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Why Did Bank Lending Rates
Diverge from Policy Rates After the
Financial Crisis?

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Why Did Bank Lending Rates Diverge from Policy Rates After the Financial Crisis?[1]

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Abstract

After the global finance crisis short-term policy rates were cut to near-zero levels, yet, bank lending rates did not fall as much as the decline in policy rates would have suggested. If the crisis represents a structural break in the relationship between policy rates and lending rates, how should central banks view the post-crisis transmission of policy to lending rates? This poses a major puzzle for monetary policymakers. Using a new weighted average cost of liabilities to measure banks' effective funding costs we show a model of interest rate pass-through with dynamic panel data methods solves this puzzle, and has many other advantages over policy rates. It suggests central banks should focus on the cost of bank liabilities more broadly to understand the dynamics of lending rates.

JEL: E43, E52, G21

Keywords: lending rates, policy rates, panel cointegration, financial crisis

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1.   **Introduction**

The global financial crisis prompted central banks in many countries to cut short-term policy rates to near zero levels after the Lehman collapse in September 2008. Based on the pre-crisis relationship between bank lending rates on mortgages or loans to businesses with policy rates, it would have been reasonable to expect lending rates to have fallen by similar amounts. But examination of the lending rates reveals they did not fall that much, indeed in some peripheral European countries the lending rates rose (Von Borstel et al., 2015). In addition, the margins over policy rates widened as policy rates fell (see Graph 1).[2] Inevitably this has raised the question of whether banks were taking advantage of the low interest rate environment by failing to pass on lower rates to loans.[3] It also poses the question whether a structural break has occurred in the relationship between policy rates and lending rates set by banks requiring a re-evaluation of the determinants of lending rates. Central banks now puzzle over whether the transmission between policy actions and lending rates needs to be revisited in the light of an apparent disconnect between the two (see ECB, 2012; Beirne, 2012; ECB, 2013; Hristov et al., 2014; Von Borstel et al., 2015). The behaviour of bank lending rates during a period when the monetary stance was exceptionally loose but sovereign and credit risk were elevated has now become a major policy issue for European central banks (see Albertazzi et al 2012; Goggin et al. 2012; Arnold and van Ewijk, 2014; Darracq-Paries et al. 2014; De Sola Perea and Van Nieuwenhuyze, 2014; Holton and Rodriguez, 2015), not least because many countries in Europe have a high degree of bank dependence.[4] In this paper we present evidence that that a new weighted average cost of liabilities measure reflecting the actual funding costs of banks has a more stable relationship with bank lending rates that does not break down after the crisis. This can explain why lending rates have remained high while policy rates fell.

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[2] Comparing the average margins on short-term and long-term loans to small business for nine Euro area countries, Denmark and the United Kingdom in the pre-crisis (January 2003 – August 2008) and post-crisis period (September 2008 – April 2014) shows that they rose by 19.5%, while margins on short-term and long-term mortgage loans rose by 41.8% and 37.5% respectively.

[3] For example, Arestei and Gallo (2014) argue that since the financial crisis greater risk and high volatility has decreased the influence of policy rates (or market rates which they use as a proxy for policy rates) over lending rates. They then conclude that this reflects 'opportunistic behaviour by banks, which [have taken] advantage of the reduction in official interest rates without transferring these benefits to borrowers'. (p292, Arestei and Gallo, 2014).

[4] Bank loans comprise some 50 percent of loans to firms and 90 percent of loans to households according to Von Borstel et al (2015).

The main contribution of the paper is to focus attention on the whole range of liabilities that banks use to acquire funds (see Adrian et al. 2013; Turner, 2013) and to compare lending rates to this weighted-average cost of liabilities. We devote the first part of the paper to careful construction of a weighted average cost of liabilities for banks, which reflects the increase in the cost of funds that they have experienced. We then investigate the relationship between lending rates, bank funding costs and policy rates over the period 2003 – 2014 for European countries in the euro area (Austria, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain) and those outside of the euro area (Denmark and the United Kingdom) using state-of-the-art non-stationary dynamic heterogeneous panel model initially developed by Peseran and Smith (1995) and Peseran, Shin and Smith (1999) but more recently extended by Pesaran (2006) and Chudik and Pesaran (2015). Previous panel VAR models of interest rate pass through c.f. Sorensen and Werner (2006), and Hristov et al. (2014) have evidence of incomplete pass through but do not take into account cross-country dependence between countries as we do, which is likely to be more important in the most recent period of financial and sovereign debt crises (see Von Borstel et al., 2015).

Our paper establishes that the lending rates, policy rates and funding costs co-move in the period up to the crisis, but after extending the sample to include the crisis, we show the relationship between lending rates and policy rates breaks down. This relationship cannot be restored by allowing for structural breaks at the time of the crisis. But the relationship between lending rates and funding costs is stable for the full sample, spanning the pre-crisis *and* post-crisis periods, supporting the pass through findings by Holton and Rodriguez (2015) and Von Borstal et al. (2015). [5] Tests of robustness reveal a stable relationship but some small reduction in the reported pass-through coefficients by about 10 percent as we progressively

extend sample into the post-crisis period, and a more substantial reduction by about 33 percent in the speed of adjustment.

How do we explain these results? Our contention is that while policy rates were a reasonable proxy for funding costs in the pre-crisis period, because liquidity and counterparty risks were low and stable, they ceased to be a good proxy for funding costs once the financial crisis occurred (see Albertazzi et al 2012; Goggin et al. 2012; Arnold and van Ewijk, 2014; De Sola Perea and Van Nieuwenhuyze, 2014; Holton and Rodriguez, 2015).[6] The policy rate is not an accurate representation of the marginal cost of funds for banks after 2007 when the cost of funds from the impaired interbank market diverged from policy rates. Since the global financial crisis larger risk premia associated with securities issued by banks and interbank borrowing have raised the cost of market funding for banks (see ECB, 2009, 2010a,b; Zoli, 2013) illustrated by the divergence of bond yields across borders, which has reversed the trend of lower and more similar rates since the late 1990s (ECB, 2012). The sovereign debt crisis limited the ability of governments to recapitalise their banks as their own debt increased, widening bond spreads further (ECB, 2012). In addition, mark downs on deposit rates, which would normally be below policy rates, have been constrained by the zero lower bound. On top of that, there has been greater competition among banks for term deposits, which further raised these rates, as higher-yield assets such as fixed-term securities issued by governments have increasingly been seen as substitutes for low-yielding deposits by savers (see Darracq-Paries et al. 2014, and Von Borstal et al., 2015).

There are significant implications from our findings. If our new measures of funding costs are the primary determinants of the banks' lending rates, then banks have been passing on their costs of funds as did before the crisis and do not appear to be taking advantage of the low interest rate environment. Our work shows that banks respond to the full range of liabilities included in the measure of funding costs and not just to changes in policy rates. This requires an appreciation of the impact of policy on short term and longer term market rates,

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[6] The empirical literature on pass through represented by Borio and Fritz (1995), De Bondt (2002, 2005), Ehrmann et al (2003) Hofmann and Mizen (2004) has used policy rates or money market rates to explain short-term lending rates, and has used longer-dated, often maturity-matched yields on securities to explain longer-term loans. An exception in this respect is De Bondt et al. (2005) which refers to the cost of funding measured by short-term and long-term market rates, and our paper follows in that tradition, but uses information from bank balance sheets to structure the funding costs.

and the implications for banks that borrow from multiple sources at different maturities.[7] This creates a research agenda for future work by central banks and academics to revisit the channels of the monetary transmission mechanism after the crisis.

The rest of the paper is organised as follows. In Section 2, we present a simple model to frame our results. Section 3 discusses the construction of the weighted average cost of liabilities, including details on the data sources and their characteristics. This new measure of average funding costs is the cornerstone of our empirical analysis. In Section 4 we show that the relationship between lending rates and policy rates breaks down. Section 5 shows the relationship to funding costs is stable, robust and has sensible dynamic properties. Section 6 discusses the policy implications and conclusions.

2. *An Illustrative Model and Some Background Literature*

2.1 The Berlin-Mester Model

To set our empirical analysis in a theoretical framework, we consider a simple illustrative model based on Berlin and Mester (1999), which considers the contracting relationship between a firm and a bank. The core feature of the model is the setting of lending rates subject to the liability structure of the bank, which we will generalise to make our point.

The decisions of the firm and the bank are made over two periods, 0 and 1. The state of the world s in period 1 is unknown to the bank or the firm, and it can be good (g) or bad (b): $s \in \{g, b\}$. The probability of a good period is p, and of a bad period (1-p). Firms have positive earnings in good times, $E_g > 0$, and no earnings in bad times, $E_b = 0$. The state is revealed at the start of period 1 and the economic conditions are observable to all parties. It is assumed that the firm must borrow from the bank to invest, or liquidate some of its assets $A(k)$, where $k \in [0, K]$; this reduces the future value of the firm in order to generate liquid assets in the present.

The bank has a representative liability structure: deposits and market funds are held in proportions w and (1-w). For the purpose of exposition, we generalise this set of liabilities held by the bank to include deposits, unsecured market funds of various types and maturities that include interbank deposits and bonds, and secured market funds that include covered bonds. We assume rates on deposits are fixed but rates of interest on other liabilities are state-

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[7] Clearly, more work needs to be done to explore the relationship between policy actions and funding costs (including the impact of unconventional measures of policy) following, for example, Rogers et al., 2014; Altavilla et al. 2014; Gertler and Karadi, 2015; and Von Borstel et al. 2015).

contingent $s \in \{b, g\}$. We therefore have a weighted average cost of liabilities measure defined as:

$$L_s = C_s(w_j, R_j) = \sum_{j=1}^{J} w_j R_j \tag{1}$$

where j indexes the type of liability, with a weight, w_j, based on the proportional share in total liabilities and the rate of interest R_j. Certain restrictions are assumed: the cost of funding is state dependent and higher in bad times ($R_b > R_g$); the expected value of market funds exceeds the cost of core deposits, the cheapest available source of funding. Shares of certain liabilities can be zero. Further assumptions ensure earnings in good times cover the returns to depositors   ($E_g > R_g$), although in bad times liquidation is required, since $R_b > 0$. The capital, K, is always larger than the weighted average cost of liabilities (1) even in the bad state of the world. These assumptions ensure that liquidation levels in good times are zero, and in bad times are just sufficient to cover the cost of liabilities for the bank., L_d.

The bank and firm both maximise profits, defined in each case as revenue minus costs in each state of the world times the probability that each state of the world will occur. Thus

$$\Pi^f = p[E_b + k_b + A(k_b) - r_b] + (1-p)[E_g + k_g + A(k_g) - r_g] \tag{2}$$

$$\Pi^b = pr_b^l + (1-p)r_g^l - [pL_b + (1-p)L_g] \tag{3}$$

where r_s^l is the lending rate of interest for $s \in \{b, g\}$, and k_s is the liquidation level. The bank faces Bertrand competition in the loan market, treats its liability structure as given in the present period, and maximises its own profits, which results in a lending rate equal to the weighted average cost of liabilities defined in each state of the world[8]:

$$r_s^* = L_s \tag{4}$$

In this framework, pass through occurs between the weighted average cost of liabilities and the loan rates, not the policy rate and loan rates. Lending rates will be lower in good times than in bad times because the cost of funds will be lower in good times than bad times, but the pass through in each state of the world will be complete, since $\frac{dr_s^*}{dL_s} = 1$ for $s \in \{b, g\}$. Berlin and

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[8] In Berlin and Mester (1999) the bank maximises the joint profit then the optimal contract maximises the profit of the firm and the bank, and should ensure that (4) holds when *s=b*, but when *s=g* then $r_g^* = \dfrac{pL_b + (1-p)L_g - pk_b^*}{(1-p)}$. This is a 'relationship lending' result that causes the relationship between cost of funds and loan rates to differ between good and bad periods.

Mester show that if the bank protects its borrowers during bad time the pass through can be less than complete.

Berlin and Mester also assume that a bank could choose to divert funds to marketable securities instead of loans, which implies the bank only participates in the loan market if the return from loans under each state of the world exceeds the return on marketable securities, S_s, which for simplicity we will take to be government bonds. In our context this implies

$$pr_b^l + (1 - pr_g^l) \geq pS_b + (1 - p)S_g \equiv S^e. \tag{5}$$

This being the case, the return on marketable securities acts as a floor under lending rates. If policy rates were lower than the return on marketable securities as they were in the financial crisis, then lending rates would not fall to those levels. [9]

The modelling framework described above stands in contrast with the assumptions behind the majority of the empirical literature where it is assumed that banks obtain funds for short-term lending at contemporary market rates (or policy rates), while longer term lending rates on mortgages or business lending are funded by 5- or 10-year sovereign bond yields (as a proxy for longer term market finance for banks). There is little discussion about deposit rates or the liability structure of banks, despite extensive discussion of pass-through by banks (see Borio and Fritz, 1995; De Bondt, 2002; Ehrmann et al. 2003; Hofmann and Mizen, 2004; De Graeve et al. 2007; ECB, 2009; Kwapil and Sharler, 2010; Kopecky and Van Hoose, 2012; Banerjee *et al*. 2013; and Darracq-Paries et al., 2014).

With the onset of the global financial crisis, these results have to be re-examined to account for the fragmentation of funding arrangements noted by Arnold and Ewijk (2014), De Sola Perea and Van Nieuwenhuyze, (2014), Darracq-Paries et al (2014) and Holton and Rodriguez (2015). Short-term money market rates on unsecured interbank lending and collateralised repurchase agreements have deviated substantially from policy rates as liquidity and counterparty risk has increased. Moreover, the sovereign bond yields are no longer good proxies for the cost of market finance for banks in the period after the financial crisis. The higher default risk associated with banks in 2007-2009, lower quality of assets and undercapitalization have caused bank bond yields to deviate from sovereign bond yields

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[9] The model can be generalised to a game-theoretic context with double Bertrand competition for deposits and loans. Stahl (1988) shows that double Bertrand competition is not neutral, and competition occurs first in the market for deposits and then in the market for loans. This results in an equilibrium loan rate that maximises the return from loans, which then ties down the equilibrium deposit rate. Details of the resulting model are given in Yanelle (1997).

according to Arnold and van Ewijk (2014), De Sola Perea and Van Nieuwenhuyze, (2014) and Darracq-Paries et al (2014). As yields on senior unsecured bonds issued by banks rose, gross issuance fell to near zero in the peripheral countries and was replaced by covered bond issuance in other euro area countries (see Van Rixtel and Gasperini, 2013). This intensified in the sovereign debt crisis and the lending costs of these banks rose, particularly in the peripheral countries (see Zoli, 2013 Albertazzi et al. 2012; and Von Borstel et al., 2015). All in all, this suggests it is no longer valid practice to take a policy rate, a short-term wholesale market rate or a sovereign bond yield as a proxy for bank funding costs. We now turn to a positive proposal to measure funding costs using bank liabilities.

3. *Bank Funding Costs*

An important contribution of this paper is the construction of a weighted average cost of liabilities (WACL) as an alternative benchmark for bank funding costs in each country. There are parallels between our approach and De Bondt et al. (2005), who argue that banks apply a markup with respect to a "cost" that depends on short and long-term market interest rates. This section explains how we compiled our measure, while the detail on data sources is reported in an appendix. The main difference between our approach and De Bondt et al. (2005) is that we use the information on the banks' balance sheets to construct our liability measure, while they take a weighted average of short and long rates from the yield curve.

The WACL is a volume-weighted average of the rates at which Monetary and Financial Institutions (MFIs) can obtain finance: $WACL_{it} = \sum_{j=1}^{J} w_{ijt} r_{ijt}$, where r_{ijt} are new business rates on the different component liabilities that the banks use to provide funds, and w_{ijt} are the weights on those rates based on the component share in total liabilities for the banks in each country. Taking i to be the country index, j the index of the types of liabilities held by banks, and t the time period, we sum over liabilities to provide an index of the weighted average cost of liabilities for each country i at each point in time t. We calculate two sets of WACL based on different maturities: one for the short-term and one for the long-term. We calibrate the short-term measure with a maturity of less than 1-year, whereas the long-term measure reflects maturities of more than 1-year, with an average of 5-years.

Our sample covers a total of 11 countries, nine euro area countries and in addition Denmark and United Kingdom.[10] The data starts in 2003, based on the availability of the Monetary and Financial Institutions Interest Rates (MIR) by the ECB. We used the data from the national central banks in order to complete the database for Denmark and the United Kingdom.

3.1 Components and weights

The main issue to discuss is the weighting scheme. We use two weighting schemes using weights based on a) outstanding stock of liabilities from banks' balance sheets, and b) flows rather than outstanding volumes. Both schemes are used to form weighted averages of interest rates on new transactions in the WACL measure, labelled WACL(stock) and WACL(flow) respectively. The first has the advantage that it draws information on a wider range of components from the bank balance sheets compared to the second, while the second has the advantage that new business rates are combined with changes to volumes to give a truly marginal cost of funds. Ultimately we rely on the first weighting scheme based on outstanding stock of liabilities and use the second to provide a comparison from the flows. The results show that there similar outcomes in both cases regardless of the weight measure.

The WACL is constructed using five types of liabilities.[11] Deposit liabilities (in all currencies, and excluding the general government) vis-à-vis the euro area[12] to MFIs (interbank deposits) and to non-MFIs (deposits of the private non-financial sector) are the largest source of funds. Banks have a substantial deposit base in most countries, so that the first two components account for a large share of funding for lending: over 90 percent of total funding in

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[10] The rationale for including non-euro area countries is to test whether the issue spreads to more countries, or is just associated with the monetary union.

[11] These are discussed in greater detail in the data appendix. We exclude funding from equity issuance from the WACL since it accounts for a small percentage of the outstanding balances, and it is arguably not used by banks as a source of regular finance for bank lending, but rather as a structural adjustment (e.g. adjustment of capital ratios in response to regulatory requirements). Besides, Adrian et al. (2013) show that while changes in banks' assets (including loans) and changes in their debt move proportionally, equity remains 'sticky', i.e. it does not adjust when there is a change in assets.

[12] For Denmark and the United Kingdom, we take the country itself as reference area, as opposed to the euro area as a whole.

the short-term and 70 percent of total long-term funding. Deposits from non-MFI sources are the largest component of the funding measure.

Debt securities issued in all currencies in the euro area by the MFIs are reported at maturities up to and over one year. Bond markets are segmented to a large extent on national lines (van Rixtel and Gasperini, 2013) and tend to be influenced in different ways at times of crisis, yields showing substantial spikes. According to Table A1-A4, conventional bonds comprise a small share of short-term funding, while they account for approximately 15-30 percent of funding in the long term. We conclude that these securities are used much more extensively for long-term funding.

Covered bonds data are obtained from Dealogic, and since all of the covered bonds have a maturity of more than one year they are used only in long-term funding calculations. The volumes of covered bonds outstanding is not typically large, except for Germany and Spain, but they have grown since the crisis.

Lastly, funding from central bank operations such as the Main Refinancing Operations (MROs) and the Long-Term Refinancing Operations (LTROs) exists only for the euro area countries. Cheap funding given by the ECB in crisis time slightly lowered the funding cost of the MFIs. Van Rixtel and Gasperini (2013) show that Spain and Italy relied most heavily on liquidity operations provided by the ECB having borrowed, respectively, €400bn and €277bn in September 2012.

The alternative WACL(flow) measure is constructed using new deposit data and gross issuance of conventional and covered bonds. We use this to check that our results are not distorted by the use of outstanding amounts to construct the weights.

Tables A1 and A2 in the Appendix provide a summary of the weights averaged over time based on outstanding amounts.

3.2 Interest rates

Each type of liability has a matching interest rate, which is always based on new transactions.[13] For the MFIs deposits to other MFIs we use the interbank money market rates. For the short-term we use the overnight rates, while for the long-term the 1-year rates. The deposit rate of the non-MFI deposits is obtained from the ECB MFI interest rate statistics, and is the rate on

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[13] This implies both the baseline and the fully marginal WACL rely on the same interest rates.

euro deposits with agreed maturity for the non-financial corporations and households with maturities up to 1 year for the short-term and over 1-year for the long-term. For Denmark and United Kingdom similar rates have been obtained from the national central banks. Since Denmark reports no breakdown of interest rate by maturity, we use the same rates for both short-term and long term deposits.

As for the cost of debt securities, we measure the yield on bonds issued by banks as the interest rate swap rate plus a mark-up based on the credit default swap (CDS) rate for the banking sector in each country, using a simple average of available CDS rates for financial institutions in each country. In order to measure the long term rate we use the 5-year interest rate swap plus the 5-year financial CDS while for the short-term the 1-year interest rate swap plus the 1-year financial CDS. The interest rate on covered bonds is obtained from Barclays, which reports the yield to maturity for the outstanding amount of bonds (see the appendix where we plot the data). The rate on central bank operations is the Main Refinancing Rate of the euro area (liquidity operations were only available for banks in the euro area).

The short-term and long-term interest rates are reported in Tables A3 and A4 in the Appendix. These figures indicate one source of the differences between the funding costs for different countries in our sample. When multiplied by the relevant weights they provide the short- or long-term WACL funding costs used in our analysis.

3.3 A Comparison between WACL and the policy rate

WACL funding costs are plotted in Graph 2, together with policy rates. Short-term funding costs followed policy rates very closely in all the countries in our sample, except during the 2003-2004 downturn, while long-term funding costs were higher than policy rates, reflecting a term premium and compensation for risk. After the Lehman bankruptcy, credit risk was re-assessed, and the risk premium jumped upwards. While risk free rates fell as policy rates were reduced, market funding added a larger margin for credit risk than in the pre-crisis period (see Gilchrist and Mojon, 2013, Darracq-Paries et al. 2014). In most countries this created wider margins between short-term and long-term funding costs, creating a divergence with policy rates in the post-crisis period. This is most evident in the peripheral countries, Italy, Portugal, Spain, but also in the UK, which was more heavily exposed to the effects of the crisis at an early stage, as well as for Austria, whose banks were heavily exposed to Central and Eastern European countries. It is apparent from Graph 4 that there are sharp spikes from 2010Q1 reflecting the

higher yields on conventional and, to a lesser extent, covered bonds following the sovereign debt crisis. To some extent, recourse to ECB liquidity cut the cost of funding but the influence was rather small.

3.4 The comparison between WACL and lending rates

We now turn to the main subject of our paper: a comparison of the WACL and lending rates offered by MFIs to households and the non-financial corporations. For households we collect from the ECB lending rates on new loans for house purchases (excluding revolving loans), overdrafts and credit card debt for maturities of up to 1-year and over 1-year. For non-financial corporates we collect the lending rates on new loans (other than revolving loans) and overdrafts and credit card debt, for the same breakdown of maturities as above. For Denmark data are obtained from the national central bank.

We examine separately short- and long-term lending. Graph 3 shows the rates on mortgage lending to households and loans to non-financial corporations for terms of less than one year versus the WACL. The movements in lending rates and funding costs are fairly similar within each country: there is a co-movement between these variables and policy rates. However, in the post-crisis period funding costs diverge from policy rates, and lending rates to households and firms tend to follow more closely the movement of funding costs.

For the long term lending rates (over one year) we see a different pattern that is most evident in the peripheral countries (Ireland, Italy, Portugal and Spain), and to some extent Austria. This can be seen in Graph 4 where the funding costs peaked from 2010-12 and slowly decreased after this period.

4. Analysis of the Properties of Interest Rates

4.1 Preliminary analysis of the data

We first test the properties of the interest rates beginning with non-stationarity. We use the Im, Pesaran and Shin (2003) test, with a null hypothesis that no variable in the panel has a unit root. The test statistic is based on the standardised t-bar test statistic based on the (augmented) Dickey–Fuller statistics averaged across the groups which converges on the standard Normal. Results reported in Table 1 show we comfortably fail to reject the null in all cases, which confirms that with only one exception the interest rates are all are non-stationary,

requiring that any levels relationships between them should satisfy the requirement of being co-integrated.[14]

Many authors have noted that due to trade and financial market integration there are close international interdependences between countries, particularly in a competitive market or a common currency area (Kose et al., 2003, Canova et al., 2007, Pesaran et al., 2007, Canova and Ciccarelli, 2009, 2013). Therefore we use second generation CIPS test of panel unit root test due to Pesaran (2007) that allow for cross sectional dependence modelled using cross-sectional means of the levels and differences of the variables. The results reported in Table 1 comfortably fail to reject the null in all cases except one at the 5% level, based on the same standardised average t-statistic against critical values given in Pesaran (2007).

4.2 Long-run relationships

To explore the long run with non-stationary variables in our panel we use the Persyn and Westerlund (2008) panel cointegration test, which makes allowance for cross-sectional dependence. Failure to find cointegration would suggest that there is no long-run relationship between the variables of interest. Defining the relationship between y_{it}, (the lending rate which is the focus of our analysis), and x_{it}, the driver of the lending rate (i.e. the policy rate or the WACL) using the following equation:

$$\Delta y_{it} = \alpha_i (y_{i,t-1} - \theta_i x_{i,t-1}) + \sum_{p=1}^{P} \chi_{ip} \Delta y_{i,t-p} + \sum_{q=0}^{Q} \delta_{iq} \Delta x_{i,t-q} + e_{it} \tag{6}$$

we compute two test statistics, G_τ and P_τ, for each lending rate. The null and alternative hypotheses are formulated as

$H_0: \alpha_i = 0$ versus $H^P_1: \alpha_i = \alpha < 0$ for all *i* which can be interpreted as a null of no cointegration and a rejection of the null as evidence of cointegration for the panel as a whole.

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[14] This can be surprising to economists used to nominal variables such as interest rates and inflation being stationary. However, the literature starting with Klemperer (1987), Hannan and Berger (1991), Neumark and Sharpe (1994) and Cottarelli and Kourelis (1994) suggests that adjustment costs and imperfect competition give banks incentives to adjust their lending or deposit rates sluggishly. Berlin and Mester (1999) appeal to relationship banking to explain persistence in rates over the economic cycle, while Hofmann and Mizen (2004) and Banerjee et al. (2013) imply banks may set rates based on current and forecasts of future money market rates. De Bondt et al (2005) note that banks set loan rates on longer maturity products to minimize interest rate risk and therefore respond sluggishly to changes in short term market rates. For policy rates the persistence is often explained by the policymaking process involving committees that must build consensus around a case for change, and the desire to build credibility by avoiding reversals of rates. In the presence of parameter and model uncertainty (Brainerd, 1967), policymakers appear to smooth rates (Goodfriend, 1991; Sack, 2000; Orphanides, 2003).

H$_0$:α_i = 0 versus H$^G_1$:α_i < 0 for at least some *i* which can be interpreted as a null of no cointegration and a rejection of the null as evidence of cointegration for at least one of the cross-sectional units.

We first apply these tests to the relationship between four separate lending rates and policy rates and the results are mixed for the full sample. The test statistics are reported in the second panel of Table 1 and the null hypothesis of cointegration is rejected in the majority of cases. The G_τ test indicates three out of four rejections, and the P_τ test two out of four rejections using data over the full sample. This implies the relationship is less stable than for the period prior to the global financial crisis, where we find that the null hypothesis of cointegration is rejected in every case. It appears there is evidence of a change in the relationship at around the time of the financial crisis.

Table 1 also reports cointegration tests for WACL(stock), WACL(flow) and the four different lending rates. Results for the WACL(stock) measure rejects the null of no cointegrating relationship under G_τ and P_τ tests with no exceptions. For WACL(flow) we find the same result, except for short-term lending to businesses, where we cannot reject the null of no cointegration. We conclude that there is much more evidence of panel cointegration between lending rates and funding costs based on the WACL(stock) and WACL (flow) measures than for lending rates and policy rates. This implies a stronger and more reliable relationship between lending rates and WACL compared to the results for policy rates.

4.3 Structural Breaks

Before we consider the magnitude of pass-through for bank funding costs we first allow for structural breaks in our data after the financial crisis Figure 1 indicates that there was a well-defined level shift in the policy rate in the euro area, Denmark and the United Kingdom. Failure to allow for structural breaks can have harmful effects on the size and power of cointegration tests according to evidence in Banerjee and Carrion-i-Silvestre (2013). Therefore we utilize their procedure to search for a cointegrating relationship allowing for a structural break and cross-sectional dependence in the panel.

Banerjee and Carrion-i-Silvestre (2013) allow for several potential breaks in intercept, trend and the cointegrating relationship, which can be transferred to our model defined by equation (6), plus some assumptions about the driving processes for e_{it} and x_{it}. The

methodology allows for multiple breaks, and the number and position of the breaks need not coincide for each country in the panel. We can consider a break process defined by

$$D_{it} = \mu_i + \phi_i t + \sum_{j=1}^{m_i} \theta_{ij} DU_{ijt} + \sum_{j=1}^{m_i} \gamma_{ij} DT_{ijt} \tag{7}$$

where the $i=1,...,N$ and $t=1, ..., T$. The effect of the break is modelled using $DU_{ijt} = 1$ and $DT_{ijt} = (t-T^b_{ij})$ for $t > T^b_{ij}$ and 0 otherwise, where $T^b_{ij} = \lambda^b_{ij} T$ for $\lambda^b_{ij} \in (0,1)$ reflects the location of the break in trend, and $\theta_{it} = \theta_{ij}$ for $T^c_{ij-1} < t <= T^c_{ij}$, where $\lambda^c_{ij} \in (0,1)$ is the location of the break in the cointegrating relationship. Therefore the model can therefore investigate the possibility of a break in the intercept (DU_{ijt}), a change in trend (DT_{ijt}), or a break in the cointegrating vector (θ_{it}), which is a function of time in their model.

We report the results in Table 1 for a model allowing for a break in the intercept (Z_a) and a model allowing a break in the intercept and the cointegrating vector (Z_{ac}), for our four lending rates versus policy rates and then versus our WACL measure. The test statistics reject the null of no cointegration at conventional levels of significance against the alternative of cointegration for all four lending rates with our WACL measure, indicating evidence that the cointegrating relationships is robust to the inclusion of a structural break. The results for policy rates deliver a similar but offer weaker rejection overall of the null, and in some cases fail to reject the null. These tests lead us to conclude that our results are not overthrown when we allow for cross sectional dependence and a structural break in the equation.

5. Modelling Rates in a Dynamic Heterogeneous Panel

We wish to explore the relationship between the lending rates and the funding costs in a dynamic heterogeneous panel pooled mean group (PMG) estimator first proposed by Pesaran and Smith (1995) and Pesaran, Shin and Smith (1999) in order to obtain an estimate of the degree of pass through. This introduces a (common) long-run relationship corresponding to the cointegrating relationship we obtained in the previous section. Once again we take y_{it}, as the lending rate and x_{it}, as the driver of the lending rate (i.e. the policy rate or the WACL) in an ARDL model with lags P, Q (determined by the Bayesian Information Criterion, BIC), as follows:

$$y_{it} = \sum_{p=1}^{P} \chi_{ip} y_{it-p} + \sum_{q=0}^{Q} \delta_{iq} x_{it-q} + \mu_i + e_{it} \tag{8}$$

This can be rewritten as a stacked set of N individual equations relating y_{it} and x_{it} for groups $i = 1,2,...N$ over the time period $t = 1,2,...T$ as

$$\Delta Y_i = \alpha_i Y_{i,-1} + \beta_i X_i + \sum_{p=1}^{P-1} \chi_{ip} \Delta Y_{i,-p} + \sum_{q=0}^{Q-1} \delta_{iq} \Delta X_{i,-q} + \mu_i 1 + \varepsilon_i \tag{9}$$

where $Y_i = (y_{i1}, \dots y_{iT})'$, $X_i = (x_{i1}, \dots x_{iT})'$, $1 = (1,\dots, 1)'$, $\varepsilon_i = (e_{i1}, \dots e_{iT})'$ are all $T \times 1$ vectors of observations, ones and residual errors, and Δ is the first difference operator.

The model can be re-specified as:

$$\Delta Y_i = \alpha_i (Y_{i,-1} - \theta_i X_i) + \sum_{p=1}^{P-1} \chi_{ip} \Delta Y_{i,-p} + \sum_{q=0}^{Q-1} \delta_{iq} \Delta X_{i,-q} + \mu_i 1 + \varepsilon_i \qquad (10)$$

where the relationship $\alpha_i (Y_{i,-1} - \theta_i X_i)$ for the levels provides information on the long-run cointegrating relation between lending rates and driving variables that we discovered in the previous section. Estimates of $\beta_i = \alpha_i \theta_i$ allow us to derive the long-run pass-through coefficients by dividing through by α_i, the adjustment speed of rates to deviations from this long-run relationship for each country i.

To mitigate the effects of cross-sectional dependence we introduce cross-sectional averages of the differences and lagged differences in each variable following Pesaran (2006), Chudik and Pesaran (2015) and Eberhardt and Presbitero (2015) as follows:

$$\Delta Y_i = \alpha_i (Y_{i,-1} - \theta_i X_i) +$$
$$\sum_{r=2}^{R} \pi_{ir} \Delta \overline{Y}_{i,-r} + \sum_{s=2}^{S} \pi_{is} \Delta \overline{X}_{i,-s} + \qquad (11)$$
$$\sum_{p=1}^{P-1} \chi_{ip} \Delta Y_{i,-p} + \sum_{q=0}^{Q-1} \delta_{iq} \Delta X_{i,-q} + \mu_i 1 + \varepsilon_i$$

Terms that are over-scored are the cross-sectional averages of each variable: $\Delta \overline{Y}_i = N^{-1} \sum_{i=1}^{N} \Delta Y_i$ and $\Delta \overline{X}_i = N^{-1} \sum_{i=1}^{N} \Delta X_i$. Lag lengths $R, S = int(T^{1/3})$. Equation (11) therefore represents a dynamic PMG estimator, similar to that used by Binder and Offerman (2012), whereby cross-section averages are added to the PMG. The model can be estimated by OLS, since the terms in first differences of cross-sectional averages and first differences allow for non-stationarity, cross-sectional correlation, heterogeneity and non-linearity or asymmetry in the data (see Eberhardt and Presbitero, 2015).

5.1 Estimates of Pass Through from Funding Costs and Policy Rates

In the context of the PMG model (11) it is possible to estimate a model allowing for a common long run pass through relationship with heterogeneous responses in the short run to reflect institutional differences across countries.[15] We report our baseline results in Table 2 for

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[15] The PMG model imposes long-run homogeneity while a mean group estimator (MGE), which is a plain average of individual group i estimates of equations stacked in (12), does not. The MGE estimator is consistent but inefficient if there is a common slope coefficient.

WACL(stocks) and WACL(flows). We split the sample of countries into three groups: the first group includes all 11 countries in the euro area as well as the UK and Denmark, the second refers only to the euro area and the third includes only core euro area countries (i.e. excluding Ireland, Italy, Portugal and Spain). The tables report common long-run coefficient estimates of the relationship between the four different interest rates (short-term and long-term loans to business and short-term and long term mortgages, in successive columns) versus funding costs, over the full sample period January 2003 – April 2014. We also report the estimate of the average adjustment to the long-run relationship for each group of countries.

Results for WACL(stocks) are displayed in the first panel. We find that the common pass-through coefficient estimates take plausible positive values, which are significantly less than one for the full sample. This implies that a 100bp increase the WACL(stocks, adjusted) funding cost for banks would result in an increase in lending rates between 85-89bp. Long-term and short-term lending rates show degrees of interest rate pass-through consistent with the findings in the previous literature (see De Bondt et al., 2005, Hristov et al., 2014). Restricting the sample of countries to the euro area countries or the euro area core does not substantially change the estimates, except that the pass through for long rates for NFCs drops to around 73-75bp. A similar pattern is observed in the second panel where we report the results for WACL(flows, unadjusted) since estimated pass through coefficients are between 75-89bp. Again, the pass through for one of the long term rates is somewhat lower, but this is very much an exception to the rule. The comparability of the estimated pass through coefficients makes an important point that our results are robust to the choice of funding weights, since the similarity of the results using either stocks- or flows-based weights in the construction of the funding costs does not materially alter the majority of pass through estimates. [16]

In Table 2, we also report the average of short-run adjustment coefficients for each group of countries in two rows. To ensure that our results that average across countries are not unduly influenced by outlying observations, we can estimate the MGE model robustly.[17]

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[16] One reason for this result may be that funding weights adjust relatively slowly compared to funding rates, therefore variation in WACL(stocks) versus WACL (flows) may be mostly determined by changes in rates not weights.

[17] We compute the common relationship in lag levels using PMG and then estimate the MGE estimate using the calculated error correction term and robustness. Robustness ensures that the weight on each country is based on the proximity of the country observation to the average of all countries, reducing the influence of outlier observations compared to the non-robust estimates which use a 1/N weighting scheme for observations from each country. We report results from PGE and MGE(robust) methods. We follow standard practice in the

The first row shows the estimates with equal weights on the observations of each country, while the second adjusts the weight according to the proximity of the country observation to the average value for all countries, which we refer to as the robust estimate. The adjustment coefficients are negative and significant in every case for each of the panels. The adjustment speed is generally faster for short- and long-term lending rates to business than to households: the estimated coefficients are two or three times larger for lending rates to business using WACL(stocks) or WACL(flows) compared to the adjustment coefficients for households. The difference in the adjustment speed is illustrated by the half-life calculations reported for each of the lending rates, which show adjustment is about two-thirds as long for lending rates to business compared with lending rates for households. This may be a consequence of the bespoke nature of loans to business, which are likely to adjust to prevailing conditions more quickly than loans to households, which are generic products. The t-bar test for the PMG model shows that the adjustment coefficient is significantly different from zero when averaged across countries.

These findings contrast markedly with results for policy rates reported in Table 3, where pass-through estimates tend show more variation over the full sample according to the type of lending rate under consideration, compared to WACL results in Table 2. Short term rates to NFCs appear to have similar degree of pass through as do short rates to households for the euro area and euro core countries, but short rates for mortgages over the full sample of countries has a much lower pass through coefficient and long-term rates are noticeably lower across the board. These results contrast markedly with pass through coefficients estimated for a shorter sample up to the beginning of the global financial crisis, where we find values that are closer to the estimates provided by the WACL in Table 2. Using the full sample, we also find adjustment speeds are different when estimated using policy rates or WACL, and the half life for most of the lending rates is longer than the half life reported in Table 2 for samples including all eleven countries or the euro area.

5.2 Other Robustness Checks

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literature by using robust regression (see Hamilton, 1992) to reduce the weight on outliers in the computation of the averages. .

The previous tables have presented the long-run relationships and the average adjustment coefficients across countries when we estimate the pass-through relationship over the full 2003M1-2014M4 sample. We now consider sub-samples of the data to explore the pass-through of WACL to lending rates up to three successive break points in the data. The first break point is the onset of the global financial crisis (GFC), July 2007, after which bank funding costs increased significantly. The second is the point just before Lehman collapsed and the recession took hold, August 2008, where the data show that there was a deterioration in economic growth rates leading to a recession.[18] The third break point is just prior to the sovereign debt crisis, December 2009: banks in periphery countries were shut out of the bond market (or faced exceptionally very high costs), and perceptions of default risk for banks increased (as shown by the increased correlation of bank CDS spreads with sovereign CDS spreads).

Table 4 reports the pass-through coefficients for WACL(stocks) data for these three break points for the euro area countries. The interesting result is that coefficient estimates are larger in magnitude compared with those reported in Table 3 (a result also observed by Von Borstel et al. 2015 in the context of their FAVAR model). When we end the sample in July 2007, the pass-through is close to one for all four lending rates. Pass through was essentially complete before the crisis, and higher than the estimate for the full sample reported in Table 3. Adjustment speeds were also about 50% higher, and for lending to business the adjustment coefficients were 100% larger, than those reported in Table 2. This resulted in lower half life values for all lending rates over the pre-crisis sample. When we break the data in August 2008 the estimated coefficients are smaller in three cases out of four compared to the sample up to July 2007, but larger than the full sample estimates from Table 2. Adjustment speeds fall a little or stay the same compared to estimates to July 2007, and half life values rise in two cases. If we break the data in January 2010 at the start of the sovereign debt crisis, we find the estimated pass-through drops a little further, especially for long rates, and adjustment speeds are about the same. This evidence seems to suggest that pass through was higher in the pre-crisis period, and has fallen to some degree through the post-crisis period culminating in slightly lower but substantial values for pass through for the full sample reported in Table 3.

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[18] The growing intensity of the recession is also reflected in the fact that, banks began to tighten credit conditions in 2008Q3 according to the ECB Bank Lending Survey, and house prices began to fall.

The conclusion we draw from these tables is that the coefficient estimates from a carefully constructed weighted average cost of liabilities over a range of sample end points still gives results that imply substantial pass-through of funding costs to lending rates. It is hard to argue from these results that banks response to funding costs has fundamentally changed in the post crisis period, although there is some evidence that adjustment speeds associated with pass through have declined more substantially.

5.3 Impulse Responses

To explore the dynamic responses of each of the four lending rates to a shock to the funding cost, we resort to a panel VAR (see Canova and Ciccarelli, 2013 for an overview of panel VAR methods and applications). More specifically, we employ the methodology proposed by Love and Zicchino (2006), which is based on pooled estimation.[19] To correctly identify the shock to funding cost, i.e. a change which is orthogonal to other endogenous factors that may drive its dynamics, we resort to Choleski decompositions, which are a well-established tool in the VAR literature.[20] Our starting point are the monetary VARs popularised by Bernanke and Blinder (1992), where an exogenous shock to monetary policy is identified by controlling for movements in GDP and inflation, which could affect the endogenous response of policy rates. This is sometimes referred to as slow-to-fast identification strategy.

We adopt a similar reasoning for bank funding costs, and also add to the VAR also lending rates, to investigate their dynamic reaction. So, our VAR includes (in this order) real GDP, CPI inflation, bank funding costs and the lending rates. The underlying identifying assumption for the shock to bank funding costs is therefore that bank funding costs are allowed to react contemporaneously to all the other variables in the system except the lending rate, which is instead unrestricted. And the resulting shock to bank funding costs is net of changes due to the business cycle, as controlled for by GDP and inflation.

The results are reported in Graphs 5-8 for nine euro area countries. The impulse response is given by a thin solid line in each graph, with standard errors represented by the shading. The thick dashed line is the joint response derived from the panel VAR, while individual responses are based on the same type of VAR estimated at the individual-country level. The advantage of

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[19] For an alternative estimation approach, based on the Bayesian paradigm, we refer to Canova and Ciccarelli (2009).

[20] Love and Zicchino (2006) also rely on a Choleski decomposition to identify the shocks.

reporting the common dashed line in all nine panels is that we can compare the individual country response to it.

In all four Graphs we see the expected positive response in lending rates to a positive shock to funding costs that dies away gradually over time. The responses vary between countries, as can be seen by comparing the impulse responses and the standard error bands with the dashed lines in each Graph (note that the scales are the same for each country on each Graph, but differ between Graphs) but the dynamic effects of a shock to the funding cost are qualitatively similar and not too different quantitatively either because the results from the panel VAR lie within the confidence interval of the individual-country impulse responses in the majority of cases.

6. Conclusions

Many observers have noted since the global financial crisis that lending rates set by banks have not fallen as much as policy rates (see ECB, 2012; Beirne, 2012; ECB, 2013; Hristov et al., 2014; Von Borstel et al, 2015) and funding costs have become more dispersed across Europe (see Albertazzi et al 2012; Arnold and van Ewijk, 2014; Darracq-Paries et al. 2014; De Sola Perea and Van Nieuwenhuyze, 2014; Holton and Rodriguez, 2015). This poses important questions for monetary policymakers who are seeking to determine whether banks are taking advantage of the low interest rate environment by failing to pass on lower rates to loans, or whether a break in the relationship between policy rates and lending rates has altered the way central banks should model the transmission mechanism. These issues are central to the debate about the effectiveness of monetary policy and bank credit provision in Europe.

We investigate the relationship between lending rates, bank funding and policy rates over the period 2003 – 2014 for 11 European countries inside and outside the euro area using dynamic panel methods that allow for heterogeneity and cross country dependence developed by Pesaran (2006) and Chudik and Pesaran (2015). This extends previous panel VAR models of interest rate pass-through that have not taken these features into account. Our results show that there is stronger evidence for a stable relationship between lending rate and a weighted average cost of liabilities (WACL) measure than for policy rates. We conclude that it is funding costs that are relevant to lending rates since these variables have not diverged in the post crisis period. Policy rates on the other hand, which were a reasonable proxy for funding costs before

2007 when liquidity and counterparty risks were low and stable, are no longer good proxies under conditions that have substantially changed.

Our research suggests an agenda for policymakers to establish how their conventional and unconventional actions influence these funding costs, lending rates and loan volumes in the post crisis era. This is a task for another paper. Work by Giannone et al. (2011, 2012), Altavilla et al. (2014) and Von Borstel et al. (2015) using macroeconomic and balance sheet variables shows promising results, but more work is required to link these results with funding costs directly.

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MFI lending rates for selected countries: short- and long-term

In per cent

Graph 1

Germany

France

Italy

Short-term lending rates[1]:
— Residential

Short-term lending rates[1]:
— Non-financial corporations

- - - Policy rate

Spain

United Kingdom

Germany

France

Italy

Long-term lending rates[2]:
— Residential

Long-term lending rates[2]:
— Non-financial corporation

Spain

United Kingdom
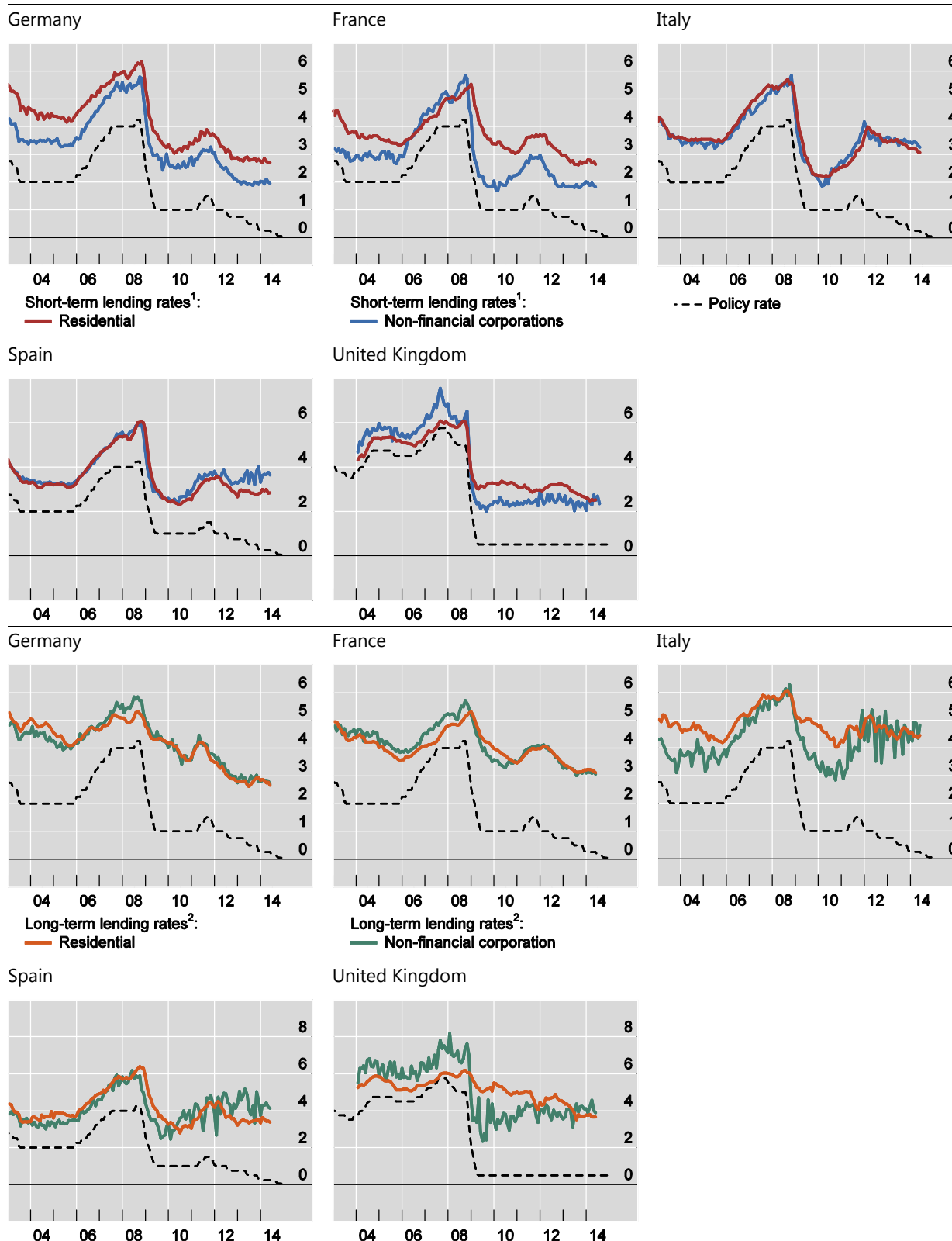
[1] The short-term is represented as less than 1-year maturity.   [2] The long-term is represented as above 1-year maturity. The average maturity assumed for the long-term is 5-year.

Sources: European Central Bank; national data.

Bank funding costs (WACL) and policy rates[1]

In per cent Graph 2

Austria

- - - Policy rate

Finland

—— MFI funding cost: short-term

France

—— MFI funding cost: long-term

Germany

Ireland

Italy

Netherlands

Portugal

Spain

Denmark

United Kingdom
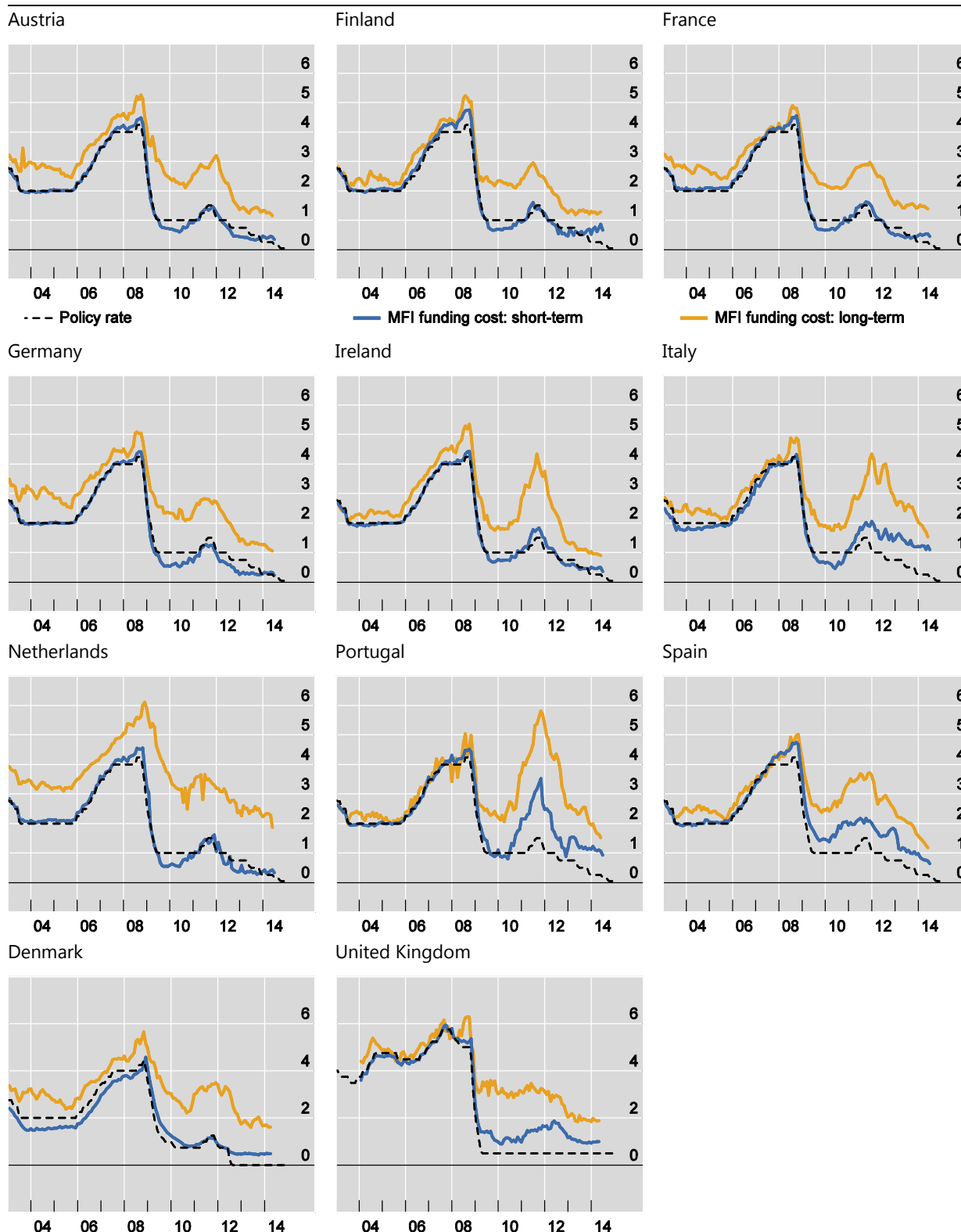
[1] The short-term represents less than 1-year maturity, while the long-term more than 1-year maturity assuming an average of 5-year.

Sources: European Central Bank; Barclays; Dealogic; national data.

MFI lending rates and funding costs: short-term[1]

In per cent

Graph 3

Austria

Finland

France

Lending rates:
- **—— Residential loans**

Lending rates:
- **—— Non-financial corporations loans**

- **—— Bank funding cost**

Germany

Ireland

Italy

- **- - - Policy rate**

Netherlands

Portugal

Spain

Denmark

United Kingdom
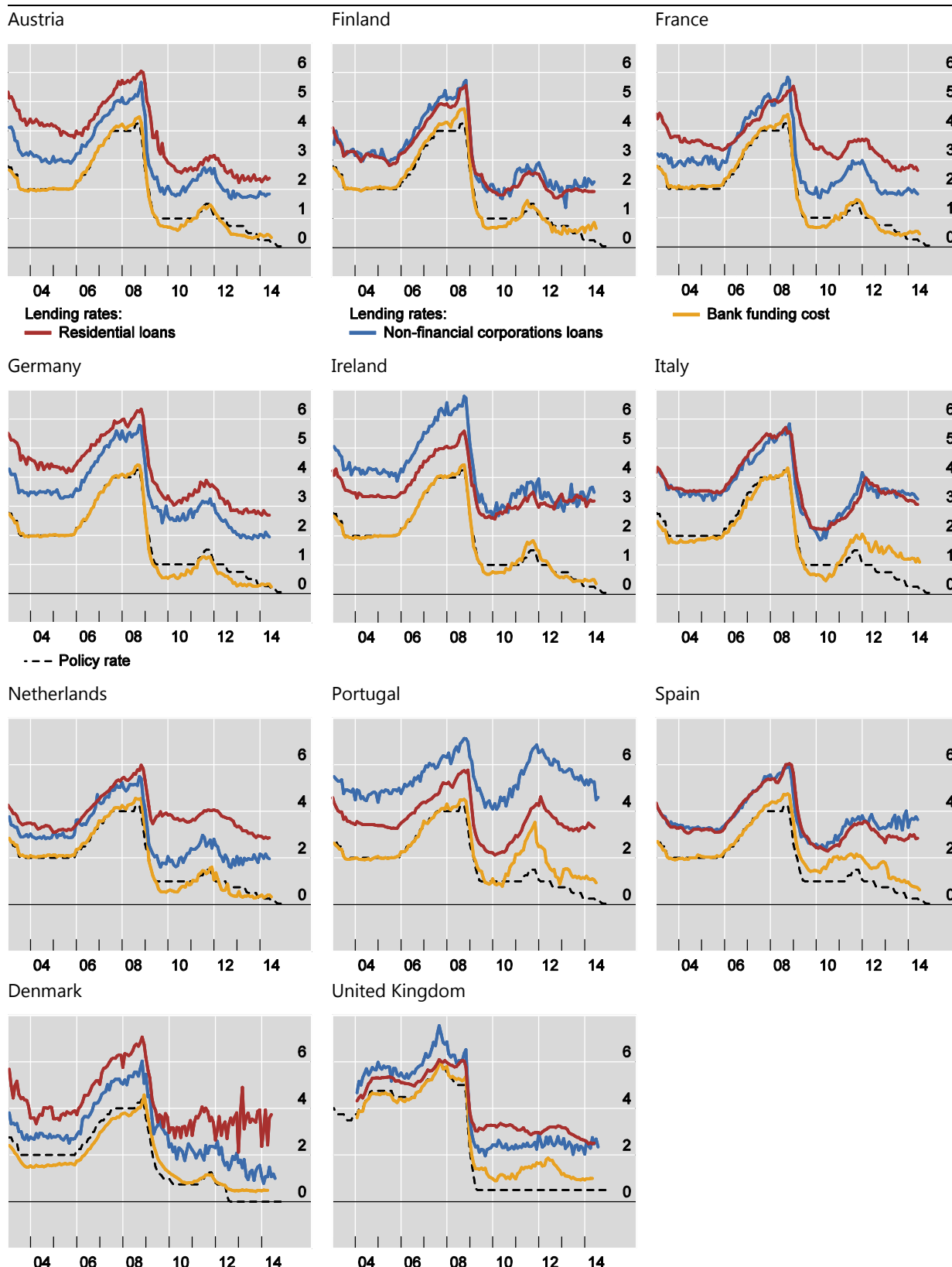
[1] The short-term is represented as less than 1-year in maturity.

Sources: European Central Bank; national data.

MFI lending rates and funding costs: long-term[2]

In per cent

Graph 4

Austria

Finland

France

Lending rates:
— Residential loans

Lending rates:
— Non-financial corporations loans

— Bank funding cost

Germany

Ireland

Italy

- - - Policy rate

Netherlands

Portugal

Spain

Denmark

United Kingdom
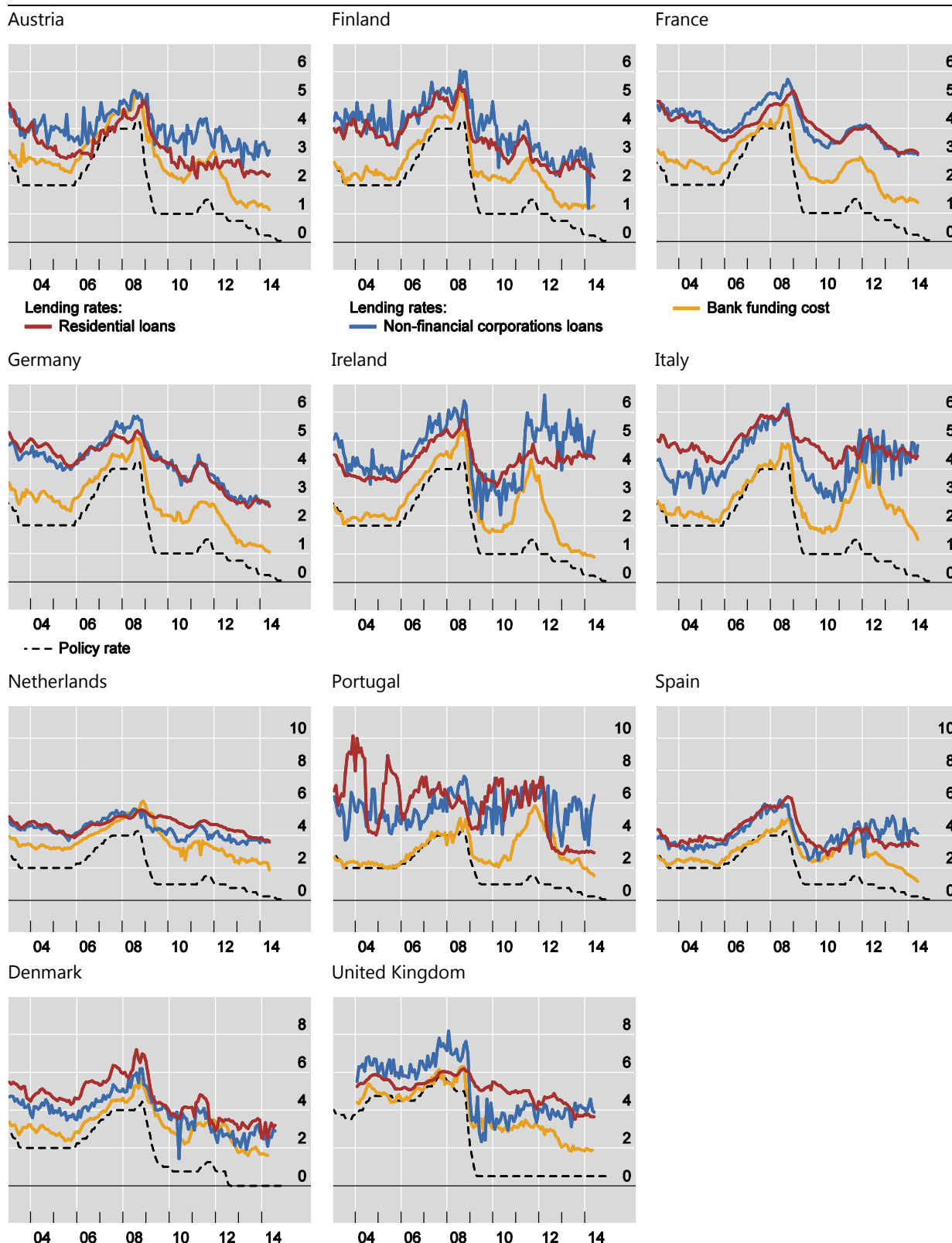
[1] The long-term is represented as above 1-year maturity. The average maturity assumed for the long-term is 5-year.

Sources: European Central Bank; Barclays; Dealogic; national data.

MFI's short-term lending rates of NFCs[1]

Response functions to a shock in the corresponding bank funding cost

Graph 1
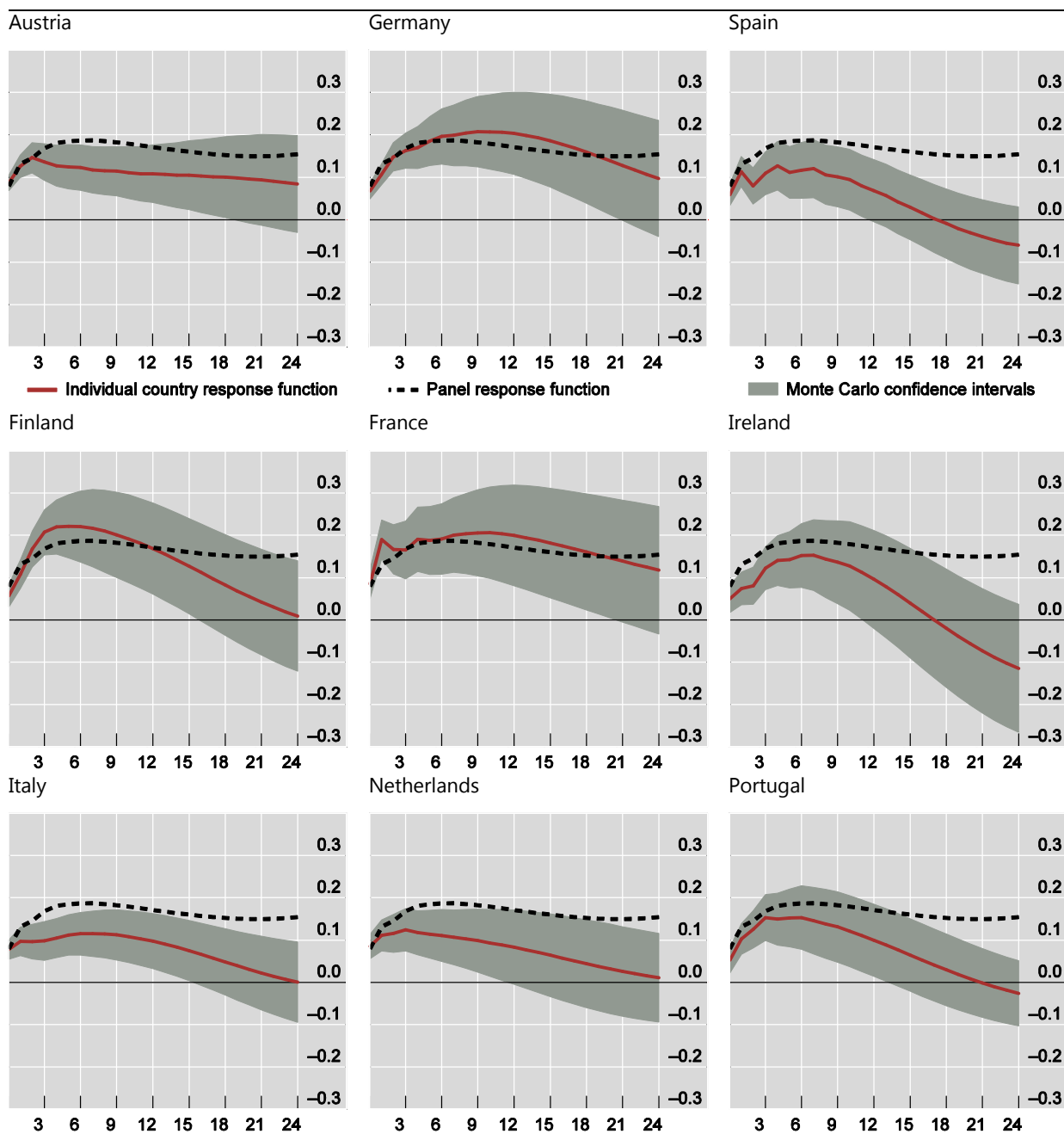
Austria

Germany

Spain

— Individual country response function   · · · Panel response function   ▨ Monte Carlo confidence intervals

Finland

France

Ireland

Italy

Netherlands

Portugal

[1] The short-term concerns rates less than 1-year maturity.

Sources: European Central Bank; authors' calculations.

MFI's long-term lending rates of NFCs[1]

Response functions to a shock in the corresponding bank funding cost

Graph 2

Austria

Germany

Spain

— Individual country response function   · · · Panel response function   ▨ Monte Carlo confidence intervals

Finland

France

Ireland

Italy

Netherlands

Portugal
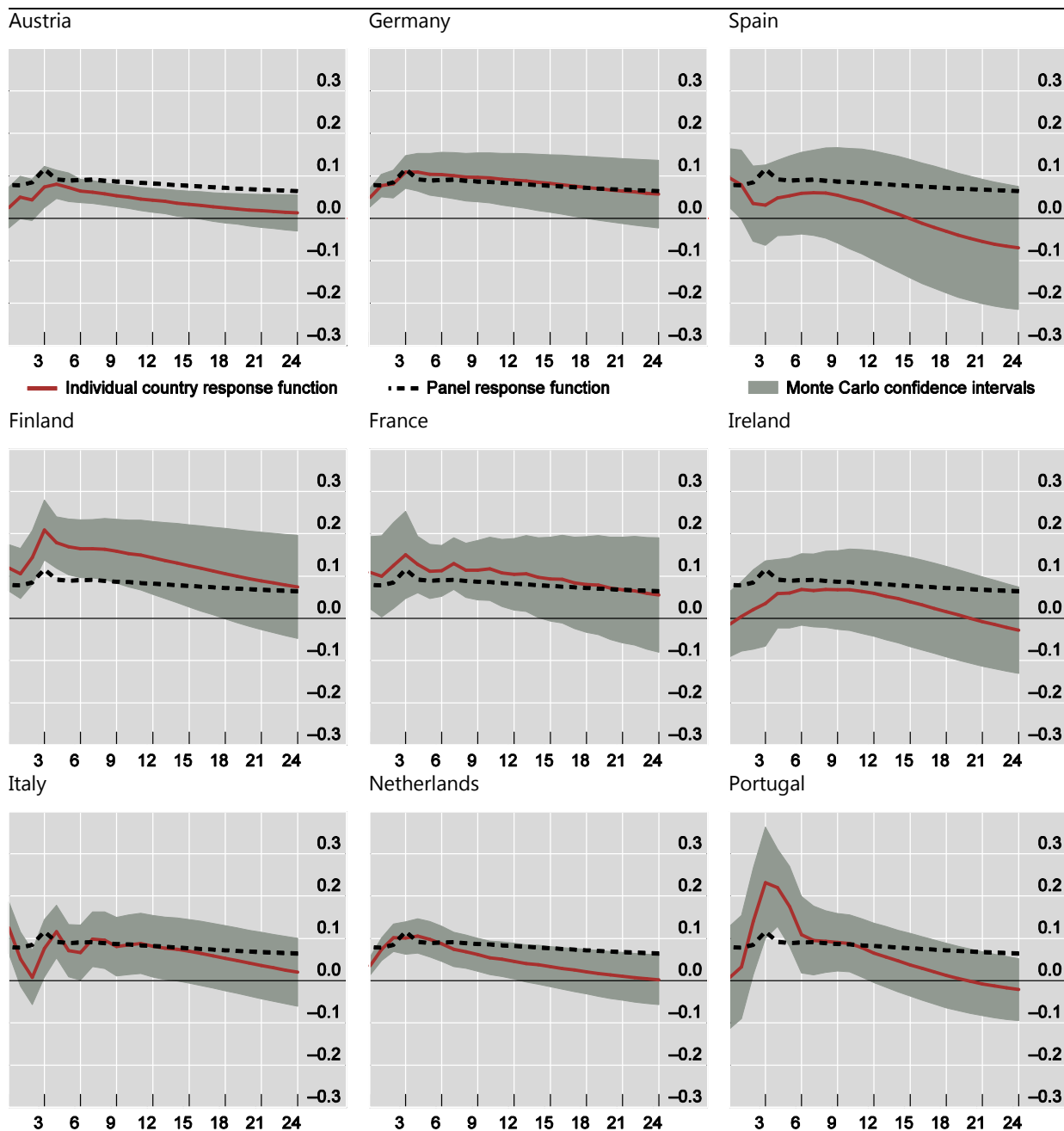
[1] The long-term concerns rates above 1-year maturity.

Sources: European Central Bank; authors' calculations.

MFI's short-term lending rates of residential loans[1]

Response functions to a shock in the corresponding bank funding cost   Graph 3
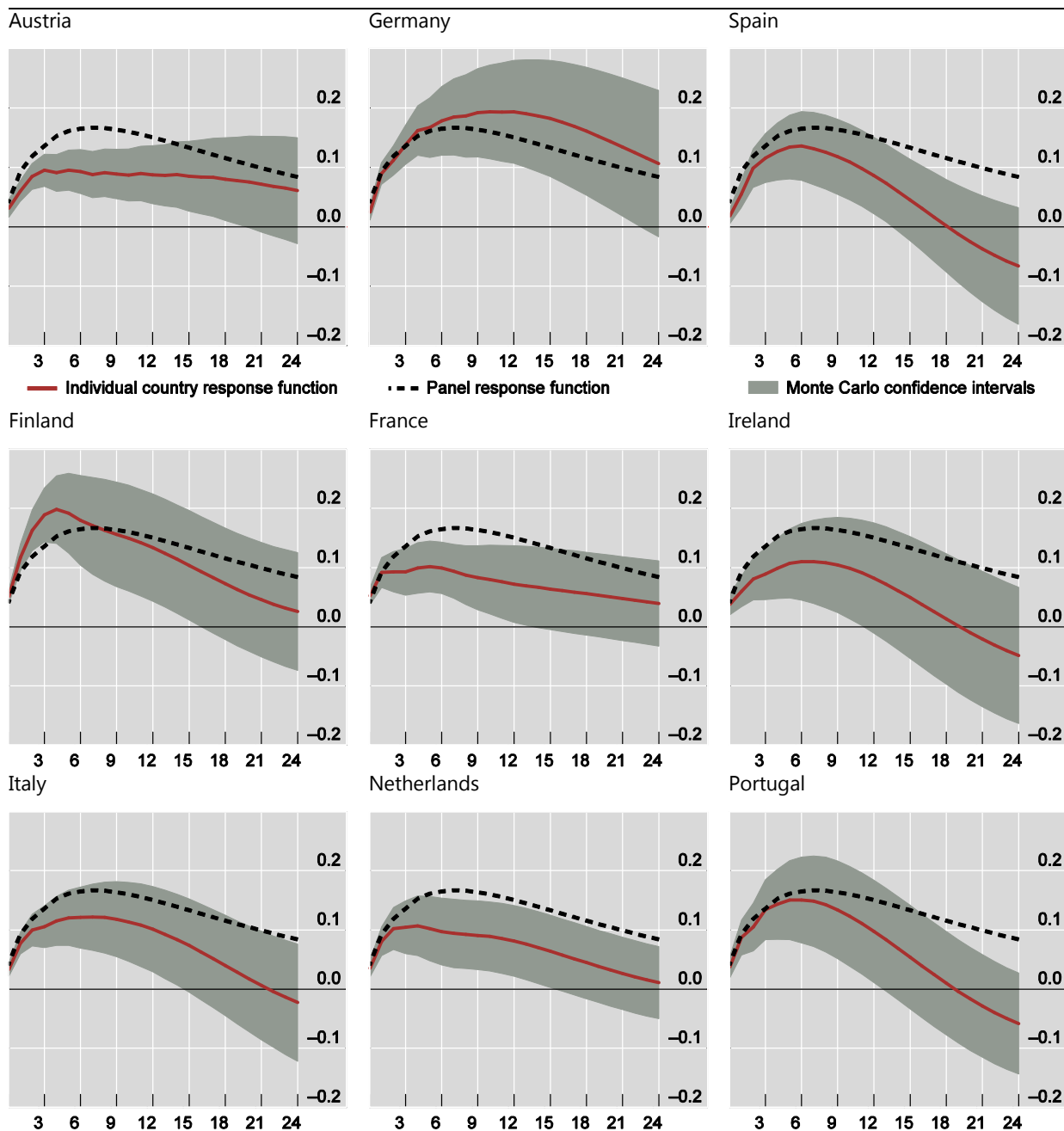
[1] The short-term concerns rates less than 1-year maturity.

Sources: European Central Bank; authors' calculations.

MFI's long-term lending rates of residential loans[1]

Response functions to a shock in the corresponding bank funding cost

Graph 4
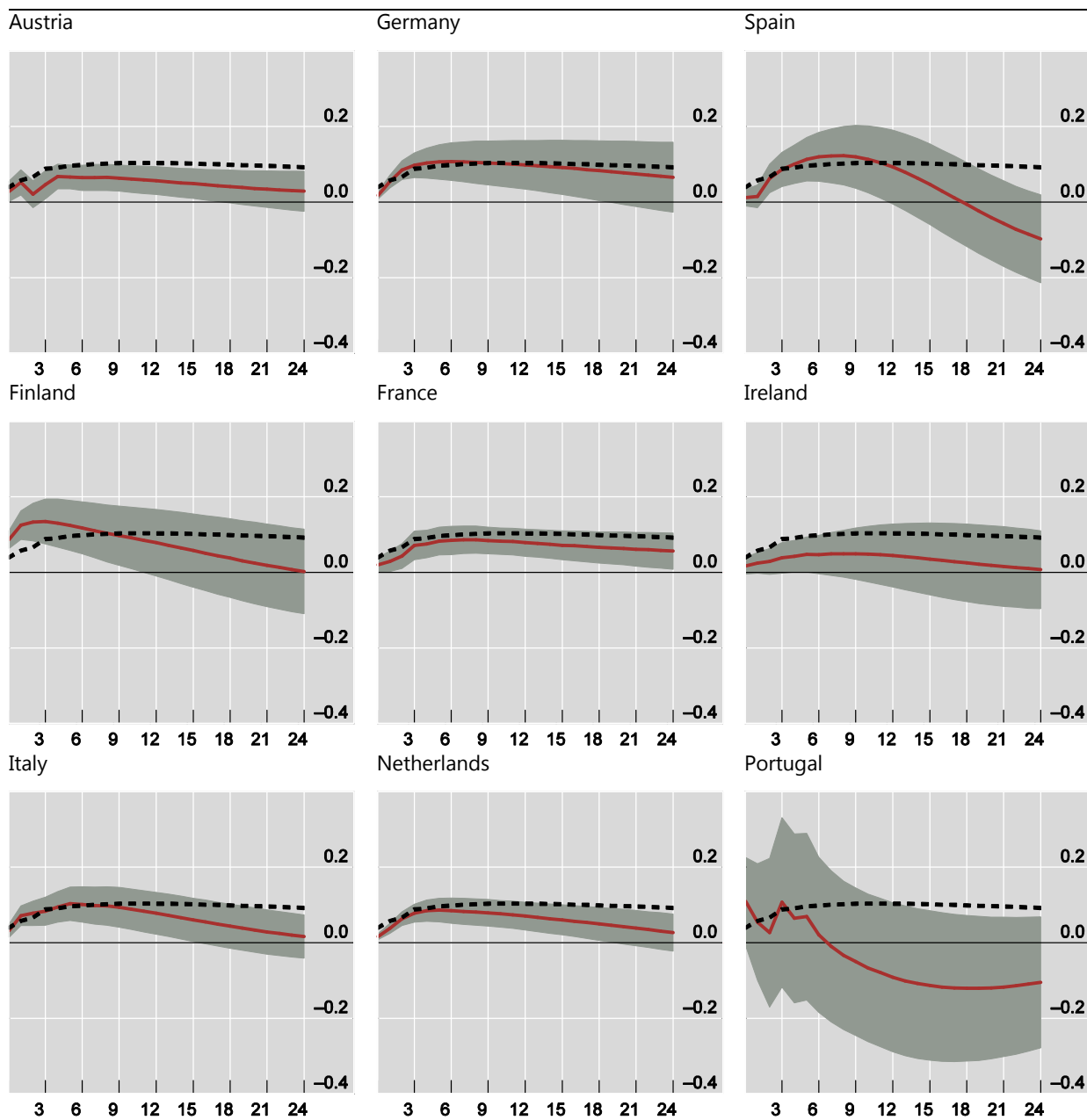
Austria

Germany

Spain

Finland

France

Ireland

Italy

Netherlands

Portugal

[1] The long-term concerns rates above 1-year maturity.

Sources: European Central Bank; authors' calculations.

Unit root tests Table 1

Im–Pesaran–Shin panel unit root test						
Lending Rates	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate		
	1.437 (0.925)	–2.531 (0.006)	–0.119 (0.453)	0.690 (0.755)		
Bank funding costs (short term)	WACL(stock, unadjusted)	WACL (stock, adjusted)	WACL (flow, adjusted)			
	0.884 (0.812)	0.884 (0.812)	1.595 (0.945)			
Bank funding costs (long term)	WACL(stock, unadjusted)	WACL (stock, adjusted)	WACL (flow, adjusted)			
	0.946 (0.828)	0.835 (0.798)	2.220 (0.987)			
Policy rate	Policy rate					
	2.593 (0.995)					
CIPS panel unit root test						
Lending Rates	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate		
	-1.777	–2.475**	–1.633	-2.289*		
Bank funding costs (short term)	WACL(stock, unadjusted)	WACL (stock, adjusted)	WACL (flow, adjusted)			
	-1.722	-1.722	-2.304*			
Bank funding costs (long term)	WACL(stock, unadjusted)	WACL (stock, adjusted)	WACL (flow, adjusted)			
	-1.972	-2.116	-2.149			
Policy rate	Policy rate					
	0.412					

Notes: The top panel reports the W–statistic for the Im, Peseran and Shin (1999) test with p-value in brackets. The bottom panel reports the Pesaran (2007) CIPS test with t–statistic and p-value in brackets

Cointegration tests					Table 1 (cont.)
Cointegration test allowing for cross sectional dependence	Persyn & Westerlund (2008) Test	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate
Policy Rate					
Policy rate (full sample)	G_τ	-1.253	-2.564***	1.069	-1.197
Policy rate (full sample)	P_τ	-0.196	-4.409***	-0.398	-3.600***
Policy rate (Pre-GFC sample)	G_τ	-6.392***	-3.681***	-3.802***	-2.080**
Policy rate (Pre-GFC sample)	P_τ	-6.673***	-5.566***	-3.868***	-1.892**
Weighted Average Cost of Liabilities (WACL)					
WACL (stock, unadjusted)	G_τ	-4.288***	-1.730**	-3.340***	-2.987***
WACL (stock, unadjusted)	P_τ	-2.571***	-4.073***	-3.712***	-3.450***
WACL (stock adjusted)	G_τ	-4.288***	-3.449***	-3.340***	-3.540***
WACL (stock, adjusted)	P_τ	-2.571***	-2.554***	-3.712***	-3.645***
WACL (flow, adjusted)	G_τ	0.270	-2.508***	-2.734***	-1.919**
WACL (flow, adjusted)	P_τ	0.737	-3.521***	-2.087**	-3.052***
Cointegration test allowing for structural breaks and cross sectional dependence	Banerjee & Carrion-i-Sylvestre (2013) Test	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate
Policy Rate					
Policy rate (full sample, intercept break)	Z_a	-3.230***	-1.0391	-2.710**	-3.229***
Policy rate (full sample, intercept and cointegrating vector break)	Z_{ac}	-4.131***	-0.2911	-1.646	-2.6664**
Weighted Average Cost of Liabilities (WACL)					
WACL (stock, unadjusted, full sample, intercept break)	Z_a	-3.716***	-3.015***	-2.959***	-4.504***
WACL (stock, unadjusted ull sample, intercept and cointegrating vector break)	Z_{ac}	-2.304**	-2.564**	-2.580**	-3.760***

Note: The critical value for Persyn and Westerlund (2008) G_τ and P_τ tests at the 5% level is -1.96 and the critical value for Banerjee and Carrion-I-Silvestre (2013) Z_a and Z_{ac} tests is -1.96.

Pesaran-Shin-Smith pooled mean group estimates of interest rate pass through using weighted average cost of liabilities (WACL)

Table 2

	WACL (stock, adjusted)				WACL (flow, unadjusted)			
	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate
Countries: Euro Area, UK and Denmark								
Cointegrating relation Pass through estimate	0.890***	0.879***	0.856***	0.886***	0.890***	0.805***	0.888***	0.748***
	0.012	*0.037*	*0.016*	*0.047*	*0.017*	*0.051*	*0.018*	*0.058*
Short run adjustment coefficient	-0.237***	-0.231***	-0.113***	-0.089***	-0.127***	-0.167***	-0.082***	-0.068***
	0.048	*0.040*	*0.033*	*0.021*	*0.046*	*0.027*	*0.021*	*0.014*
Short run adjustment coefficient (robust)	-0.238***	-0.201***	-0.070***	-0.080***	-0.120**	-0.157***	-0.051***	-0.066***
	0.056	*0.033*	*0.021*	*0.022*	*0.056*	*0.023*	*0.009*	*0.016*
No Obs.	1363	1363	1363	1363	1363	1363	1363	1363
RMSE	0.1453	0.3408	0.1050	0.2199	0.1537	0.3501	0.1105	0.2199
t-bar (PMG)	-3.105***	-2.820***	-2.990***	-2.482**	-2.090**	-2.332**	-2.756***	-2.095**
Half-life (in months)	4.0	4.2	6.7	7.0	7.8	5.9	9.3	9.1
Countries: Euro Area								
Cointegrating relation Pass through estimate	0.877***	0.733***	0.864***	0.907***	0.890***	0.817***	0.893***	0.822***
	0.013	*0.038*	*0.016*	*0.061*	*0.017*	*0.052*	*0.018*	*0.072*
Short run adjustment coefficient	-0.234***	-0.225***	-0.090***	-0.073***	-0.144***	-0.171***	-0.090***	-0.064***
	0.058	*0.040*	*0.026*	*0.018*	*0.055*	*0.032*	*0.025*	*0.016*
Short run adjustment Coefficient (robust)	-0.234***	-0.222***	-0.054***	-0.072***	-0.144**	-0.162***	-0.074***	-0.060***
	0.065	*0.044*	*0.015*	*0.020*	*0.062*	*0.031*	*0.026*	*0.020*
No Obs.	1125	1125	1125	1125	1125	1125	1125	1125
RMSE	0.1315	0.3314	0.0678	0.2319	0.1385	0.3391	0.0715	0.2317
t-bar (PMG)	-3.098***	-2.648***	-2.918***	-2.293**	-2.312**	-2.334**	-3.023***	-2.068**
Half-life (in months)	4.1	4.3	8.8	8.6	6.8	5.7	8.8	9.5

Table 2 (cont)

Countries: Euro Area Core

Cointegrating relation								
Pass through estimate	0.876***	0.749***	0.859***	0.953***	0.899***	0.853***	0.893***	0.899***
	0.014	*0.041*	*0.017*	*0.071*	*0.017*	*0.055*	*0.019*	*0.094*
Short run adjustment coefficient	-0.331***	-0.218***	-0.113**	-0.077***	-0.197**	-0.144***	-0.113***	-0.058***
	0.057	*0.054*	*0.044*	*0.029*	*0.090*	*0.030*	*0.041*	*0.015*
Short run adjustment Coefficient (robust)	-0.336***	-0.218***	-0.041***	-0.066	-0.196**	-0.095***	-0.100	-0.037***
	0.088	*0.059*	*0.005*	*0.045*	*0.092*	*0.003*	*0.071*	*0.009*
No Obs.	625	625	625	625	625	625	625	625
RMSE	0.1269	0.1941	0.0665	0.0920	0.1327	0.1988	0.0685	0.0942
t-bar (PMG)	-3.783***	-2.735***	-3.173***	-2.546**	-2.604***	-2.422**	-3.286***	-2.316**
Half-life (in months)	2.8	4.3	7.3	7.5	4.8	6.6	7.2	9.3

Notes: The pass through estimate is obtained from the pooled θ estimate from equation (11) , short run adjustment coefficient is obtained from the pooled α_i estimate from equation (11). Standard errors are given in italics beneath the coefficient estimates. The robust estimate ensures that the weight on each country is based on the proximity of the country observation to the average of all countries, reducing the influence of outlier observations compared to the non-robust estimates. *No.Obs* is the total number of observations used to estimate the pooled mean group estimator. *RMSE* is the root mean squared error of the regression. *t-bar (PMG)* is the unweighted average of the t-statistics on the short run adjustment coefficient. *Half life* is the time in months for a shock to the equilibrium relation to decay by half.

Pesaran–Shin–Smith pooled mean group estimates of interest rate pass through using policy rates

<div align="right">Table 3</div>

	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate
Countries: Euro Area, UK and Denmark				
Cointegrating relation				
Pass through estimate	0.938***	0.615***	0.523***	0.738***
	0.015	*0.032*	*0.014*	*0.031*
Short run adjustment coefficient	−0.196***	−0.165***	−0.069***	−0.101***
	0.044	*0.040*	*0.025*	*0.037*
Short run adjustment coefficient (robust)	−0.198***	−0.164***	−0.041***	−0.031**
	0.048	*0.043*	*0.009*	*0.013*
No Obs.	1363	1363	1372	1363
RMSE	0.1466	0.3464	0.1087	0.2200
t-bar (PMG)	-2.633***	-1.942*	-2.108**	-2.328**
Half-life (in months)	4.7	6.2	10.3	5.9
Countries: Euro Area				
Cointegrating relation				
Pass through estimate	0.937***	0.633***	0.943***	0.699***
	0.015	*0.051*	*0.023*	*0.049*
Short run adjustment coefficient	−0.205***	−0.119***	−0.069***	−0.079***
	0.053	*0.034*	*0.024*	*0.026*
Short run adjustment coefficient (robust)	−0.211***	−0.118***	−0.033***	−0.031**
	0.064	*0.040*	*0.010*	*0.014*
No Obs.	1125	1125	1134	1125
RMSE	0.1365	0.3482	0.0740	0.2311
t-bar (PMG)	-2.719***	-1.740	-2.310**	-2.203**
Half-life (in months)	4.5	8.5	10.5	7.6
Countries: Euro Area Core				
Cointegrating relation				
Pass through estimate	0.939***	0.661***	0.958***	0.720***
	0.016	*0.054*	*0.024*	*0.054*
Short run adjustment coefficient	−0.325***	−0.173***	−0.106***	−0.089**
	0.023	*0.035*	*0.036*	*0.040*
Short run adjustment coefficient (robust)	−0.326***	−0.165***	−0.103**	−0.091**
	0.027	*0.039*	*0.041*	*0.041*
No Obs.	625	625	630	625
RMSE	0.1289	0.2072	0.0707	0.0944
t-bar (PMG)	-4.236***	-2.734***	-3.155***	-2.692***
Half-life (in months)	2.7	5.3	7.1	5.6

Notes: See Table 2

	Short rate to NFCs	Long rate to NFCs	Short mortgage rate	Long mortgage rate
Pesaran-Shin-Smith pooled mean group estimates of interest rate pass through using WACL for sub-samples (Euro area) — Table 4				
Sample extends until global financial crisis (2003M1 - 2007M7)				
Cointegrating relation				
Pass through estimate	1.040***	1.182***	1.000***	0.949***
	0.020	*0.090*	*0.034*	*0.055*
Short run adjustment coefficient	-0.451***	-0.294***	-0.153***	-0.167***
	0.103	*0.077*	*0.035*	*0.072*
Short run adjustment coefficient (robust)	-0.389***	-0.299***	-0.152**	-0.050***
	0.049	*0.086*	*0.039*	*0.023*
No Obs.	432	432	432	432
RMSE	0.0658	0.1914	0.0357	0.1307
t-bar (PMG)	-2.694***	-1.509	-1.873*	-2.155**
Half-life (in months)	1.7	3.1	4.8	4.1
Sample extends until post crisis recession (2003M1 - 2008M8)				
Cointegrating relation				
Pass through estimate	0.950***	0.894***	1.003***	0.789***
	0.010	*0.031*	*0.017*	*0.032*
Short run adjustment coefficient	-0.429***	-0.379***	-0.132***	-0.170**
	0.095	*0.103*	*0.031*	*0.069*
Short run adjustment coefficient (robust)	-0.363***	-0.385***	-0.110***	-0.138**
	0.093	*0.119*	*0.030*	*0.063*
No Obs.	549	549	549	549
RMSE	0.0764	0.2090	0.0420	0.1469
t-bar (PMG)	-2.861***	-1.930*	-2.459**	-2.262**
Half-life (in months)	1.9	2.4	5.5	3.7
Sample extends until sovereign debt crisis (2003M1 - 2009M12)				
Cointegrating relation				
Pass through estimate	0.916***	0.783***	0.811***	0.697***
	0.010	*0.025*	*0.015*	*0.023*
Short run adjustment coefficient	-0.434***	-0.360***	-0.162***	-0.167**
	0.066	*0.078*	*0.050*	*0.066*
Short run adjustment coefficient (robust)	-0.426***	-0.359***	-0.147***	-0.104***
	0.072	*0.085*	*0.049*	*0.035*
No Obs.	693	693	693	693
RMSE	0.0941	0.2374	0.0536	0.1947
t-bar (PMG)	-4.173***	-2.596***	-2.612***	-2.735***
Half-life (in months)	2.0	2.4	5.1	3.6

Notes: See Table 2

Appendix

WACL Stock Measure

The following measures of outstanding volumes were recorded:

Deposit liabilities (in all currencies, and excluding the general government) vis-à-vis the euro area to MFIs and to non-MFIs, obtained from the ECB, which reports the MFIs aggregate balance sheet on a national basis (excluding the ESCB). For non euro area countries we use sources from national central banks.

Debt securities, issued in all currencies in the euro area by the MFIs. This is obtained from the MFIs balance sheets, which also report breakdowns of maturities up to and over one year.

Covered bonds, which are obtained from Dealogic. This component is only used for the long-term calculations, as we assume that all of the covered bonds have a maturity of more than one year.

Funding from central bank operations. We only use this for the euro area countries. Liquidity provided by the central bank is a component that became important in the period after 2009. For the short-term, we include the amounts of the Main Refinancing Operations (MROs), while for the long-term we sum up the amounts of MROs and the long-term refinancing operations (LTROs).

WACL Flow Measure

The following items of flows were recorded:

New deposits with agreed maturity for non-MFIs from the ECB record the deposit flows. Since there is no new deposits data for the MFIs, we approximated this by multiplying the flow data of the non-MFIs with the ratio between the outstanding amounts of interbank and private deposit liabilities.

Data on debt securities is obtained from the ECB debt securities database, which reports the gross issuance by sector of securities other than shares for the short- (less than one year) and the long-term (more than one year).

The covered bonds gross issuance is obtained from Dealogic, which reports the gross issuance by the financial sector; this is used only in the long-term calculation.

Weight Adjustments

We assume that banks will use cheapest available funding, unless constrained, and will not borrow at rates above lending rates of the same maturity. At some points the cost of issuing debt securities exceeds the lending rate, therefore, we impose the condition that in this case securities will be funded by less expensive covered bonds rather than conventional bonds, which will be zero weighted. This produces an adjusted WACL.

Funding from the central bank is often the cheapest available form of funding, but banks will not always borrow from this source rather than from depositors or bond holders if they are constrained by the availability of collateral.

Weight components of the short-term WACL[1]

In per cent

	MFI deposits			Non-MFI deposits			Short-term securities other than shares			Central bank operations[2]		
	All	Pre	Post	**All**	Pre	Post	**All**	Pre	Post	**All**	Pre	Post
Austria	**40.1**	38.8	41.2	**57.9**	58.5	57.3	**1.1**	1.1	1.1	**0.9**	1.6	0.4
Finland	**17.9**	17.7	18.1	**69.8**	67.3	72.1	**11.8**	14.0	9.7	**0.5**	1.1	0.0
France	**47.2**	47.2	47.2	**44.5**	44.2	44.8	**8.3**	8.6	8.0	**0.0**	0.0	0.1
Germany	**35.5**	38.7	32.6	**61.7**	57.1	65.9	**1.0**	1.1	0.9	**1.8**	3.1	0.6
Ireland	**55.2**	53.6	56.7	**39.1**	39.9	38.3	**3.1**	4.5	1.9	**2.6**	2.0	3.1
Italy	**38.1**	40.5	35.9	**61.0**	58.4	63.5	**0.1**	0.0	0.1	**0.8**	1.1	0.5
Netherlands	**22.1**	29.2	15.5	**74.9**	68.5	80.8	**3.0**	2.3	3.7			
Portugal	**30.4**	31.5	29.3	**68.1**	68.3	67.8	**0.4**	0.1	0.7	**1.2**	0.2	2.1
Spain	**25.3**	25.9	24.7	**71.1**	69.3	72.8	**2.3**	3.2	1.5	**1.3**	1.6	1.0
Denmark	**34.7**	30.2	38.9	**64.2**	69.1	59.6	**1.1**	0.7	1.4			
United Kingdom	**30.3**	36.4	24.7	**63.8**	57.5	69.8	**5.8**	6.2	5.5			

[1] All refers to all the sample, pre-crisis is from January 2003 (depending on data availability) to August 2008; post-crisis is from September 2008 to the latest data available.   [2] ECB main refinancing operations.

Sources: European Central Bank; national data.

Weight components of the long-term WACL[1]

In per cent

	MFI deposits			Non-MFI deposits			Long-term securities other than shares			Covered bonds			Central bank operations[2]		
	All	Pre	Post	All	Pre	Post	All	Pre	Post	All	Pre	Post	All	Pre	Post
Austria	**28.0**	27.3	28.6	**40.3**	41.2	39.4	**28.8**	29.1	28.4	**1.5**	0.9	2.1	**1.5**	1.5	1.5
Finland	**15.6**	17.0	14.3	**61.0**	64.6	57.5	**19.9**	16.5	23.3	**2.1**	0.2	3.9	**1.3**	1.6	1.0
France	**40.7**	42.0	39.5	**38.3**	39.4	37.3	**16.3**	15.5	17.0	**4.1**	3.1	5.1	**0.6**	0.0	1.2
Germany	**23.8**	24.0	23.5	**41.6**	35.4	47.6	**22.0**	23.4	20.6	**10.4**	14.2	6.6	**2.3**	2.9	1.6
Ireland	**44.1**	43.4	44.9	**31.0**	32.5	29.5	**14.2**	16.3	12.1	**3.2**	3.6	2.8	**7.5**	4.2	10.8
Italy	**27.5**	29.6	25.4	**43.6**	42.7	44.5	**27.0**	26.2	27.7	**0.8**	0.0	1.6	**1.2**	1.6	0.8
Netherlands	**16.3**	22.0	10.8	**53.3**	50.9	55.7	**25.8**	24.7	26.9	**0.8**	0.3	1.3	**3.7**	2.1	5.2
Portugal	**24.4**	27.6	21.3	**54.3**	59.9	49.0	**14.7**	11.0	18.4	**1.9**	0.4	3.3	**4.7**	1.2	8.0
Spain	**19.8**	21.6	18.0	**55.4**	57.5	53.3	**11.7**	11.4	12.0	**9.6**	7.8	11.4	**3.5**	1.6	5.3
Denmark	**13.5**	11.7	15.2	**24.9**	26.5	23.3	**61.4**	61.8	61.0	**0.3**	0.0	0.5			
United Kingdom	**27.6**	33.6	21.7	**56.8**	53.0	60.5	**14.0**	13.0	15.1	**1.6**	0.5	2.7			

[1] All refers to all the sample, pre-crisis is from January 2003 (depending on data availability) to August 2008; post-crisis is from September 2008 to the latest data available.   [2] ECB main refinancing operations and long-term refinancing operations.

Sources: European Central Bank; Dealogic; national data.

Interest rate components of the short-term WACL[1]

In per cent   Table A3

	MFI deposits[2]			Non-MFI deposits[3]			Short-term securities other than shares[4]			Central bank operations[5]		
	All	Pre	Post	**All**	Pre	Post	**All**	Pre	Post	**All**	Pre	Post
Austria	1.67	2.80	0.60	1.98	2.77	1.22	2.89	3.33	2.48	1.81	2.75	0.98
Finland	1.67	2.80	0.60	1.92	2.80	1.05	2.58	3.32	1.88	1.81	2.75	0.98
France	1.67	2.80	0.60	2.06	2.81	1.33	2.63	3.29	2.01	1.81	2.75	0.98
Germany	1.67	2.80	0.60	1.82	2.73	0.93	2.61	3.35	1.91	1.81	2.75	0.98
Ireland	1.67	2.80	0.60	2.08	2.62	1.55	5.65	3.36	7.81	1.81	2.75	0.98
Italy	1.67	2.80	0.60	2.16	2.47	1.85	3.22	3.31	3.13	1.81	2.75	0.98
Netherlands	1.67	2.80	0.60	1.90	2.87	0.95	3.35	3.62	3.09	1.81	2.75	0.98
Portugal	1.67	2.80	0.60	2.49	2.74	2.24	4.67	3.34	5.91	1.81	2.75	0.98
Spain	1.67	2.80	0.60	2.45	2.80	2.12	3.54	3.35	3.71	1.81	2.75	0.98
Denmark	1.81	2.89	0.79	1.75	2.11	1.38	2.86	3.41	2.35	1.71	2.75	0.78
United Kingdom	2.66	4.70	0.74	3.01	4.65	1.65	3.55	5.12	2.06	2.54	4.64	0.69

[1] All refers to all the sample, pre-crisis is from January 2003 (depending on data availability) to August 2008; post-crisis is from September 2008 to the latest data available. [2] Interbank overnight rates. [3] Deposit rate on euro deposits with agreed maturity for the non-financial corporations and households with maturities up to 1 year; if data not available close approximation to this rate. [4] The 1-year interest rate swap plus the 1-year financial CDS for selected banks in each country. [5] The central bank policy rate.

Sources: European Central Bank; national data.

Interest rate components of the long-term WACL[1]

In per cent   Table A4

	MFI deposits[2]			Non-MFI deposits[3]			Long-term securities other than shares[4]			Covered bonds			Central bank operations[5]		
	All	Pre	Post	**All**	Pre	Post	**All**	Pre	Post	**All**	Pre	Post	**All**	Pre	Post
Austria	2.28	3.20	1.42	2.57	3.15	2.01	3.91	4.02	3.81	3.14	4.02	2.27	1.81	2.75	0.98
Finland	2.28	3.20	1.42	2.47	2.97	1.99	3.44	3.95	2.96	2.82	3.62	2.03	1.81	2.75	0.98
France	2.28	3.20	1.42	2.82	3.02	2.63	3.66	3.93	3.40	3.14	3.74	2.54	1.81	2.75	0.98
Germany	2.28	3.20	1.42	2.78	3.33	2.25	3.65	4.04	3.28	2.66	3.54	1.80	1.81	2.75	0.98
Ireland	2.28	3.20	1.42	2.08	2.62	1.55	5.91	4.07	7.65	4.10	3.71	4.48	1.81	2.75	0.98
Italy	2.28	3.20	1.42	2.30	2.35	2.25	4.23	3.97	4.48	3.79	4.20	3.39	1.81	2.75	0.98
Netherlands	2.28	3.20	1.42	3.82	4.22	3.44	4.24	4.22	4.26	3.19	3.80	2.58	1.81	2.75	0.98
Portugal	2.28	3.20	1.42	2.68	2.56	2.81	5.39	4.04	6.66	4.83	4.40	5.25	1.81	2.75	0.98
Spain	2.28	3.20	1.42	2.62	2.70	2.55	4.51	4.02	4.97	4.17	4.01	4.34	1.81	2.75	0.98
Denmark	2.54	3.33	1.79	1.75	2.11	1.38	3.82	4.04	3.60	2.89	3.36	2.43	1.71	2.75	0.78
United Kingdom	3.28	5.06	1.59	3.97	4.95	3.16	4.49	5.28	3.73	3.49	4.05	2.95	2.54	4.64	0.69

[1] All refers to all the sample, pre-crisis is from January 2003 (depending on data availability) to August 2008; post-crisis is from September 2008 to the latest data available. [2] Interbank overnight rates. [3] Deposit rate on euro deposits with agreed maturity for the non-financial corporations and households with maturities over 1 year; if data not available close approximation to this rate. [4] The 5-year interest rate swap plus the 5-year financial CDS for selected banks in each country. [5] The central bank policy rate.

Sources: European Central Bank; Barclays; national data.