in the simple ECM (Eq. (2)) the retail rates and the speed of adjustment coefficient (θ) cannot be analysed separately when the wholesale rates are increasing or decreasing. The disaggregated GETS model tackles the above issues.

We know from the literature that a simple aggregate dynamic Granger–Engle Vector Error Correction (*VECM)* model has the following form:

$$\Delta i_{R,t} = \mu + \sum_{i=1}^{n1} \beta_{R,t-i} \Delta i_{R,t-i} + \sum_{i=0}^{n2} \beta_{W,t-i} \Delta i_{W,t-i} + \pi_1 Z_{t-1} + e_t \tag{3}$$

where $i_{W,t}$ and $i_{R,t}$ are the wholesale and retail interest rates, respectively. The Z_{t-1} term is the error correction term. The disaggregated *VECM* model can be presented in the following form:

$$\Delta i_{Rt} = \mu + \sum_{i=0}^{n1} \beta_{Rt}^{-} \Delta i_{R,t-i}^{-} \sum_{i=1}^{n2} \beta_{Wt}^{-} \Delta i_{W,t-i}^{-} + \pi_1^{-} Z_{t-1} + \sum_{i=0}^{n3} \beta_{Rt}^{+} \Delta i_{R,t-1}^{+}$$
$$+ \sum_{i=1}^{n4} \beta_{Wt}^{+} i_{W,t-i}^{+} + \pi_2^{+} Z_{t-1} + \varepsilon_t \tag{4}$$

As Rao and Rao (2008) pointed out, the (+)/(−) superscript on the coefficients indicate a positive/negative change in the variables included in the model. On the one hand, for any positive change ($\Delta i_{W,t} > 0$) in the independent variable, a corresponding response of all positive coefficients (β^{+}, π^{+}) is expected. On the other hand, the corresponding negative coefficients (β^{-}, π^{-}) will respond in any negative change of the dependent variable ($\Delta i_{W,t} < 0$).[5] Moving a step forward, the disaggregated GETS model could be presented in the following form:

$$\Delta i_{R,t} = \sum_{i=1}^{j1} \beta^{-}_{R,t} \Delta i^{-}_{R,t-i} + \sum_{i=0}^{j2} \beta^{-}_{W,t} \Delta i^{-}_{W,t-i} + \theta^{-}(i_{R,t} - \varphi_0 - \varphi_1 i_{W,t} - \varphi_2 T)_{t-1}$$

$$+ \sum_{i=0}^{j3} \beta^{+}_{W,t} \Delta i^{+}_{W,t-i} + \sum_{i=1}^{j4} \beta^{+}_{R,t} \Delta i^{+}_{R,t-i} + \theta^{+}(i_{R,t} - \varphi_0 - \varphi_1 i_{W,t} - \varphi_2 T)_{t-1} + \xi_t \quad (5)$$

where θ^{-} and θ^{+} are the speed of adjustment coefficients in the positive and negative case, respectively and T the time trend. Alternatively, Eq. (5) can be rearranged in the following way (Rao and Rao, 2008):

$$\Delta i_{R,t} = \gamma_o + \gamma_1 T + \sum_{i=1}^{j1} \beta^{-}_{R,t} \Delta i^{-}_{R,t-i} + \sum_{i=0}^{j2} \beta^{-}_{W,t} \Delta i^{-}_{W,t-i} + \theta^{-}(i_{R,t} - \varphi_0 i_{W,t})_{t-1}$$

$$+ \sum_{i=0}^{j3} \beta^{+}_{W,t} \Delta i^{+}_{W,t-i} + \sum_{i=1}^{j4} \beta^{+}_{R,t} \Delta i^{+}_{R,t-i} + \theta^{+}(i_{R,t} - \varphi_1 i_{W,t})_{t-1} + \xi_t \quad (5a)$$

The choice between the two disaggregated GETS models (5) and (5a) depends on the performance and plausibility of the estimation results.

The main advantages of the disaggregated GETS model include: (i) its capability of estimating both negative and positive short-run elasticities[6] (e.g. the $\beta^{-}_{W,t}$ and $\beta^{+}_{W,t}$ in Eqs. (5) and (5a)) and (ii) the direct and simultaneous estimation of the long-run (φ_1 or alternatively $\varphi_0 + \varphi_1$) and the short-run price transmission rigidities in the same model. Thus, using a GETS model two different impact multipliers (a negative and a positive one), two interim multipliers and two different speed of adjustments, can simultaneously be estimated.

Data used for the two countries are collected from the International Financial Statistics produced by the International Monetary Fund (see Appendix A for a discussion of data). Before we proceed to the disaggregated GETS model implementation, it is necessary to trace the number of co-integrated vectors (r) between the dependent and the independent variable by using the Johansen's methodology (Johansen, 1995). The number of the existing co-integrating vectors from the Johansen's process, is sensitive to the number of lagged variables (n) of the initial vector (see Karfakis, 2004). Due to this sensitivity five different lag selection criteria will be applied. These include the modified Likelihood Ratio test statistic, the Final Prediction Error test, the Akaike, the Schwarz and the Hannan–Quinn information criteria. In most of the examined cases

[5] In econometric terms the corresponding "activation" will be triggered in eq. 4 with the help of dummy variables. More specifically, all positive coefficients will take the value of 1 when a positive change in the dependent variable occurs and will be zero otherwise.

[6] The ability of testing both negative and positive short-run pass through elasticities ($\beta^{-}_{W,t}$ and $\beta^{+}_{W,t}$) in the same model is actually enriching the Cottareli and Kourelis (1994) pass through interest rates multipliers with positive and negative values.

the aforementioned selection criteria do not all agree about the optimal lag length. In each case, the majority rule is applied as a sub-optimal solution.[7]

5. Empirical results

We employ the Johansen (1995) methodology on testing the existence of a long-run relationship among retail and wholesale rates in the Eurozone and USA. According to the eigenvalue and trace tests in all the bivariate cases, there is a unique co-integrated vector of order 1 ($r = 1$), which supports the hypothesis that interest rates in the Eurozone tend to co-integrate pairwise (see Table 1 in Appendix B). For the US case the same tests were implemented and it is found that a unique co-integrated vector exists only between the money market rate and the deposit rate (see Table 2 in Appendix B).

5.1. Speed of adjustment estimates and the degree of pass-through completeness

With the wholesale rates and retail rates integrated of the same order, we estimate the disaggregated GETS model[8] for the two types of interest rates in the Eurozone. According to Table 3, column 2, the coefficients of the two error correction terms θ^+ and θ^-, are statistically significant (although the speed of adjustment in both cases are quite low) when the wholesale rate is the CB rate (i_{CB}) and the retail rate is the loan rate (i_L). This means that CB rate increases and decreases are both transmitted to the loan rate. Also, the θ^+ and θ^- coefficients are statistically significant when the wholesale rate is the MM rate (i_{MM}) and the retail rate is the loan rate (i_L) (Table 3, column 4). Again, this implies that MM rate increases and decreases are both transmitted on the loan rate. The magnitude of θ^+ is roughly five times higher (in absolute terms) than that of θ^- (−0.59 and −0.12 respectively). Lastly, when the wholesale rate is the MM rate (i_{MM}) and the retail rate is the deposit rate (i_D) (Table 3, column 3) only the θ^- coefficient is statistically significant, which means that only the downward PT transmission is operative in this case. The speed of adjustment θ^- is relatively high (−0.45). It is evident from the above results that the MM rate is transmitted to both deposit and loan rates while the CB rate is transmitted to the loan rate alone. Our findings show that MM rate compared to the CB rate is more effective as a policy vehicle variable in the Eurozone.

We continue our analysis by examining the degree of PT completeness between the two types of interest rates in the Eurozone. Coefficient ϕ_1 (in Eqs. (5) and (5a)) measures the degree of pass-through. Complete PT exists when $\phi_1 = 1$, which implies that all of the change in the policy-vehicle rate (either CB or MM) is transmitted to the retail rates. In the Eurozone, the interest rate PT is complete in the long run (0.97) and statistically significant when the wholesale rate is the MM rate (i_{MM}) and the retail rate is the deposit rate (i_D) (Table 3, column 3 and Table 5). In contrast, ϕ_1 is 0.48, when the CB is the policy-controlled interest rate and 0,42 when the MM is the policy-vehicle variable, which indicates an incomplete PT to the loan rates (Table 3, columns 2 & 4 and Table 5). In other words, not all of the change in the policy rate is transmitted to the loan rates. Lastly, most of the impact multipliers are statistically insignificant.

As far as USA is concerned, we also estimate the disaggregated GETS model for the two types of interest rates. According to Table 4, column 1, the coefficients of the two error correction terms

[7] Results about the optimal lag structure using the five different selection criteria are available from the authors upon request.

[8] This model is estimated with Non-Linear Least Squares method.

θ^{+} and θ^{-}, are statistically significant (although the speed of adjustment in both cases are quite low) when the wholesale rate is the CB rate (i_{CB}) and the retail rate is the deposit rate (i_D). The magnitude of θ^{-} is roughly ten times higher (in absolute terms) than that of θ^{+} (−0.10 and −0.01 respectively). Also, the θ^{+} and θ^{-} coefficients are statistically significant when the wholesale rate is the CB rate (i_{CB}) and the retail rate is the loan rate (i_L) (Table 4, column 2). Overall, this implies that CB rate increases and decreases are both transmitted to the deposit and loan rates. Lastly, it is evident from Table 4 (columns 3 and 4) that the MM rate is not transmitted to the retail rates, which probably shows that the MM rate does not work effectively as a policy vehicle variable in the USA.

We continue our analysis by examining the degree of PT completeness between the two types of interest rates in the USA. The interest rate PT is nearly complete in the long run (0.67) and statistically significant, when the wholesale rate is the CB rate and the retail rate is the deposit rate (i_D) (Table 4, column 1 and Table 6). In contrast, ϕ_1 is 0.49, when the CB is the policy-controlled interest rate and 0,42 when the MM is the policy-vehicle variable (Table 4, columns 2 & 4 and Table 6), which indicates that not all of the change in the policy rate is transmitted to the loan rates. Lastly, most of the impact multipliers are statistically insignificant.

5.2. *Testing the symmetry hypothesis*

Lastly, we ask what is the effect of an upward or downward change in the policy-controlled variables to the retail rates in the two banking systems. More specifically, we test the symmetry hypothesis that $\theta^{+}=\theta^{-}$. The existence of symmetric speed of adjustment is tested by using the Wald χ^2-test.

We present the results for the Eurozone in Table 7. On the one hand, when the wholesale rate is CB rate (i_{CB}) and the retail rate is the loan rate (i_L), a symmetry exists, that is $\theta^{+}=\theta^{-}$. This means that banks tend to pass to borrowers equally the decreases and increases of the original CB rate change. On the other hand, when the wholesale rate is the MM rate (i_{MM}) and the retail rate is the deposit rate (i_D) it seems that there is only a negative asymmetry which means that banks tend to pass to depositors only decreases of the original MM rate change. The magnitude of the decrease of the deposit rate in this case is given by the long run elasticity which, as we saw in Table 5, is 0.97. Since only θ^{-} is statistically significant (negative asymmetry), we can infer that for a 1% decrease in the MM rate, banks pass to depositors 0.97 of that decrease. Lastly, when the wholesale rate is the MM rate (i_{MM}) and the retail rate is the loan rate (i_L) it seems that the positive asymmetry is stronger than the negative one. This means that banks tend to pass to borrowers more of the increases of the original MM rate change rather than its decreases.

Our empirical tests regarding the symmetry hypothesis in the USA (Table 8) shows that, when the wholesale rate is the CB rate (i_{CB}) and the retail rate is the deposit rate (i_D), there is only a negative asymmetry, which means that banks tend to pass to depositors only decreases of the original CB rate change. The magnitude of the decrease of the deposit rate in this case is given by the long run elasticity which, as we saw in Table 5, is 0.67. Since only a negative asymmetry (θ^{-} is statistically significant) is observed, we can infer that for a 1% decrease in the CB rate, banks pass to depositors 0.67 of that decrease. Additionally, when the wholesale rate is the CB rate (i_{CB}) and the retail rate is the loan rate (i_L), it seems that the negative asymmetry is stronger than the positive one. This means that banks tend to pass to borrowers more of the decreases of the original CB rate change rather than its increases.

Such behaviour is theoretically consistent with the *customer reaction hypothesis* regarding the loan market in the USA (Hannan & Berger, 1991). It is also in line with the *bank's col-*

lusive hypothesis regarding the deposit and loan markets in the Eurozone (Berger & Hannan, 1989; Hannan & Berger, 1991; Neuwark & Sharpe, 1992). The speed of retail rates adjustment can be interpreted as the commercial bank managers' power to transmit to their clients any wholesale rate changes. Such speed is possibly affected by the degree of the retail market competitiveness in the banking sector. For example, in a competitive banking environment, the deposit rates are expected to be raised by the bank managers, in response to wholesale rates increases. The asymmetry results for the Eurozone and USA might be explained by this framework. As far as the European banking sector is concerned, where the *bank's collusive hypothesis* seems to prevail, bank managers are eager to transmit money market rate decreases/increases to depositors/borrowers. Our results for the US banking sector, where the *customer reaction hypothesis* dominates, show that bank managers are happy to transmit central bank rate decreases to borrowers and are equally happy to transmit only part of the central bank rate decreases to depositors.

6. Conclusions and policy suggestions in the context of the financial crisis

This study focuses on how the interest rate PT works in the Eurozone and the USA. It is the first attempt to make a comparative study for the Eurozone and the US in an effort to unveil the existence and importance of an interest rate PT behaviour. The disaggregated GETS methodology is employed, which allows us to reveal the relative importance of the central bank and money market rates as policy vehicle variables in the two banking systems. Our empirical results for the two banking systems are rather mixed as far as it concerns the wholesale rates PT transmission and completeness. We believe though that these results can be useful for the European and US regulatory authorities in their attempt to monitor the competitiveness of their banking systems and reinforce monetary policy effectiveness.

The interest rate transmission channel has become particularly important in the context of the recent financial crisis that led to a disturbance in the functioning of the money markets both in the US and the Eurozone. As a result, the efficiency of the monetary policy transmission in the two regions has been disrupted and this was mirrored in a widening of the spreads between the central bank policy rates and the money market rates as well as between the former and the retail rates. Active policies from the central bank authorities and regulators' end, were rendered essential for the monetary transmission mechanism to be restored. There are a number of lessons to be learned prior to and after the collapse of the monetary and financial system on both sides of the Atlantic. Necessary policy measures to be taken in similar financial crisis in the future, should involve: active liquidity management from the central bank authorities, financial institution and market regulation, central bank cooperation and information dissemination and fiscal policy (Chailloux, Gray, & McCaughrin, 2008). Specifically, central banks should have a properly designed strategy, accurately executed, for channelling liquidity in the financial system and thus restoring the smooth monetary transmission. Such strategy could possibly include indirect measures, for example money market support by exchanging treasury bills for other types of securities used as collateral. Having said that, the "lender of last resort" role of the central bank should not be exaggerated during periods of liquidity stress. Emergency liquidity facilities should be used with caution by the market participants to ensure that banks do not become overly dependent on central bank support and avoid the associated "moral hazard" problem.

Secondly, various quantitative regulations should be put forward by the supervisory authorities and central banks, to ensure prudent lending practices. More specifically, rules can be imposed regarding the size of the loan-to-value ratios and the use of periodic and frequent property valuation used as collateral (Panagopoulos and Vlamis, 2009). The un-controlled 'structured finance' industry (credit default swaps, collateralised debt obligations, collateralised loan obligations, asset-backed securities, collateralised debt obligations) as well as the hedge fund and the private equity industries, should be regulated and brought under strict supervision of securities and exchange commissions. It has been suggested by OECD (2008) that re-regulation of international financial markets is necessary to include coverage of both financial products and institutions and to identify and prevent excessive risk-taking behaviour from the market participants' end. EU authorities responded to the new challenges by creating (i) the European Systemic Risk Council, (ii) supervisory colleges, and (iii) taking the initiative to create a single European rule book applicable to all financial institutions. As far as it concerns the response of the G20, they decided to rename and upgrade the former Financial Stability Forum into the newly established Financial Stability Board, which will provide early warning of macroeconomic and financial risks as well as the necessary actions needed to address them.

Third, during a period of financial distress it becomes even more important to establish information sharing between central banks in order to enhance collaboration and frequent communication between them (IMF, 2008). Also, central banks should provide more information to economic agents in order to maintain the smooth functioning of the markets. Last but not least, when markets face liquidity crises, fiscal authorities need to work closely with central bank, without jeopardising its independence, to design the optimal fiscal-monetary policy mix to achieve price and output stability.

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Appendix A. Presentation of data

We use monthly data for the USA and the Eurozone but the examined time period is not identical for the two banking systems. In the case of USA the time period ranges between 1994:1 and 2007:9 while in the Eurozone the time period is rather limited (1998:1–2003:9). In the case of USA the "discount rate" and the "federal fund rate" are used as the central bank rate and the money market rate, respectively. Concerning the retail rates, we use the "3-month certificate of deposits" and the "bank prime loan rate" as proxies for the deposit and lending rates. In the Eurozone the "margin lending facility rate" is used as the central bank rate and the "interbank rate (3-month maturity)" is used as the money market rate. As far as is it concerns the retail rates, we use the "deposit rate" and the "lending rate", correspondingly.

Appendix B. Empirical tables

See Tables 1–8.

Table 1
The Johansen pairwise co-intregration tests in Eurozone.

Causality test	No. of lags	Rank	Max. eigenvalue	Trace	No. of co-integrating vectors (of r order)
i_{CB} vs. i_D	(2)	$r=0$	29.22	30.65	$r=1$
		$r\leq 1$	1.43	1.43	
i_{CB} vs. i_L	(2)	$r=0$	23.49	26.50	$r=1$
		$r\leq 1$	3.00	3.00	
i_{mm} vs. i_D	(1)[a]	$r=0$	19.33	21.78	$r=1$
		$r\leq 1$	2.44	2.44	
i_{mm} vs. i_L	(1)[a]	$r=0$	14.67	17.67	$r=1$
		$r\leq 1$	2.71	2.71	

The critical value for accepting that $r=1$ at the 5% level for both the maximum eigenvalue test and the trace test is 3.84.

Table 2
The Johansen pairwise co-intregration tests in USA.

Causality test	No. of lags	Rank	Max. eigenvalue	Trace	No. of co-integrating vectors (of r order)
i_{CB} vs. i_D	(2)	$r=0$	7.04	9.17	$r=0$
		$r\leq 1$	2.13	2.13	
i_{CB} vs. i_L	(2)	$r=0$	6.04	9.32	$r=0$
		$r\leq 1$	3.28	3.28	
i_{mm} vs. i_D	(2)	$r=0$	6.04	9.32	$r=1$
		$r\leq 1$	3.28	3.28	
i_{mm} vs. i_L	(2)	$r=0$	9.42	12.07	$r=0$
		$r\leq 1$	2.65	2.65	

The critical value for accepting that $r=1$ at the 5% level for both the maximum eigenvalue test and the Trace test is 3.84.

Table 3
The Eurozone banking system.

Independent variable	Central bank (i_{CB}) rate		Money market (i_{mm}) rate	
Dependent variable	Deposit rate (i_D)	Loan rate (i_L)	Deposit rate (i_D)	Loan rate (i_L)
C.V. (r)[a]	$r=1$	$r=1$	$r=1$	$r=1$
	(1)	(2)	(3)	(4)
Regressor	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios
$\Delta i^{+}_{D,t-1}$	0.50 (3.63)	–	0.66 (2.98)	–
$\Delta i^{-}_{D,t-1}$	−1.26 (−1.36)	–	−0.26 (−0.95)	–
$\Delta i^{+}_{D,t-2}$	0.08 (0.63)	–	–	–
$\Delta i^{-}_{D,t-2}$	−0.62 (−0.61)	–	–	–
$\Delta i^{+}_{L,t-1}$	–	0.47 (3.04)	–	0.01 (0.07)
$\Delta i^{-}_{L,t-1}$	–	1.50 (2.80)	–	0.43 (2.53)
$\Delta i^{+}_{L,t-2}$	–	0.03 (0.22)	–	–
$\Delta i^{-}_{L,t-2}$	–	−0.04 (−0.07)	–	–
$\Delta i^{+}_{CB,t-1}$	0.05 (0.67)	0.009 (0.22)	–	–
$\Delta i^{-}_{CB,t-1}$	1.70 (2.58)	0.27 (1.11)	–	–
$\Delta i^{+}_{CB,t-2}$	0.02 (0.27)	0.001 (0.04)	–	–
$\Delta i^{-}_{CB,t-2}$	1.47 (1.65)	−0.39 (−2.15)	–	–
$\Delta i^{+}_{MM,t-1}$	–	–	0.06 (0.42)	−0.08 (−1.32)
$\Delta i^{-}_{MM,t-1}$	–	–	0.44 (1.70)	0.10 (2.05)
$\Delta i^{+}_{MM,t-2}$	–	–	–	–
$\Delta i^{-}_{MM,t-2}$	–	–	–	–

Table 3 (*Continued*)

Independent variable	Central bank (i_{CB}) rate		Money market (i_{mm}) rate	
Dependent variable	Deposit rate (i_D)	Loan rate (i_L)	Deposit rate (i_D)	Loan rate (i_L)
C.V. (r)[a]	$r=1$	$r=1$	$r=1$	$r=1$
	(1)	(2)	(3)	(4)
Regressor	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios
θ^+	−0.01 (−0.848)	−0.29 (−3.01)	0.20 (1.60)	−0.59 (−4.52)
θ^-	0.25 (1.13)	−0.30 (−3.09)	−0.45 (−2.37)	−0.12 (−2.08)
ϕ_0 (or γ_0)	1.32 (0.66)	0.32 (3.12)	−0.20 (−2.74)	1.27 (57.07)
ϕ_1	0.04 (0.04)	0.48 (15.75)	0.97 (20.07)	0.42 (26.01)
T (time)	–	–	−0.0001 (−0.33)	0.0006 (3.44)
R^2	0.79	0.72	0.66	0.74

For the determination of the optimal lag structure the following information criteria are used: the *modified Likelihood Ratio* test, the *Final Prediction Error* test, the *Akaike* Information Criterion, the *Schwarz* Information Criterion and the *Hannan-Quinn* information criterion.

[a] This is the number of co-integrating vectors of an r order.

Table 4
The US banking system.

Independent variable	Central bank (i_{CB}) rate		Money market (i_{mm}) rate	
Dependent variable	Deposit rate (i_D)	Loan rate (i_L)	Deposit rate (i_D)	Loan rate (i_L)
C.V. (r)[a]	$r=0$	$r=0$	$r=1$	$r=0$
	(1)	(2)	(3)	(4)
Regressor	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios	Coefficients – t-ratios
$\Delta i^+_{D,t-1}$	0.50 (4.61)	–	0.36 (2.14)	–
$\Delta i^-_{D,t-1}$	0.84 (4.11)	–	0.50 (2.33)	–
$\Delta i^+_{D,t-2}$	0.12 (1.32)	–	−0.06 (−0.41)	–
$\Delta i^-_{D,t-2}$	−0.31 (−0.93)	–	0.05 (0.26)	–
$\Delta i^+_{L,t-1}$	–	0.35 (3.66)	–	0.02 (0.15)
$\Delta i^-_{L,t-1}$	–	0.67 (2.68)	–	0.27 (1.00)
$\Delta i^+_{L,t-2}$	–	0.17 (1.99)	–	0.15 (0.84)
$\Delta i^-_{L,t-2}$	–	−0.41 (−1.08)	–	0.13 (0.49)
$\Delta i^+_{CB,t-1}$	−0.0004 (−0.01)	−0.01 (−0.87)	–	–
$\Delta i^-_{CB,t-1}$	−0.33 (−1.83)	−0.16 (−1.97)	–	–
$\Delta i^+_{CB,t-2}$	−0.02 (−0.81)	−0.01 (−0.97)	–	–
$\Delta i^-_{CB,t-2}$	0.32 (1.43)	0.10 (0.67)	–	–
$\Delta i^+_{MM,t-1}$	–	–	0.20 (1.45)	0.13 (1.51)
$\Delta i^-_{MM,t-1}$	–	–	0.01 (0.07)	0.17 (1.49)
$\Delta i^+_{MM,t-2}$	–	–	0.07 (0.65)	−0.003 (−0.04)
$\Delta i^-_{MM,t-2}$	–	–	0.03 (0.24)	−0.005 (−0.41)
θ^+	−0.01 (−1.50)	−0.03 (−2.20)	0.000005 (0.00004)	−0.07 (−1.39)
θ^-	−0.10 (−2.42)	−0.06 (−4.15)	−0.000006 (−0.00004)	−0.08 (−1.61)
ϕ_0 (or γ_0)	0.02 (1.54)	0.05 (2.75)	−478.9	0.11 (1.61)
ϕ_1	0.67 (3.81)	0.49 (6.01)	1465.6 (0.00004)	0.42 (9.26)
T (time)	−0.00006 (−0.77)	−0.00009 (−1.12)	8.22 (0.00004)	−0.000004 (−1.18)
R^2	0.49	0.61	0.45	0.55

For the determination of the optimal lag structure the following information criteria are used: the modified Likelihood Ratio test, the *Final Prediction Error* test, the *Akaike* Information Criterion, the *Schwarz* Information Criterion and the *Hannan-Quinn* information criterion.

[a] This is the number of co-integrating vectors of an r order.

Table 5
EU rigidities estimates.

Dependent variable	*P–T* variable	*L–R* rigidities (ϕ_1)
Deposit rates ($\Delta i_{D,t}$)	$\Delta i^{+}_{CB,t-1}$ $\Delta i^{-}_{CB,t-1}$	0.04
Loan rates ($\Delta i_{L,t}$)	$\Delta i^{+}_{CB,t-1}$ $\Delta i^{-}_{CB,t-1}$	0.48
Deposit rates ($\Delta i_{D,t}$)	$\Delta i^{+}_{MM,t-1}$ $\Delta i^{-}_{MM,t-1}$	0.97
Loan rates ($\Delta i_{L,t}$)	$\Delta i^{+}_{MM,t-1}$ $\Delta i^{-}_{MM,t-1}$	0.42

Table 6
US rigidities estimates.

Dependent variable	*P–T* variable	*L–R* rigidities (ϕ_1)
Deposit rates ($\Delta i_{D,t}$)	$\Delta i^{+}_{CB,t-1}$ $\Delta i^{-}_{CB,t-1}$	0.67
Loan rates ($\Delta i_{L,t}$)	$\Delta i^{+}_{CB,t-1}$ $\Delta i^{-}_{CB,t-1}$	0.49
Deposit rates ($\Delta i_{D,t}$)	$\Delta i^{+}_{MM,t-1}$ $\Delta i^{-}_{MM,t-1}$	[a]
Loan rates ($\Delta i_{L,t}$)	$\Delta i^{+}_{MM,t-1}$ $\Delta i^{-}_{MM,t-1}$	0.42

[a] The estimated number does not have an economic meaning and that is why we do not report it.

Table 7
The asymmetry results in Eurozone.

Model	Hypothesis H_0: ($\theta^{+}=\theta^{-}$)[a]	Result
i_{CB} vs. i_D	Both θ^{+} & θ^{-} are statistically insignificant	–
i_{CB} vs. i_L	1.08 (accept H_0)	Symmetry
i_{mm} vs. i_D	Only the negative change is statistically significant	Negative asymmetry
i_{mm} vs. i_L	10.12 (reject H_0)	Positive asymmetry

[a] We test the symmetry hypothesis by applying the Wald (χ^2) test. The critical value of χ^2 statistic with one degree of freedom is 3.84 (5% confidence interval) and 5.02 (2.5% confidence interval).

Table 8
The asymmetry results in USA.

Model	Hypothesis H_0: ($\theta^{+}=\theta^{-}$)[a]	Result
i_{CB} vs. i_D	Only the negative change (θ^{-}) is statistically significant	Negative asymmetry
i_{CB} vs. i_L	36.35 (Reject H_0)	Negative asymmetry
i_{mm} vs. i_D	Both θ^{+} & θ^{-} are statistically insignificant	–
i_{mm} vs. i_L	Both θ^{+} & θ^{-} are statistically insignificant	–

[a] We test the symmetry hypothesis by applying the Wald (χ^2) test. The critical value of χ^2 statistic with one degree of freedom is 3.84 (5% confidence interval) and 5.02 (2.5% confidence interval).

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