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Bank asset quality and monetary policy pass-through

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Abstract

The funding mix of European firms is weighted heavily towards bank credit, which underscores the importance of efficient pass-through of monetary policy actions to lending rates faced by firms. Euro area pass-through has shifted from being relatively homogenous to being fragmented and incomplete since the financial crisis. Distressed loan books are a crisis hangover with direct implications for profitability, hampering banks ability to supply credit and lower loan pricing in response to reductions in the policy rate. This paper presents a parsimonious model to decompose the cost of lending and highlight the role of asset quality in diminishing pass-through. Using bank-level data over the period 2008-2014, we empirically test the implications of the model. We show that a one percentage point increase in the impairment ratio lowering short run pass-through by 3 per cent. We find that banks with severely impaired balance sheets do not adjust their loan pricing in response to changes in the policy rate at all. We derive a measure of the hidden bad loan problem, the NPL gap, which we define as the excess of non-performing loans over impaired loans. We show that it played a significant role in the fragmentation of euro area pass-through post-crisis.

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Keywords: Monetary Policy Pass-through, Impaired Loans, Non-Performing Loans, Interest Rates

1 Introduction

The post-financial crisis period of sluggish growth and low inflation resulted in substantial monetary policy easing by major central banks. One of the channels through which monetary policy can affect the real economy is the credit channel, with monetary easing affecting the cost of borrowing for firms from banks. This channel is particularly important for European firms because they face a relatively less-developed market for alternatives to bank finance[1].

The efficacy of the credit channel depends on the successful pass-though of changes in the policy rate to loan pricing. Pass-through in Europe became fragmented post-crisis, however (Ciccarelli et al., 2014). In this paper, we examine the extent to which fragmentation in lending rates in Europe can be explained by the decline in the quality of the assets held by European banks. Non-performing loans (NPLs) were a consequence of the overheated property markets pre-crisis and have direct implications for the price of credit. Price setting must reflect the higher risk weights associated with a stock of distressed loans and the reduction in net interest margin due to bad loans not bearing interest.

This paper investigates the degree to which pass-through of monetary policy was affected by the decline in bank asset quality. Our contribution to the understanding of the role played by the quality of banks' balance sheets in determining pass-though is two-fold. Firstly, we extend the loan pricing model of Ruthenberg and Landskroner (2008) to allow the quality of a bank's assets to affect its lending. We allow the capital reserve to be based on the stock of lending, as well as the flow of new lending. If default rates prove to be greater than expected at origination, capital costs are incurred through provisioning. We show that this reduces the pass-through from the policy rate to the lending rate.

Secondly, using bank-level data over the period 2008-2014, we empirically test the implications of the model for both short-run and long-run adjustment of lending rates to policy rate movements. We find an average short-run pass-through of 71.5 per cent. However, there is a large dispersion in pass-through based on asset quality. We find approximately 84 per

[1] The ECB conducts a semi-annual Survey on the Access to Finance for Enterprises (SAFE) showing more than 50 per cent of firms use bank finance compared to 25 per cent in the US.

cent pass-through in the absence of impaired loans, compared to 62 per cent for a bank with the mean impairment ratio. Furthermore, banks with large reductions in asset quality, i.e., with impairment rates greater than 17 per cent, do not adjust their loan pricing in response to reductions in the policy rate at all.

Banks operate with a limited capital reserve and, facing solvency issues, impairments may not keep pace with a growing non-performing loan ratio. To investigate if impairments underestimate the full extent of the bad loan problem, we calculate an "NPL Gap" for each bank. We define this as the difference between the NPL and impairment ratios. This gap grows with rising NPL levels, whereby for rates above 10 per cent, an average of half the loans are impaired. The results show that this gap both increases the level of loan pricing and reduces pass-though by a magnitude that is comparable to impairments. Furthermore, the NPL gap is concentrated within European countries which experienced sovereign stress, and can provide an explanation for the divergence in pass-through rates since 2008.

The pass-through of monetary policy actions across the euro area is a well-investigated topic, initially focusing on the joining of monetary union (Marotta, 2009) and resulting gains in the speed and homogeneity of pass-through (Sander and Kleimeier, 2004). More recently, research has focused on the post-financial crisis era, showing increased fragmentation across countries (Ciccarelli et al., 2014; Aristei and Gallo, 2014) and less completeness of pass-through (Hristov et al., 2014). This divergence has been explained by higher funding costs (Illes et al., 2015), funding uncertainty (Ritz and Walther, 2015) and the changing marginal cost of raising deposits (Avouyi-Dovi et al., 2017). The use of micro data on banks balance sheets has grown to help understand the factors underlying these changes. They point to the importance of bank-specific characteristics, in addition to macro variables in explaining developments in pass-through (Gambacorta, 2008; Holton and Rodriguez d'Acri, 2015). Similar to the US, size (Kashyap and Stein, 1995), liquidity (Kashyap and Stein, 2000) and capital ratios (Kishan and Opiela, 2000) are key to lending rates adjusting to policy changes.

The post-crisis overhang of bad loans has brought the macroeconomic impact into sharp focus. Constâncio (2017) shows that NPL resolution yields increases in credit supply of 2.5

to 6 per cent in countries with higher ratios. Balgova et al. (2016) estimates the damage of prolonged periods of a high NPL ratio, finding 2 per cent of growth is foregone annually. On the bank side, along with reducing credit supply, NPLs distort credit allocation, cause market uncertainty and act as a drag on economic growth (Kwan and Eisenbeis, 1995; Cucinelli, 2015; Jorda et al., 2013; Peek and Rosengren, 2000, 2005). Exploiting credit registry information, Jiménez et al. (2012) separate demand and supply side effects, showing the significant negative role of existing or previous bad debts on the firm side in the granting of new credit. Wang (2018) shows that competition in deposit and loan markets drove non-performing loan ratios in US banks, while Borio and Zhu (2012) highlight how monetary policy can induce risk-taking by banks. Our results, and literature on the macroeconomic impacts of NPLs, underscore the importance of effective regulation to mitigate the build-up of risks on bank balance sheets.

The rest of this paper is structured as follows: Section 2 outlines a theoretical framework in which the asset quality affects the pass-through of monetary policy. Section 3 presents the data. Section 4 outlines the empirical strategy and provides empirical results. Section 4.4 compares the impairment and NPL ratios and examines the consequences for pass-through from the existence of a non-perfoming loan overhang. Finally, section 5 concludes.

2 Theory

Ruthenberg and Landskroner (2008) develop a model with loan pricing as a function of credit risk, market structure (power), cost of debt, cost of equity and sensitivity of capital to new lending. In this model, the pricing of new lending includes a premium that covers expected future losses from default on that lending. However, the scale of the economic slowdown and large real estate price corrections for many countries during the crisis meant that bank losses were much greater than expected, as were the effects on bank capital. Therefore, we extend the model to allow loan pricing to reflect the sensitivity of capital to the stock of lending, as well as expected losses from the flow of new lending. Furthermore, we allow loan pricing to be affected by yields on bank bonds, which themselves are related to the sovereign yield, and by the recoverability of debt in the event of default.

The model takes a risk-neutral commercial bank which operates in an imperfectly-competitive lending market for non-financial corporation (NFC) credit. The basis for this model is an oligopolistic extension to the Monti-Klein model of a monopolistic bank, as outlined in Freixas and Rochet (2008) The bank raises deposits from the public and may also raise funds on the interbank market. We extend the previous literature by allowing the state of the bank's balance sheet to affect the pricing of its loans.

Let $L(R_L, \alpha)$ represent the aggregate demand for credit from the banking system, which is decreasing in the lending rate R_L and depends on a shift parameter α, which can represent macro conditions and other factors which may affect aggregate credit demand. Let $PD \in (0, 1)$ be the "through-the-cycle" probability of default for lending, which we assume to be symmetric between banks. Let $LGD \in (0, 1)$ be the loss given default for a loan, i.e., the share of the loan which is not recoverable given a default event occurs. Thus we can say that the return on lending for bank i is given by:

$$\begin{cases} (1 + R_L)L_i(R_L, \alpha) & \text{with probability (1-PD);} \\ (1 - LGD)L_i(R_L, \alpha) & \text{with probability PD.} \end{cases} \tag{1}$$

Similarly, we define $D(R_D, \beta)$ as the supply function for deposits from the public, which is increasing in the interest rate paid on deposits, R_D and depends on a shift parameter β which captures the impact of macroeconomic conditions on the supply of deposits. We also define $r \in (0, 1)$ as the reserve requirement on deposits. Let $Z_i = [L_i(\cdot) - (1 - r)D_i(\cdot)]$ be the shortfall in funding for bank i, which we assume to be positive without loss of generality. The bank may borrow in the interbank market at interest rate R_w to fund this shortfall. We assume that the interbank rate is a function of the interest rate R_m set by the monetary policy authority, i.e. $R_w = f(R_m)$ where $f(\cdot)$ is a continuous, differentiable function with $f'(\cdot) > 0$. The bank may also issue bonds, the yield of which Y_b is assumed to be a function of the yield on the sovereign Y_s, i.e., $Y_b = h(Y_s)$ where $h(\cdot)$ is a continuous, differentiable function with

$h'(\cdot) > 0$. Let the shares of inter-bank lending and issuance of bonds with respect to the funding shortfall be given by γ and $(1-\gamma)$ respectively.

The bank is required by the regulator to be sufficiently capitalised against unexpected losses. We thus define $K_i(L_i, L^S)$ as the capital of the bank, which is increasing both in new lending L_i, and the stock of existing lending L^S. The interpretation of the stock of lending can include lending in other markets, i.e., to households as well as to NFCs. The return on equity is given by R_e which is a function of the monetary policy rate, i.e. $R_e = g(R_m)$ where $g(\cdot)$ is a continuous, differentiable function with $g'(\cdot) > 0$. The bank may raise equity in equity markets at this rate, to satisfy its capital requirements.

We allow that a share of the bank's outstanding lending does not perform. We assume that the bank takes impairment charges against its non-performing loans, thus realising a cost from having a stock of loans of this type. We denote the ratio of impaired loans to total loans as IMP and, intuitively, the effect of impairments on bank capital is negative:

$$\frac{\partial K}{\partial IMP} < 0. \tag{2}$$

The short-run expected profits of the commercial bank are given by:

$$\begin{aligned} E(\Pi_i) \quad &= (1-PD)(1+R_L)L_i(R_L,\alpha) + PD(1-LGD)L_i(R_L,\alpha) \\ &-(1+R_D)D_i(R_D,\beta) - [\gamma(1+R_w) + (1-\gamma)(1+Y_b)][L_i(\cdot) - (1-r)D_i(\cdot)] \\ &-R_e.K_i(L_i,L^S) - F_i \end{aligned} \tag{3}$$

where F_i is a fixed cost of operation for the bank, incorporating its branch network and other factors. Taking the derivative of (3.3) with respect to $L = \Sigma_i L_i(\cdot)$, yields the following first order condition:

$$\frac{\partial \Pi_i}{\partial L} = (1-PD)(1+R_L)\tfrac{\partial L_i}{\partial L} + (1-PD)L_i(\cdot)\tfrac{\partial(1+R_L)}{\partial L} + PD(1-LGD)\tfrac{\partial L_i}{\partial L} \quad (4)$$
$$-\gamma(1+R_w)\tfrac{\partial L_i}{\partial L} - (1-\gamma)(1+Y_b)\tfrac{\partial L_i}{\partial L} - R_e.\tfrac{\partial K_i}{\partial L} = 0.$$

Note that $L_i(\cdot)\frac{\partial(1+R_L)}{\partial L} = -\frac{s_i}{\epsilon}R_L$ where s_i is the share of lending of bank i in aggregate lending, L_i/L and ϵ is the elasticity of loan demand to the interest rate on lending. Multiplying by s_i, summing over banks, and using the Cournot assumption that $\Sigma_i s_i \frac{\partial L_i}{\partial L} = 1$, yields the following equivalence of Marginal Revenue and Marginal Cost:

$$(1-PD)(1+R_L)\left(1-\frac{H}{\epsilon}\right) + PD(1-LGD) = \gamma(1+R_w) + (1-\gamma)(1+Y_b) + R_e.\frac{\partial K_i}{\partial L_i} \quad (5)$$

where $H = \Sigma_i s_i^2$, $H \in (0,1)$ is the Herfindahl-Hirschmann index of concentration in lending. Rearranging equation (3.5), and substituting for R_w, Y_b and R_e yields the loan pricing equation:

$$(1+R_L) = \frac{1+\gamma f(R_m) + (1-\gamma)h(Y_s) + g(R_m).\frac{\partial K_i}{\partial L_i} - PD(1-LGD)}{(1-PD)\left(1-\frac{H}{\epsilon}\right)}. \quad (6)$$

Proposition 1: The interest rate on lending, R_L, is increasing in:

(i) The probability of default, PD

(ii) Market concentration, H

(iii) The loss given default, LGD

(iv) The sovereign bond yield, Y_s

(v) The sensitivity of capital to new lending, $\frac{\partial K_i}{\partial L_i}$.

Conversely, the interest rate on lending, R_L, is decreasing in:

(vi) The elasticity of credit demand to the interest rate, ϵ.

Proof: See Appendix.

The pass-through of the monetary policy rate to the lending rate is given by the partial derivative of R_L with respect to R_m:

$$\frac{\partial R_L}{\partial R_m} = \frac{\gamma f'(R_m) + g'(R_m).\frac{\partial K_i}{\partial L_i}}{(1 - PD)\left(1 - \frac{H}{\epsilon}\right)} > 0. \tag{7}$$

Intuitively, the lending rate is an increasing function of the monetary policy rate. To determine the impact of impairments on the transmission mechanism, one must take the cross partial derivative of (3.7) with respect to the impairment ratio of the bank.

Proposition 2: The pass-through of changes in the monetary policy rate to changes in the lending rate is lower the higher the impairment ratio of the bank.
Proof: See Appendix.

3 Data

To empirically evaluate the propositions in Section 2, we link data from a number of sources. We use two ECB datasets providing information on the balance sheets and loan pricing of euro area monetary financial institutions (MFIs): the Individual Balance Sheet Items (IBSI) dataset and Individual MFI Interest Rate statistics (IMIR) dataset. The former dataset provides detailed information on the assets and liabilities of euro area banks, including for instance granular information on their loans, liquid assets and deposits. The latter dataset encompasses granular data on the volume of, and interest rate on, each MFI's new lending to euro area non-financial corporations and households.

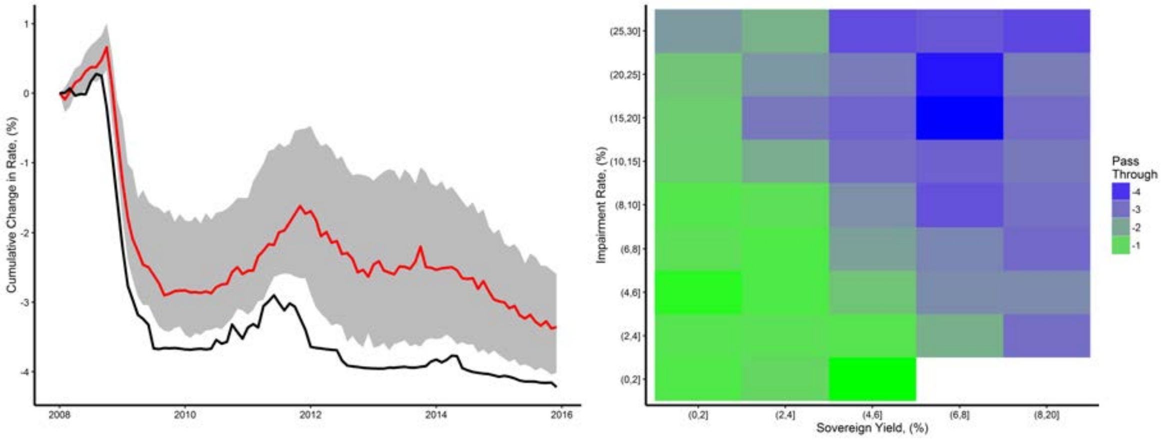
In this paper, we solely look at the lending rates to euro area non-financial corporations. Specifically, we focus on the pricing of lending rates on loans to NFCs on loans of up to €1 million in size and for up to one year of fixation; this includes loans which have adjustable rates at origination and loans which are fixed for up to one year. We choose this category of lending for a number of reasons. First, this is the most common category of lending, and thus has the greatest data coverage across banks and through time. Second, this category of lending is the one in which we would expect to find the greatest degree of sensitivity of loan pricing to monetary policy, given the short-term nature of the lending. Third, we exclude loans with longer periods of fixation to avoid potential problems with the embedding of term premia and interest rate expectations in the prices of these products. Last, our datasets provide two size categories for loans: greater or less than €1 million. We focus on the category of loans less than €1 million, given that we are more likely to be observing lending over which the borrower is a price taker and to have little bargaining power over the price. Thus, we are more likely to cleanly identify bank-driven changes in loan pricing[2].

To these datasets, we link additional information on the banks in our sample from other sources. Table 8 provides a full description of the data and sources which are used in this paper. The IBSI and IMIR datasets do not contain information on the impairment of the balance sheets of the banks, so we rely on information from the SNL Financial data provider. We are able to extract data on the asset quality of Europe's banks from this source, specifically focusing on the impairment ratio for its representation of the realisation of costly impacts from a non-performing position, as discussed in Section 2. The impairment ratio is given by the ratio of impaired loans, i.e., loans against which an impairment charge has been taken, to total loans. We also extract the ratio of non-performing loans from this source, where non-performing loans are defined as loans from which interest is no longer accruing. From the NPL ratio and impairment ratio, we are able to define an "NPL gap" measure, as the percentage point excess of the NPL ratio over the impairment ratio. We examine the impact of having an NPL overhang on pass-through in Section 4.4.

[2]In the literature, loans of up to €1 million in size are commonly chosen as a proxy for the SME credit market, given that the datasets do not allow the counterparty classification to be explicitly identified (Holton and McCann, 2016). Individual loans which exceed €1 million in size are more likely to be taken out by large firms, which are more likely to have some degree of bargaining power over the price of the loan.

Figure 1: Cumulative changes in lending rates

(a) Against changes in Eonia (b) By impairment ratio and sovereign yields



Notes: Figure 1a shows the cumulative change in Eonia (black line) since Jan. 2008, against the median cumulative change in bank lending rate, with shaded area showing the inter-quartile range. Figure 1b shows the heatmap of categories of impairment rate and sovereign yield between Jan. 2008 and Dec. 2015. The colour scale captures cumulative pass-through, measured as the median lending rate less Eonia for each category.

We take both the impairment and NPL ratios on a consolidated basis, i.e., accounting for the possible non-performance of a bank's lending book in other jurisdictions than its home market, if it has any lending of this type. Similarly, we account for the existence of banking groups in the euro area: we assign members of a banking group the consolidated impairment and NPL ratios of the banking group. This accounts for the possibility that the pricing of the loans issued by one member of a banking group can be driven by group-level asset quality, and affected by within-banking group subsidisation effects, rather than the non-performance of that member's previous loans on a residency basis. The impairment and NPL ratios are reported at half-yearly frequency, and we interpolate to monthly frequency using the method of Stineman (1980)[3].

Figure 1 depicts two ways in which we can visualise pass-through in our sample: how lending rates have evolved through time compared with the money market rate and how the degree of pass-through differs based on degrees of balance sheet impairment and sovereign stress. The left-hand panel shows the cumulative changes in the median lending rate in our

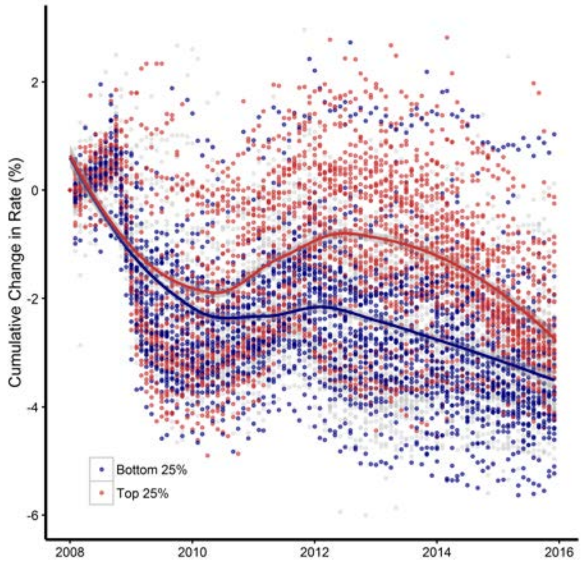
[3]The results are also not sensitive to using a linear interpolation process.

sample in red, the cumulative change in Eonia in black, and the interquartile range shaded in grey. The median lending rate tracks Eonia quite closely between 2009 and 2011, including the monetary easing in 2009 and tightening in 2011. Thereafter, particularly between 2012 and 2014, there is a notable increase in dispersion of lending rates. Latterly there has been some convergence of the lending rate toward the money market rate, and a decrease in dispersion.

The right-hand panel of Figure 1 shows a heatmap of the cumulative change in lending rate over the sample, i.e., a measure of overall pass-through. The vertical axis shows categories of the impairment ratio, while the horizontal axis shows categories of the yield of the sovereign. The most complete pass-through is shaded in green, while the least pass-through is shown in dark blue. Pass-through deteriorates the more stressed the sovereign and the higher the level of balance sheet impairment. However, there is also clear variation on the off-diagonal, consistent with the impairment ratio lowering pass-through for a given level of sovereign yield, and vice versa. This motivates our view that there is bank-level heterogeneity in pass-through in Europe, driven by non-performing loans, which is not adequately explained through country-level measures.

Figure 2 provides a scatter plot of the cumulative change in the NFC lending rate since 2008 against the impairment ratio, with fitted lines by quartile. The top quartile of the impairment ratio is coloured in red, the bottom quartile is coloured in blue, and the remaining quartiles are shaded in light grey. Pass-through appears to be more complete among banks in the bottom quartile of the impairment ratio, with lending rates decreasing by less among banks with higher levels of impairments. There is no significant difference in pass-through between groups in the initial stages of 2008-2010, but thereafter a divergence appears as balance sheets become increasingly impaired among some European banks. Among the highly-impaired banks, lending rates also increased by more during the period of tightening of the monetary policy stance in 2011. The divergence between the groups is greatest in 2013, at 1.5 percentage points. In 2015 and 2016, there has been some degree of convergence in lending rates between the banks in the top and bottom quartiles, with the banks in the top quartile lowering their lending rates. While the period we study is also characterised by sovereign

Figure 2: Scatter plot of cumulative pass-through to impairment level



Notes: Figure 2 shows the cumulative change in individual banks' lending rate since Jan. 2008. The top and bottom 25 per cent of the impairment ratio is coloured red and blue respectively, with fitted lines and confidence intervals for each group.

stress in some countries, Figure 1b suggests that balance sheet impairment is a stand-alone factor which affects pass-through in its own right. In Section 4 we will employ statistical techniques to separate the impacts of these.

Table 6 includes summary statistics of each of the explanatory variables which we use in our estimations. We measure the concentration of European banking markets using Herfindahl indices available from the ECB. These capture the competitive structure of a country's lending market as a whole, not solely from banks in our sample. This also addresses the importance of other credit institutions which are particularly prevalent in certain European countries. The measures of concentration for each country are shown in Figure 6. We also use the asset shares of the five largest credit institutions in each country to represent market structure. We address bank size using total assets, which we include on a consolidated basis, following our treatment of balance sheet impairment. We measure bank liquidity using the share of liquid assets to total assets. This includes holdings of loans to, and securities from, other MFIs, and so can capture within-group positions. We use the share of non-financial private sector deposits in total liabilities to capture the funding structure of banks. We include CDS spreads, for the banks for which these are available, to capture market perceptions of bank credit risk.

Table 7 shows how lending rates differ by values of the explanatory variables in our model. We include the mean and standard deviation of the lending rate for the top and bottom quartiles of each variable. The mean lending rate for the whole sample is 4.1 per cent. For banks within the lowest quartile of the impairment ratio, this is 3.6 per cent, with lending rates on average one percentage point higher for banks in the top quartile of the impairment ratio. Given that balance sheet impairment increases through our sample, we also split banks by quartiles of the impairment ratio at three separate time points to show how there is variation in lending rates by impairment within time and not solely between times. In June 2010, there is a one percentage point difference between average lending rates in the top and bottom quartiles, while in June 2014 there is a 2.3 percentage point difference. Similarly, we find higher lending rates within the top quartiles of the NPL ratio and the NPL gap. We find that bigger banks, more liquid banks and banks with greater deposit-to-liability shares have lower lending rates, while banks in the top quartiles of market concentration and by CDS have higher lending rates.

4 Empirical Model and Results

4.1 Empirical Model

One of the channels through which monetary policy can affect the real economy is the bank lending channel. Central banks may adjust their short term policy rate such that it affects the level of interest rates in the money market, and thereby have an impact of the cost of bank funding. This adjustment in the funding cost of the bank affects the supply of credit, with resulting impacts on the volume and price of bank lending. Given that our interest lies with credit supply, we follow Gambacorta (2008) throughout this paper in focusing on bank-specific variables which economic theory suggests affect the supply of loans but not loan demand. We also focus exclusively on identifying how the pricing of bank loans responds to changes in monetary policy as banks have direct control over loan pricing. To examine lending volumes would require separating supply and demand effects, with identification likely to be hampered by shifts in demand for credit (Jiménez et al., 2012).

Following Gambacorta (2008) and Holton and Rodriguez d'Acri (2015), we use a single equation error correction model to estimate the pass-through of changes in monetary policy to banks' lending rates. This approach allows us to capture both short- and long-term dynamics in interest rate setting. Equation (3.8) provides the exact formulation which we use: an Autoregressive-Distributed Lag specification, a detailed discussion of which is provided in Banerjee et al. (1990). We relate the monthly change in lending rate to non-financial corporations for bank i at time t, $\Delta ir_{i,t}$, to the change in money market rate Δmr_t and the lagged change in the bank's own lending rate $\Delta ir_{i,t-1}$. We also include an error term capturing the difference in lagged levels of the lending rate and the money market rate $(ir_{t-1} - mr_{t-1})$. The error term tests the assumption of an equilibrium relationship between lending rate and money market rate; it must be significantly negative to support such an assumption. However, following Banerjee et al. (1990), we do not impose the assumption that a one-to-one long run relationship necessarily must hold between the lending rate and money market rate. As such, the ir_{t-1} and mr_{t-1} terms enter equation (3.8) separately.

$$\begin{aligned}\Delta ir_{i,t} = \mu_i + \Delta ir_{i,t-1} + (\beta_0 + \beta \mathbf{Z}_{i,t-1})\,\Delta mr_t + (\delta_0 + \delta \mathbf{Z}_{i,t-1})\,ir_{i,t-1} \\ + (\theta_0 + \theta \mathbf{Z}_{i,t-1})\,mr_{t-1} + \lambda \mathbf{Z}_{i,t-1} + \gamma \mathbf{X}_{k,t} + \epsilon_{i,t}. \qquad (8)\end{aligned}$$

Our model includes bank fixed effects, denoted by μ_i, to capture unobservable heterogeneity between banks in the setting of interest rates. We address the possibility of heterogeneity between banks in pass-through to their lending rates by introducing a vector of bank-specific variables, $\mathbf{Z}$, to the model. These variables are described fully in Table 8, and are lagged to mitigate endogeneity concerns. The bank-specific variables are interacted with the change in money market rate, Δmr_t, to investigate how they affect immediate pass-through. Furthermore, they are interacted with the components of the error term to investigate if there is heterogeneity in the long run elasticity of lending rate to money market rate. Finally, we also allow the bank-specific variables and a vector of macroeconomic variables, $\mathbf{X}$, to have direct effects on the interest rate setting.

Immediate pass-through to lending rates is given by aggregating the terms in β, i.e., the sum of the main effect of the change in the money market rate, Δmr_t, and of the interaction of this with the levels of the bank-specific variables:

$$\beta_0 + \beta\overline{\mathbf{Z}}_{t-1}, \tag{9}$$

where $\overline{\mathbf{Z}}_{t-1}$ denotes the mean of the bank-specific variables. The measure of immediate pass-through given by (3.9) describes how much of a unit change in the money market rate is passed-through to the lending rate, controlling for the impact of bank characteristics. We examine the long-run elasticity of the lending rate to the money market rate in similar fashion. The terms in δ and θ in equation (3.8) capture the impact of the levels of the lending and money market rates, aggregated as in the case of the measure of immediate pass-through. We can express the long run elasticity by the ratio of the δ and θ expressions:

$$-\left(\frac{\theta_0 + \theta\overline{\mathbf{Z}}_{t-1}}{\delta_0 + \delta\overline{\mathbf{Z}}_{t-1}}\right). \tag{10}$$

With full long run pass-through, this ratio would be equal to unity. The δ expression may itself also be interpreted as giving the adjustment dynamics of the system: it expresses the share of a disequilibrium position between lending rate and money market rate which is closed in the next time period.

Our model features a lagged dependent variable and individual fixed effects. Given our panel is at monthly frequency (T=78), however, we have sufficiently long time series to mitigate concerns relating to bias arising from the dynamic panel data structure (Nickell bias). In our main specifications, we thus employ the fixed-effects estimator to estimate equation (8), with robustness checks featuring pooled Ordinary Least Squares. The money market rate we choose is Eonia. Time-invariant funding premia over Eonia would not be a concern for our model, as we are interested in how changes in the money market rate are passed through to the lending rate. However, there may be concerns relating to time-varying premia, i.e., that certain banks experience periods in which they cannot fund themselves at a rate close to Eonia. To address this, we include robustness checks in which we interact Eonia with a bank-specific Credit Default Swap spread, which should capture the periods in which the bank's own funding cost is elevated relative to the market rate.

Our parameter of interest is the impairment ratio, which captures the costly impact on the bank from the impairment of its balance sheet. In Section 2, we derived an analytical prediction for the sign of the impact of balance sheet impairment on pass-through. We empirically validate this prediction and measure the magnitude of the impact on pass-through. Given that our time period does not exclusively feature easing of the monetary policy stance, we are also able to test for symmetry of the effect of impairments on pass-through. Peltzman (2000) documents the phenomenon of asymmetric cost pass-through in approximately two-thirds of 242 markets studied, whereby prices rise faster than they fall, while symmetry of cost pass-through is observed in approximately a third of cases.

We focus on the impairment ratio, rather than the non-performing loan ratio, because the impairment ratio offers the cleaner measure of how an impaired balance sheet can affect interest rate pricing. While the impairment ratio clearly depends upon the non-performing loan ratio, the impairment ratio represents the realisation of costs arising from a stock of non-performing loans. As we outline in our theoretical model, it is the costly nature of the problem which leads to a change in the pass-through behaviour to lending rates. The NPL ratio itself is not as clean a measure of costly balance sheet impairment because there may be variation in the degree to which banks realise impairment charges from their non-performing loans. In the Appendix, we include robustness checks in which we use the NPL ratio itself.

To capture the impact of competition on interest rate pricing, our baseline model includes a measure of country-specific concentration in the banking market. As shown in Figure 6, there are intuitively substantial differences in the structures of European banking market, as shown by level differences in the Herfindahl indices between countries. However, given that we are using the within transformation, what matters is that we account for how concentration changes in the sample. As the left-hand panel of Figure 6 indicates, there is also a significant degree of within country variation in concentration throughout the time period we study. The range is shaded in grey, with the values in 2008 and 2014 highlighted in red and blue, respectively. The right-hand panel of the figure also plots average lending rates for banks above and below the median value of the concentration measure, with pass-through worse in markets with a high degree of concentration.

Following the literature, we control for bank size and liquidity in our loan-pricing equation (Kashyap and Stein, 2000; Gambacorta, 2008; Gambacorta and Mistrulli, 2014). Economic theory suggests that both larger and more liquid banks should have better pass-through. Theory also highlights the importance of bank capital, although there have been contrasting views on the economic significance of capital for the bank lending channel, with Berrospide and Edge (2010) and Deli and Hasan (2017) finding small effects and Ciccarelli et al. (2015) finding larger ones. Similarly, regarding pass-through, there is disagreement on the effect of capital. Altavilla et al. (2016) finds that pass-through is increasing in bank capital, while Holton and Rodriguez d'Acri (2015) and Gambacorta (2008) find pass-through is worse for well-capitalised banks.

A number of papers have pointed to identification issues with bank capital (Berrospide and Edge, 2010; Holton and Rodriguez d'Acri, 2015; Gambacorta, 2008). The ratio of capital to assets does not take into account the riskiness of a bank's lending and that banks with riskier portfolios must have higher capitalisation. Bank capital shocks and credit extension can both also be correlated with the state of the economy. Furthermore, in the period we study, capital in European banking is even more likely to suffer from endogeneity given that banks received recapitalisations in the post-financial crisis era (Brei et al., 2013). As a result, there is good reason to expect there to be reverse causality between interest rate pass-through and bank capital. For these reasons, we do not include bank capital in our main specification and caution inference based on capital. We do include capital as a robustness check, however, and find results that are in line with Holton and Rodriguez d'Acri (2015) and Gambacorta (2008): pass-through is worse the greater the capital ratio.

To control for macroeconomic conditions, we include the country-specific unemployment rate, inflation rate and 10 year government bond yield in our main specification. The unemployment and inflation rates capture economic conditions, and thus serve as a proxy for credit demand (Kashyap et al., 1993). We thus expect a-priori that there should be a positive relationship with interest rates for both. We include the sovereign bond yield to address the sovereign-banking nexus which was a feature of European banking during our sample. As outlined in Section 2, we expect that a tightening in financing conditions, as represented by an increase in sovereign bond yields, should be reflected in an increase in the funding cost of banks. We thus expect that lending rates on bank credit should rise as a result. As shown in the Appendix, our results are not sensitive to whether the macroeconomic variables are expressed in levels, changes, or both. We also include robustness checks in which we include country-year fixed effects, which should address concerns relating to unobserved country- and time-specific factors.

We include a number of additional robustness checks for our pass-through model. To examine the role that the funding structure of a bank has on its loan pricing, we control for the share of deposits from the non-financial private sector in all liabilities. This addresses how the stability of a bank's funding profile may affect how it passes through changes in monetary policy. We test for sensitivity of the results to the definition of the competition variable by using the asset market shares of banks rather than the concentration measure. We also estimate the model using the ECB's key interest rates themselves, rather than the money market rate. We show that our results for the impact of impairment on pass-through are robust to inclusion or omission of sets of the bank-specific characteristics. We also estimate the model using pooled OLS with year and country-year fixed effects to address the impact of any unobserved macroeconomic factors.

4.2 Results

In Table 1, we provides estimates of the pass-through equation. In column (1), we estimate equation (3.8) with no bank-specific balance sheet variables: this specification outlines the coefficients on the immediate pass-through, and the long-run elasticity, of the money market rate to the lending rate in the absence of any bank-specific factors. We find that 71.5 per cent of a change in the money market rate is passed through immediately to the lending rate. Following equation (3.10), we find also that 76 per cent is passed through in the long run. This magnitude of pass-through is in line with the approximately 72 per cent pass-through found by Holton and Rodriguez d'Acri (2015) for the euro area. We find that long-run pass-through in our sample is incomplete, as also found by Hristov et al. (2014) and De Graeve et al. (2007). In contrast, Gambacorta (2008) finds full long run pass-through in Italy, while de Bondt (2002) found full pass-through in Europe pre-crisis. Altavilla et al. (2016) show that pass-through is only complete for well-capitalised banks. We find the expected positive coefficients on the measures of unemployment and inflation.

In column (2), we include our measures of size, liquidity, market concentration and balance sheet impairment, interacted fully with the components of immediate and long-run pass-through. We find that bank size appears not to have a significant impact on immediate pass-through, but does improve long-run pass-through. Looking at liquidity, it appears that more liquid banks pass-through more in both the short run and long run. A one percentage point increase in the liquidity ratio improves immediate pass-through by 0.5 percentage points. These results are in line with those found in Kashyap and Stein (1995, 2000). Greater market concentration appears to result in higher levels of interest rates but not to have an impact on immediate pass-through.

Consistent with our theoretical predictions, we find that immediate pass-through is decreasing in the impairment ratio. A one percentage point increase in the impairment ratio lowers immediate pass-through by 3.7 percentage points. We also find that an elevated impairment ratio results in higher levels of interest rates. Our results are in line with those of Altavilla et al. (2016), in which pass-through coefficients are shown to be lower for banks in the top quartile of the NPL distribution than in the lowest quartile. To the best of our knowledge, our paper is the first to measure the continuous impact of loan impairments on pass-through in the euro area.

In column (3), we include the sovereign bond yields to address the sovereign - banking nexus. We find a positive coefficient on yields, implying that sovereign stress does result in higher lending rates. In column (4), we include bank capital in the model. As noted in in Section 4.1, however, we caution inference from the inclusion of bank capital given identification issues. We find that pass-through is decreasing in the capital ratio, a result which is in line with the findings of Holton and Rodriguez d'Acri (2015) and Gambacorta (2008)

Hereafter, we take column (3) to be our main specification. Based on the results from this specification, we find that the pass-through coefficient drops from 84 per cent for a bank with no impaired loans to 62 per cent for a bank with the mean impairment ratio. For banks with a sufficiently high impairment ratio, of 17 per cent or more, we cannot reject the hypothesis that their pass-through coefficient is zero. These results imply that the efficacy of the transmission mechanism weakens significantly when banks have impaired balance sheets with declining asset quality. Banks with severely impaired balance sheets do not change their lending rates at all when the central bank adjusts its policy rate, resulting in a complete breakdown in the pass-through mechanism for borrowers with these banks.

In Table 2 we examine whether the effect of impairments on pass-through is symmetric for rising and falling money market rates. Hannan and Berger (1991) showed that there was asymmetric pass-through of retail banking rates in the US and that this was linked to higher levels of concentration in banking markets. Frey and Manera (2007) provide a survey of the literature on asymmetric pass-through. Sander and Kleimeier (2004) find that for the majority of national retail interest rates in the euro area are best described by asymmetric pass-through models. Karagiannis et al. (2010) find results for euro area pass-through that are overall ambiguous but that do show asymmetry of pass-through from money market rates to lending rates.

In contrast to these papers, we are able to examine the post-crisis period in which NPLs are a feature of European banking. As a result of the cost of balance sheet impairment, banks may be more willing to pass through increases in their funding costs than decreases. To test for this, we interact a dummy variable for the sign of the change in the money market rate with the rate change and with the interactions of the bank characteristics and the rate change. We find that the impairment ratio lowers the pass-through coefficient when the rate is falling. However, we find that pass-through is increasing in the impairment ratio when the money market rate rises. A one percentage point increase in the impairment ratio increases pass-through by 7 percentage points in this case. We thus find an asymmetric effect of balance sheet impairment on pass-through based on the direction of the change in bank funding cost. We also cannot reject that banks with an impairment ratio of 12 per cent or more fully pass-through increases in money market rates.

In Table 3 we introduce measures of bank credit risk to our baseline model to investigate whether our results may be affected by funding premia for certain banks, as represented by CDS spreads. CDS spreads should represent market perceptions of the riskiness of a bank, and so a bank with elevated spreads would likely face funding premia, which could plausibly affect its lending rate. These premia are unlikely to be constant through time and thus would affect our results if they were to occur at a period of diminished pass-through.

Annaert et al. (2013) show that during the financial crisis, credit risk drove steep increases in CDS spreads, as predicted. They also show that market liquidity factors affected CDS spreads in this time too. Lovreta and Mladenovi (2018) show that stock and CDS markets price credit risk equally in the long run using data on European firms. Benbouzid et al. (2017) show that bank CDS spreads can be explained by bank profitability, asset liquidity, balance sheet quality and leverage ratios. Overall, CDS spreads should represent a satisfactory measure of potential bank funding premia.

In column (1), we thus include a triple interaction of the CDS spread with the impairment ratio and change in the money market rate. We find that our previous results remain robust, with pass-through decreasing significantly in the impairment ratio. We also do not find any evidence for a differential effect for banks which are deemed to be riskier by the market.

In column (2), we also include the main effect of the credit risk measure and interact this with the change in the money market rate. We find that banks with higher CDS spreads have higher lending rates. Holton and Rodriguez d'Acri (2015) find that CDS spreads negatively affect pass-through to lending rates. In contrast, we do not find any significant effect from CDS spreads to pass-through, when controlling for the impairment ratio of the balance sheet. We again find evidence for the effect of the balance sheet on pass-through, with the interaction of the impairment ratio on pass-through remaining robust. As in column (1), we find that the triple interaction of CDS spreads with impairments and the change in the money market rate is not statistically significant. From this we conclude that the balance sheet impairment is not being driven by market perceptions of banks' riskiness, which could result in funding premia.

In Table 4, we examine the sensitivity of our results to the specification of the competition variable. van Leuvensteijn et al. (2013) find that immediate pass-through to lending rates in the euro area is not determined by the degree of competition in the lending market, but that long run pass-through is stronger in more competitive markets. De Graeve et al. (2007) find that long run pass-through is lower the greater a bank's market share. In column (2), we replace the Herfindahl measure of concentration in the banking sector with a measure based on the asset shares of the top five credit institutions in each country. We find that market concentration continues to be associated with higher lending rates and find some evidence for negative impacts on pass-through. Our results on the impact of impairments on pass-through remain robust to specification of the competition variable.

4.3 Robustness Checks

In Table 9, we specify the monetary policy variable in the pass-through model in terms of Eonia and the ECB's key interest rates: the interest rate on Main Refinancing Operations and the interest rate on the Deposit Facility. We find that the results are not sensitive to the choice of monetary policy variable. The magnitude of the impairment effect on immediate pass-through is similar for Eonia and the MRO, at -3.4 percentage points and -3.5 percentage points, respectively. The effect is slightly larger for the DFR, at -4.8 percentage points for a one percentage point increase in the impairment ratio.

Table 10 specifies the measure of balance sheet impairment in terms of the NPL ratio as well as the impairment ratio. Our finding of a negative impact of balance sheet impairment on pass-through is robust to specifying the balance sheet measure using the NPL ratio. The impact of non-performing loans on pass-through is negative and significant, as is expected, but the magnitude of the effect is smaller than with the impairment ratio. A one percentage point increase in the NPL ratio lowers pass-through by 2.3 percentage points, compared with the 3.4 percentage point decrease for an equivalent increase in the impairment ratio. It is likely that the impairment effect is underestimated when using the NPL ratio because the NPL ratio mis-measures the costliness of balance sheet impairment, the key channel through which non-performing loans should affect loan pricing.

In Table 11, we include the ratio of non-financial private sector deposits to total liabilities to test whether banks with greater stability of their funding structure have greater pass-through to their lending rates. We find no evidence of a significant effect of the deposit share on immediate pass-through, but we do find that banks with more stable funding have lower lending rates. The coefficient on the impairment effect is stable across these specifications.

In Table 12, we show that coefficient on the interaction of the impairment ratio with immediate pass-through is stable across specifications in which we iteratively add the liquidity, size and concentration measures to the equation. In Table 13, we re-run our main specification as a pooled OLS estimation. In column (2) we include individual fixed effects, in column (3) we include year fixed effects to capture common macroeconomic shocks, while in column (4) we include country-year fixed effects to account for unobserved macroeconomic factors. We thus account for possible heterogeneity in demand facing banks across the sample by country and time, which possibly could have an impact on loan pricing, allowing us more cleanly to identify how a bank's own balance sheet may affect their loan pricing. Our key result is unchanged across these specifications: greater impairment of bank balance sheet weakens pass-through to lending rates. In Table 14, we further address the issue of credit demand through specifications of the macroeconomic variables. We include the sovereign bond yield, unemployment rate and inflation rate measures in levels, changes and both levels and changes. The balance sheet effect is robust to these specifications.

Table 1: Main specifications

	(1)	(2)	(3)	(4)
Δir_{t-1}	−0.259***	−0.239***	−0.237***	−0.235***
	(0.012)	(0.013)	(0.013)	(0.013)
$\Delta eonia_t$	0.715***	0.722***	0.693***	0.995***
	(0.037)	(0.116)	(0.116)	(0.150)
$eonia_{t-1}$	0.176***	0.077***	0.075***	0.102***
	(0.009)	(0.024)	(0.024)	(0.029)
ir_{t-1}	−0.233***	−0.122***	−0.118***	−0.092***
	(0.010)	(0.022)	(0.022)	(0.026)
$Herf_{t-1}$		0.018*	0.026***	0.029***
		(0.010)	(0.010)	(0.010)
$Size_{t-1}$		−0.072	−0.081	−0.079
		(0.113)	(0.113)	(0.113)
$Liquidity_{t-1}$		0.007***	0.007***	0.007***
		(0.002)	(0.002)	(0.002)
Imp_{t-1}		0.015**	0.020***	0.021***
		(0.006)	(0.006)	(0.007)
$Capital_{t-1}$				0.009
				(0.009)
$Herf_{t-1} \times \Delta eonia_t$		−0.001	0.000	−0.001
		(0.007)	(0.007)	(0.007)
$Herf_{t-1} \times eonia_{t-1}$		0.002*	0.003*	0.002
		(0.001)	(0.001)	(0.001)
$Herf_{t-1} \times ir_{t-1}$		−0.005***	−0.006***	−0.006***
		(0.002)	(0.002)	(0.002)
$Size_{t-1} \times \Delta eonia_t$		0.006	0.010	−0.009
		(0.064)	(0.064)	(0.064)
$Size_{t-1} \times eonia_{t-1}$		0.050***	0.044***	0.042***
		(0.014)	(0.014)	(0.014)
$Size_{t-1} \times ir_{t-1}$		−0.031**	−0.027*	−0.029*
		(0.015)	(0.015)	(0.015)
$Liquidity_{t-1} \times \Delta eonia_t$		0.005*	0.005*	0.003
		(0.003)	(0.003)	(0.003)
$Liquidity_{t-1} \times eonia_{t-1}$		0.002***	0.002***	0.002***
		(0.001)	(0.001)	(0.001)
$Liquidity_{t-1} \times ir_{t-1}$		−0.002***	−0.002***	−0.002***
		(0.001)	(0.001)	(0.001)
$Imp_{t-1} \times \Delta eonia_t$		−0.037***	−0.034***	−0.025**
		(0.010)	(0.010)	(0.011)
$Imp_{t-1} \times eonia_{t-1}$		−0.001	−0.002	0.000
		(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$		−0.002**	−0.003***	−0.003**
		(0.001)	(0.001)	(0.001)
$Capital_{t-1} \times \Delta eonia_t$				−0.036***
				(0.012)
$Capital_{t-1} \times eonia_{t-1}$				−0.003*
				(0.002)
$Capital_{t-1} \times ir_{t-1}$				−0.003**
				(0.002)
GB_t			0.016***	0.013***
			(0.004)	(0.004)
Un_t	0.032***	0.029***	0.022***	0.023***
	(0.003)	(0.004)	(0.004)	(0.004)
$HICP_t$	0.052***	0.051***	0.047***	0.049***
	(0.006)	(0.007)	(0.007)	(0.007)
Constant	0.401***	0.086	0.035	−0.043
	(0.033)	(0.102)	(0.103)	(0.121)
Fixed effects	Bank	Bank	Bank	Bank
N	5,944	5,350	5,350	5,350
R-squared	0.251	0.248	0.251	0.254

Notes: Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 2: Asymmetric effect of impairment on pass-through

	(1)
$\Delta eonia_t^{neg} \times \Delta eonia_t$	0.923***
	(0.141)
$\Delta eonia_t^{pos} \times \Delta eonia_t$	−0.407
	(0.366)
$\Delta eonia_t^{neg} \times Herf_{t-1} \times \Delta eonia_t$	0.003
	(0.009)
$\Delta eonia_t^{pos} \times Herf_{t-1} \times \Delta eonia_t$	−0.015
	(0.023)
$\Delta eonia_t^{neg} \times Size_{t-1} \times \Delta eonia_t$	−0.042
	(0.078)
$\Delta eonia_t^{pos} \times Size_{t-1} \times \Delta eonia_t$	0.313
	(0.200)
$\Delta eonia_t^{neg} \times Liquidity_{t-1} \times \Delta eonia_t$	0.004
	(0.003)
$\Delta eonia_t^{pos} \times Liquidity_{t-1} \times \Delta eonia_t$	0.005
	(0.008)
$\Delta eonia_t^{neg} \times Imp_{t-1} \times \Delta eonia_t$	−0.054***
	(0.013)
$\Delta eonia_t^{pos} \times Imp_{t-1} \times \Delta eonia_t$	0.070**
	(0.027)
Fixed effects	Bank
Other controls	Yes
N	5,350
R-squared	0.256

Notes: Coefficients on long run pass-through available from Appendix. Macroeconomic variables included in specification. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 3: Impact of bank credit risk on pass-through

	(1)	(2)
Δir_{t-1}	−0.212***	−0.210***
	(0.016)	(0.016)
Imp_{t-1}	0.037***	0.050***
	(0.007)	(0.007)
CDS_t		0.037***
		(0.007)
$\Delta eonia_t$	0.827***	0.804***
	(0.145)	(0.160)
$eonia_{t-1}$	0.026	0.082***
	(0.029)	(0.031)
ir_{t-1}	−0.062**	−0.075***
	(0.029)	(0.029)
$CDS_t \times \Delta eonia_t$		−0.022
		(0.033)
$Imp_{t-1} \times \Delta eonia_t$	−0.062***	−0.050***
	(0.019)	(0.019)
$Imp_{t-1} \times eonia_{t-1}$	0.012***	0.006*
	(0.003)	(0.004)
$Imp_{t-1} \times ir_{t-1}$	−0.007***	−0.007***
	(0.001)	(0.001)
$Imp_{t-1} \times CDS_t \times \Delta eonia_t$	0.001	0.001
	(0.001)	(0.002)
Fixed effects	Bank	Bank
Other controls	Yes	Yes
N	3,451	3,451
R-squared	0.256	0.266

Notes: Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01. CDS unit = 100bp.

Table 4: Alternative measures of lending market competition

	(1)	(2)	(3)	(4)
Δir_{t-1}	−0.256***	−0.258***	−0.237***	−0.238***
	(0.012)	(0.012)	(0.013)	(0.013)
$Herf_{t-1}$	0.024**		0.026***	
	(0.010)		(0.010)	
$Share^{T5}_{t-1}$		0.012***		0.013***
		(0.003)		(0.003)
Imp_{t-1}			0.020***	0.021***
			(0.006)	(0.006)
$\Delta eonia_t$	0.750***	0.849***	0.693***	0.746***
	(0.059)	(0.095)	(0.116)	(0.146)
$eonia_{t-1}$	0.163***	0.180***	0.075***	0.091***
	(0.012)	(0.020)	(0.024)	(0.031)
ir_{t-1}	−0.209***	−0.193***	−0.118***	−0.107***
	(0.014)	(0.022)	(0.022)	(0.030)
$Herf_{t-1} \times \Delta eonia_t$	−0.007		0.000	
	(0.007)		(0.007)	
$Herf_{t-1} \times eonia_{t-1}$	0.002		0.003*	
	(0.001)		(0.001)	
$Herf_{t-1} \times ir_{t-1}$	−0.005***		−0.006***	
	(0.002)		(0.002)	
$Share^{T5}_{t-1} \times \Delta eonia_t$		−0.004*		−0.001
		(0.002)		(0.002)
$Share^{T5}_{t-1} \times eonia_{t-1}$		0.000		0.000
		(0.000)		(0.000)
$Share^{T5}_{t-1} \times ir_{t-1}$		−0.001**		−0.001***
		(0.000)		(0.000)
$Imp_{t-1} \times \Delta eonia_t$			−0.034***	−0.033***
			(0.010)	(0.010)
$Imp_{t-1} \times eonia_{t-1}$			−0.002	−0.002
			(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$			−0.003***	−0.003***
			(0.001)	(0.001)
Fixed effects	Bank	Bank	Bank	Bank
Liquidity	No	No	Yes	Yes
Bank size	No	No	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
N	5,944	5,944	5,350	5,350
R-squared	0.254	0.256	0.251	0.252

Notes: Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

4.4 Excess non-performing loans

Thus far, we have considered the impact of impaired balance sheets on pass-through solely through the lens of the impairment ratio. However, it is possible for there to be an additional channel through which non-performing loans can affect pass-through. Having an excess of non-performing loans over impaired loans may lead a forward-looking bank to expect to realise impairment charges against these loans, in whole or in part. The NPL ratio thus can be thought of as nesting two components: the actual realisation of costly balance sheet impairment (the impairment ratio) and the expected additional cost which will arise from future impairment. As we have argued in Section 4.1, to cleanly identify the balance sheet impairment effect, one must focus on the former. However, the latter may also affect loan pricing. In this section, we thus examine whether excess non-performing loans affect pass-through, controlling for the direct balance sheet impairment effect.

We refer to the difference between the NPL ratio and the impairment ratio as the NPL gap. The left-hand panel of Figure 3 shows a scatter plot of the NPL gap against the NPL ratio. There is a positive correlation between the two measures so that the higher the NPL ratio, the greater the share of these loans against which an impairment charge has not yet been realised. The mean value of the NPL gap is 3.3 percentage points and the gap is almost always positive[4]. In the right-hand panel of Figure 3, we show simple linear fits of the cumulative change in lending rate in our time period against each of the impairment ratio and the NPL gap. Banks with the healthiest balance sheets have lowered their lending rates by approximately 3 percentage points between January 2008 and June 2014, representing a considerable degree of pass-through of the change in Eonia over the period. The data show that pass-through is decreasing in both the impairment ratio and the NPL gap, motivating further investigation of whether the NPL gap affects pass-through in our full mode, controlling for the direct impairment effect.

In Table 5, we include the NPL gap measure as an additional bank-specific characteristic in

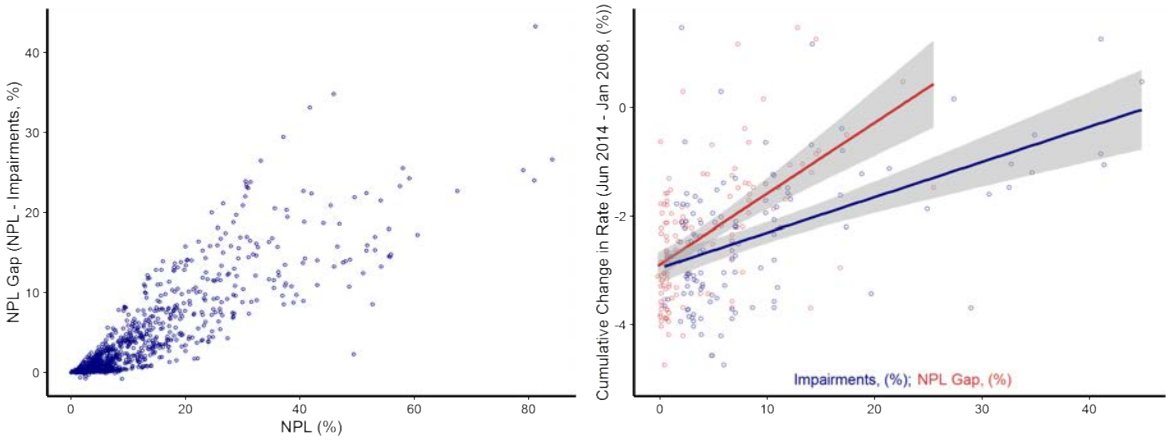
[4] As can be seen from Table 6, the NPL gap is not exclusively positive: in some instances banks have taken precautionary impairment charges in excess of their current NPL ratio.

our main specification. In the first column, we include only the macroeconomic variables, the bank-specific impairment ratio and the NPL gap. The main effect of the impairment ratio is no longer significant, but the main effect of the NPL gap is positive and highly significant. This indicates that banks with a proliferation of excess non-performing loans have higher interest rates. We find that the effect of the impairment ratio on immediate pass-through is robust to adding the NPL gap to the model, and of similar magnitude to the model in Table 1. The NPL gap also has a significant and negative impact on immediate pass-through, controlling for the direct impairment effect. A one percentage point increase in excess non-performing loans lowers immediate pass-through by 2.2 percentage points. These results suggest that the weakening of pass-through to lending rates caused by balance sheet impairment which we have identified is exacerbated by the presence of excess non-performing loans. We show across the columns of Table 5 that this finding is robust to the addition of the other balance sheet explanatory variables.

Taking the results of this specification, we are able to decompose the contributions of the explanatory variables to both immediate and long-run pass-through. In Figure 4 we split the sample by vulnerable and non-vulnerable country groups[5]. We plot the fitted values for the pass-through coefficients in the black lines and the contributions of the explanatory variables in the bars. In the left panel, the pass-through coefficient declines slightly throughout the sample for banks in non-vulnerable countries. Pass-through falls to a much greater extent in the vulnerable countries (right panel), declining by approximately 25 percentage points to 50 per cent by 2014, before increasing somewhat in 2016. The blue bars depict the positive contribution of bank liquidity to pass-through in both groups throughout. The red bars show the negative impact of the impairment ratio to pass-through. This impairment effect holds across country groups, albeit with greater magnitude in the vulnerable countries. Excess non-performing loans also contribute to falling pass-through, as shown in the purple bars. Toward the end of the sample, the problem of excess NPLs is mitigated somewhat in the vulnerable

[5]The former group includes Austria, Belgium, Germany, France and the Netherlands, while the latter includes Greece, Ireland, Italy, Portugal and Spain.

Figure 3: NPL Gap and pass-through



Notes: The left-hand panel of Figure 3 shows a scatter plot of the NPL gap, the excess of the NPL ratio over the impairment ratio against the NPL ratio. The right-hand panel shows a scatter plot and fitted lines with confidence intervals of the cumulative changes in individual banks' lending rates against their impairment ratios (in blue) and the NPL gap (in red).

countries, contributing to some improvement in immediate pass-through.

Figure 5 shows the decomposition of the contributions to long run pass-through. Pass-through is incomplete and falling through time in both areas, although the decline is more pronounced in the vulnerable countries. Notably, competition effects have a larger impact on long-run pass-through than immediate pass-through. Market concentration weakens the long run elasticity of the lending rate to the money market rate in both vulnerable and non-vulnerable countries, but relatively by more in the vulnerable countries. The negative competition effect also grows throughout the time period in the vulnerable countries, intuitively reflecting the changes in the competitive backdrop of banking markets in Europe since the global financial crisis. As found above in terms of immediate pass-through, the impairment ratio makes the largest negative contribution to long run pass-through in the vulnerable countries. The NPL gap also lowers long run pass-through in both country groups, but by less than the competition effect.

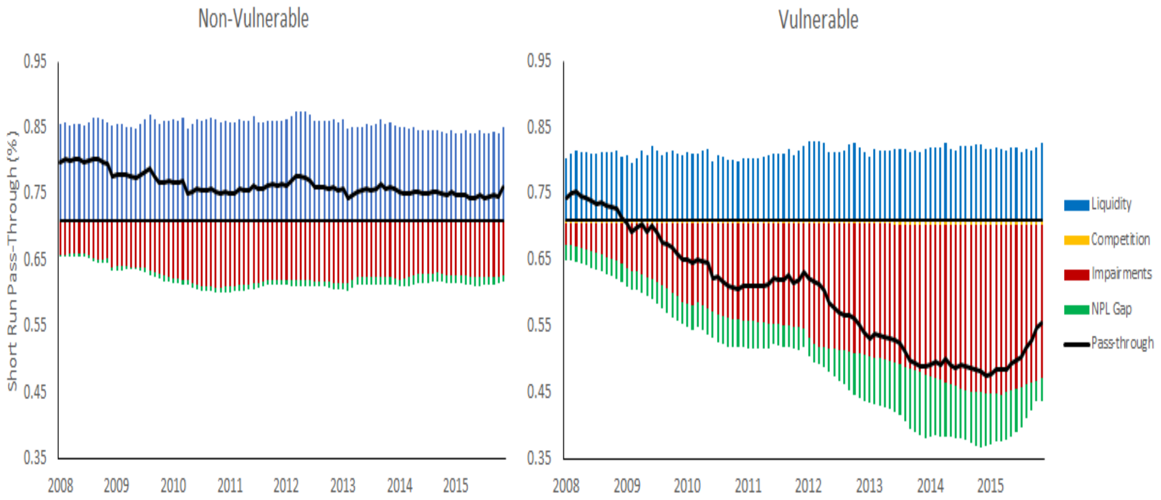
Table 5: Impact of excess non-performing loans

	(1)	(2)	(3)	(4)
$\Delta eonia_t$	0.838***	0.706***	0.715***	0.714***
	(0.055)	(0.092)	(0.103)	(0.116)
$eonia_{t-1}$	0.162***	0.118***	0.086***	0.078***
	(0.011)	(0.020)	(0.021)	(0.024)
ir_{t-1}	−0.196***	−0.162***	−0.144***	−0.116***
	(0.012)	(0.019)	(0.020)	(0.022)
Imp_{t-1}	0.006	−0.001	−0.001	−0.003
	(0.007)	(0.007)	(0.007)	(0.007)
$NPLGap_{t-1}$	0.061***	0.060***	0.062***	0.060***
	(0.010)	(0.010)	(0.010)	(0.010)
$Imp_{t-1} \times \Delta eonia_t$	−0.023**	−0.025**	−0.025**	−0.025**
	(0.011)	(0.011)	(0.011)	(0.011)
$Imp_{t-1} \times eonia_{t-1}$	−0.003	−0.003	−0.002	−0.003
	(0.002)	(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	−0.001	0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
$NPLGap_{t-1} \times \Delta eonia_t$	−0.022*	−0.022*	−0.022*	−0.022*
	(0.012)	(0.012)	(0.012)	(0.012)
$NPLGap_{t-1} \times eonia_{t-1}$	0.006***	0.006***	0.007***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
$NPLGap_{t-1} \times ir_{t-1}$	−0.011***	−0.010***	−0.011***	−0.010***
	(0.002)	(0.002)	(0.002)	(0.002)
Fixed effects	Bank	Bank	Bank	Bank
Liquidity	No	Yes	Yes	Yes
Bank size	No	No	Yes	Yes
Market concentration	No	No	No	Yes
Other controls	Yes	Yes	Yes	Yes
N	5,658	5,350	5,350	5,350
R-squared	0.263	0.254	0.256	0.258

Notes: Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Figure 4: Determinants of short run pass-through

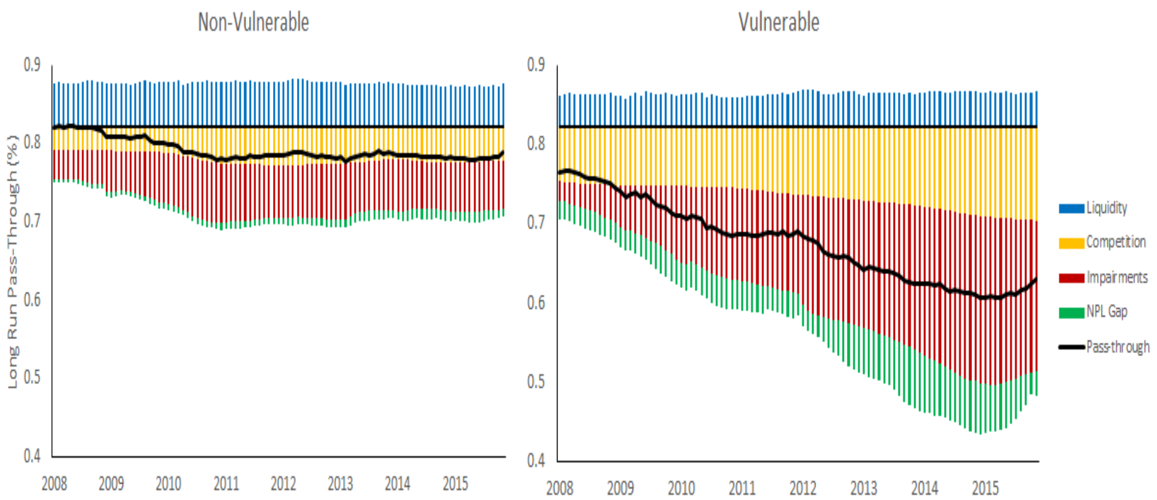
(a) Non-Vulnerable countries (b) Vulnerable countries



Notes: Figure 4a shows the immediate pass-through coefficient through time (black line) for banks in non-vulnerable European countries, while Figure 4b shows the equivalent for the vulnerable countries. The contributions of the NPL gap, impairment ratio, market concentration and bank liquidity are included in the coloured bars.

Figure 5: Determinants of long run pass-through

(a) Non-Vulnerable countries (b) Vulnerable countries



Notes: Figure 5a shows the long run pass-through coefficient through time (black line) for banks in non-vulnerable European countries, while Figure 5b shows the equivalent for the vulnerable countries. The contributions of the NPL gap, impairment ratio, market concentration and bank liquidity are included in the coloured bars.

5 Conclusion

The vast majority of European firms (99.8 per cent) are small and medium enterprises, responsible for over 70 per cent of employment making them central to the economic growth of the euro area[6]. Unlike their US counterparts, their sources of finance are more limited, relying heavily on bank debt to fund investment. To assess the impact of monetary policy decisions on this group, it is paramount to examine the credit channel, whereby credit supply and price may respond strongly to shifts in the policy rate. Euro area pass-through has shifted from being relatively homogenous to fragmented and incomplete since the financial crisis. While sovereign risk plays a role, the direct implications for bank profitability from distressed lending hamper banks ability to supply credit and lower loan pricing in response to reductions in the policy rate.

This paper derives a parsimonious model decomposing the drivers of loan pricing into the contribution of the policy rate, default risk, loss given default, sovereign bond yield, market concentration and sensitivity of capital to new lending. This allows us to characterise the channels through which asset quality diminishes pass-through of the changes in the policy rate. Using bank level data over the period 2008-2014, we empirically test the implications of the model for both short and long run adjustment of lending rates. Results show that asset quality, measured through a one percentage point increase in the impairment ratio have a significant negative impact, lowering immediate pass-through by 3 per cent. For impairment rates greater than 17 per cent, we find pass-though is not significantly different from zero.

Distressed loan books erode limited bank capital and result in impairments being unable to keep pace with bad loans. To investigate if impairments therefore underestimate the extent of the bad loan problem, we calculate an NPL gap for each bank, as the difference between NPL and impairment ratios. This gap is significant and grows with level of non-performing loans. We find that excess non-performing loans further diminish pass-through to lending rates, controlling for the direct effect of impairments. Further, there is a clear concentration

[6]Source: ECB SAFE survey

of the NPL gap with the stressed countries and thus these play a key role in explaining the fragmentation of pass-through rates since 2008. This underlines the importance of realisation and resolution of bad loans to lower loan pricing and improve the functioning of euro area credit supply to Europe's heavily bank credit dependent firms.

6 Appendix

Proof of Proposition 1: Let $A = 1 + \gamma f(R_m) + (1-\gamma)h(Y_s) + g(R_m).\frac{\partial K_i}{\partial L_i} - PD(1 - LGD)$. Then we have

$$\frac{\partial R_L}{\partial PD} = \frac{LGD + \gamma f(R_m) + (1-\gamma)h(Y_s) + g(R_m).\frac{\partial K_i}{\partial L_i}}{[(1-PD)\big(1-\frac{H}{\epsilon}\big)]^2} > 0$$

$$\frac{\partial R_L}{\partial H} = \frac{(\frac{1}{\epsilon})A}{(1-PD)\big(1-\frac{H}{\epsilon}\big)^2} > 0$$

$$\frac{\partial R_L}{\partial LGD} = \frac{PD}{(1-PD)\big(1-\frac{H}{\epsilon}\big)} > 0$$

$$\frac{\partial R_L}{\partial Y_s} = \frac{(1-\gamma)h'(Y_s)}{(1-PD)\big(1-\frac{H}{\epsilon}\big)} > 0$$

$$\frac{\partial R_L}{\partial(\frac{\partial K_i}{\partial L_i})} = \frac{g(R_m)}{(1-PD)\big(1-\frac{H}{\epsilon}\big)} > 0$$

$$\frac{\partial R_L}{\partial \epsilon} = \frac{-(\frac{H}{\epsilon^2})A}{(1-PD)\big(1-\frac{H}{\epsilon}\big)^2} < 0$$

Proof of Proposition 2: The impact of impaired loans on pass-through is given by the cross-partial derivative of equation (7) with respect to the impairment ratio (IMP):

$$\frac{\partial^2 R_L}{\partial R_m \partial IMP_i} = \frac{(1-\gamma)g'(R_m)}{(1-PD)\big(1-\frac{H}{\epsilon}\big)}.\frac{\partial^2 K_i}{\partial L_i \partial IMP_i} < 0. \tag{11}$$

The first term in equation (3.11) is positive, hence the overall sign is determined by the sign of the cross partial derivative of the bank's capital position with respect to the flow of lending and the impairment ratio of the stock of lending. This must be negative given that the negative impact of the impairments on bank capital is mitigated by the issuance of equity in response to the flow of lending. Equivalently, the positive impact of issuance of equity on the capital position diminishes the greater the realised cost from impairing the bank's non-performing loans. As a result, we have it that the pass-through of changes in the monetary policy rate to changes in the lending rate is weakened the higher the impairment ratio of the bank.

Table 6: Summary statistics

Variable	Obs.	Mean	St. Dev.	Min.	Max.
Impairment Ratio (%)	5,350	6.5	6.7	0.5	55
NPL Ratio (%)	5,350	9.9	10.7	0.5	82.5
NPL Gap (pp)	5,350	3.3	5.1	-0.8	34.8
Size (€ bn.)	5,350	536.2	572.1	0.6	2249.1
Liquidity (%)	5,350	26.9	13.2	0.1	86
Market Concentration (%)	5,350	7.1	5	1.8	21.7
Deposit Share (%)	5,350	16.9	14.3	0	71.5
CDS Spreads (bp)	3,451	311.3	402.8	38.4	2640.6
EONIA (%)	5,350	0.8	1.2	0.1	4.3
10 Year Sovereign Yield (%)	5,350	4.3	2.8	1.2	29.2
Inflation (%)	5,350	2.1	1.2	-2.5	6.1
Unemployment (%)	5,350	10.1	6.1	3.4	27.9

Table 7: Lending rates by bank characteristic

	Quartile	Mean	St. Dev.
Total sample		4.1	1.6
Impairment Ratio	<p25	3.6	1.6
	>p75	4.6	1.7
Impairment Ratio (2010:6)	<p25	3.1	1.2
	>p75	4.1	1.5
Impairment Ratio (2012:6)	<p25	3.1	0.8
	>p75	5.5	1.9
Impairment Ratio (2014:6)	<p25	2.7	0.6
	>p75	5	1.6
NPL Ratio	<p25	3.6	1.6
	>p75	4.6	1.6
NPL Gap	<p25	3.8	1.6
	>p75	4.4	1.6
Size	<p25	3.9	1.7
	>p75	3.6	1.4
Liquidity	<p25	4.3	1.6
	>p75	3.4	1.5
Market Concentration	<p25	3.3	1.3
	>p75	4.7	1.7
Deposit Share	<p25	3.6	1.5
	>p75	3.4	1.2
CDS Spreads	<p25	3.5	1.7
	>p75	4.8	1.5

Table 8: Data description

Variables	Symbols	Description
Dependent variable	ir	Interest rate on loans to euro area non-financial corporations of up to €1m in volume and for up to 1 year in fixation (ECB IMIR)
Monetary policy variables	mr	EONIA (DataStream) Main Refinancing Operations rate Deposit Facility rate (both ECB SDW)
Bank-specific variables	Z	Ratio of impaired loans to all loans Ratio of non-performing loans to all loans Size: total assets of bank (all SNL Financial) Liquidity: ratio to total assets of holdings of securities (MFI, NFC and government) and holdings of loans to MFIs and to the Eurosystem Capital: Capital to assets ratio Deposit share: Share of non-financial private sector deposits to total assets (all ECB IBSI) CDS spreads (Bloomberg)
Country-specific variables	X	Herfindahl index for credit institutions' total assets Share of total assets of top five largest credit institutions to total assets of banking sector (both ECB SDW) 10 year government bond yield HICP inflation rate Unemployment rate (all DataStream)

Table 9: Alternative interest rates

	EONIA	MRO	DFR
Δir_{t-1}	−0.237***	−0.248***	−0.243***
	(0.013)	(0.013)	(0.013)
$Herf_{t-1}$	0.026***	0.024**	0.028***
	(0.010)	(0.010)	(0.010)
$Size_{t-1}$	−0.081	−0.241**	−0.081
	(0.113)	(0.109)	(0.113)
$Liquidity_{t-1}$	0.007***	0.005**	0.007***
	(0.002)	(0.002)	(0.002)
Imp_{t-1}	0.020***	0.024***	0.019***
	(0.006)	(0.006)	(0.006)
Δmr_t	0.693***	0.883***	0.864***
	(0.116)	(0.144)	(0.115)
mr_{t-1}	0.075***	0.070***	0.086***
	(0.024)	(0.026)	(0.030)
ir_{t-1}	−0.118***	−0.104***	−0.118***
	(0.022)	(0.022)	(0.023)
$Herf_{t-1} \times \Delta mr_t$	0.000	0.005	−0.004
	(0.007)	(0.009)	(0.007)
$Herf_{t-1} \times mr_{t-1}$	0.003*	0.003*	0.003*
	(0.001)	(0.002)	(0.002)
$Herf_{t-1} \times ir_{t-1}$	−0.006***	−0.005***	−0.006***
	(0.002)	(0.002)	(0.002)
$Size_{t-1} \times \Delta mr_t$	0.010	0.002	0.009
	(0.064)	(0.079)	(0.062)
$Size_{t-1} \times mr_{t-1}$	0.044***	0.045***	0.055***
	(0.014)	(0.016)	(0.018)
$Size_{t-1} \times ir_{t-1}$	−0.027*	−0.023	−0.027*
	(0.015)	(0.015)	(0.015)
$Liquidity_{t-1} \times \Delta mr_t$	0.005*	0.006*	0.003
	(0.003)	(0.003)	(0.003)
$Liquidity_{t-1} \times mr_{t-1}$	0.002***	0.002***	0.003***
	(0.001)	(0.001)	(0.001)
$Liquidity_{t-1} \times ir_{t-1}$	−0.002***	−0.002***	−0.002***
	(0.001)	(0.001)	(0.001)
$Imp_{t-1} \times \Delta mr_t$	−0.034***	−0.035***	−0.048***
	(0.010)	(0.011)	(0.011)
$Imp_{t-1} \times mr_{t-1}$	−0.002	−0.004*	−0.003
	(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	−0.003***	−0.004***	−0.003***
	(0.001)	(0.001)	(0.001)
GB_t	0.016***	0.013***	0.017***
	(0.004)	(0.004)	(0.004)
Un_t	0.022***	0.022***	0.021***
	(0.004)	(0.004)	(0.004)
$HICP_t$	0.047***	0.051***	0.046***
	(0.007)	(0.007)	(0.007)
Constant	0.035	0.043	0.071
	(0.103)	(0.101)	(0.103)
Fixed effects	Bank	Bank	Bank
N	5,350	5,350	5,350
R-squared	0.251	0.248	0.252

Notes: Models (1) - (3) use the FE estimator. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 10: Alternative measures of balance sheet impairment

	NPL	Impairment
Δir_{t-1}	−0.236***	−0.237***
	(0.013)	(0.013)
$Herf_{t-1}$	0.015	0.026***
	(0.010)	(0.010)
$Size_{t-1}$	−0.030	−0.081
	(0.112)	(0.113)
$Liquidity_{t-1}$	0.006**	0.007***
	(0.002)	(0.002)
$BalSheet_{t-1}$	0.021***	0.020***
	(0.004)	(0.006)
$\Delta eonia_t$	0.708***	0.693***
	(0.114)	(0.116)
$eonia_{t-1}$	0.092***	0.075***
	(0.023)	(0.024)
ir_{t-1}	−0.137***	−0.118***
	(0.022)	(0.022)
$BalSheet_{t-1} \times \Delta eonia_t$	−0.023***	−0.034***
	(0.006)	(0.010)
$BalSheet_{t-1} \times eonia_{t-1}$	0.000	−0.002
	(0.001)	(0.002)
$BalSheet_{t-1} \times ir_{t-1}$	−0.004***	−0.003***
	(0.001)	(0.001)
Fixed effects	Bank	Bank
Liquidity	Yes	Yes
Bank size	Yes	Yes
Market concentration	Yes	Yes
Other controls	Yes	Yes
N	5,454	5,350
R-squared	0.255	0.251

Notes: Models (1) - (2) use the FE estimator. Model (1) uses the NPL ratio, Model (2) uses the Impairment ratio. Other co Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 11: Impact of share of deposits in bank liabilities

	(1)	(2)
Δir_{t-1}	-0.237***	-0.234***
	(0.013)	(0.013)
$Impt-1$	0.020***	0.019***
	(0.006)	(0.006)
$DepShare_{t-1}$		-0.008***
		(0.003)
$\Delta eonia_t$	0.693***	0.709***
	(0.116)	(0.128)
$eonia_{t-1}$	0.075***	0.114***
	(0.024)	(0.027)
ir_{t-1}	-0.118***	-0.171***
	(0.022)	(0.026)
$Imp_{t-1} \times \Delta eonia_t$	-0.034***	-0.034***
	(0.010)	(0.010)
$Imp_{t-1} \times eonia_{t-1}$	-0.002	-0.001
	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	-0.003***	-0.003***
	(0.001)	(0.001)
$DepShare_{t-1} \times \Delta eonia_t$		-0.001
		(0.003)
$DepShare_{t-1} \times eonia_{t-1}$		-0.002***
		(0.001)
$DepShare_{t-1} \times ir_{t-1}$		0.002***
		(0.001)
Fixed effects	Bank	Bank
Liquidity	Yes	Yes
Bank size	Yes	Yes
Market concentration	Yes	Yes
Other controls	Yes	Yes
N	5,350	5,350
R-squared	0.251	0.253

Notes: Models (1) - (2) use the FE estimator. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 12: Robustness to omitting balance sheet variables

	(1)	(2)	(3)	(4)
Δir_{t-1}	−0.262***	−0.243***	−0.240***	−0.237***
	(0.013)	(0.013)	(0.013)	(0.013)
$Liquidity_{t-1}$		0.007***	0.007***	0.007***
		(0.002)	(0.002)	(0.002)
$Size_{t-1}$			−0.060	−0.081
			(0.112)	(0.113)
$Herf_{t-1}$				0.026***
				(0.010)
Imp_{t-1}	0.033***	0.025***	0.025***	0.020***
	(0.006)	(0.006)	(0.006)	(0.006)
$\Delta eonia_t$	0.837***	0.709***	0.700***	0.693***
	(0.055)	(0.093)	(0.103)	(0.116)
$eonia_{t-1}$	0.171***	0.120***	0.091***	0.075***
	(0.011)	(0.020)	(0.021)	(0.024)
ir_{t-1}	−0.201***	−0.163***	−0.151***	−0.118***
	(0.012)	(0.019)	(0.020)	(0.022)
$Imp_{t-1} \times \Delta eonia_t$	−0.033***	−0.035***	−0.034***	−0.034***
	(0.010)	(0.010)	(0.010)	(0.010)
$Imp_{t-1} \times eonia_{t-1}$	−0.001	−0.002	−0.001	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	−0.005***	−0.004***	−0.004***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
$Liquidity_{t-1} \times \Delta eonia_t$		0.005*	0.005*	0.005*
		(0.003)	(0.003)	(0.003)
$Liquidity_{t-1} \times eonia_{t-1}$		0.002***	0.002***	0.002***
		(0.001)	(0.001)	(0.001)
$Liquidity_{t-1} \times ir_{t-1}$		−0.001***	−0.002***	−0.002***
		(0.001)	(0.001)	(0.001)
$Size_{t-1} \times \Delta eonia_t$			0.012	0.010
			(0.064)	(0.064)
$Size_{t-1} \times eonia_{t-1}$			0.044***	0.044***
			(0.014)	(0.014)
$Size_{t-1} \times ir_{t-1}$			−0.026*	−0.027*
			(0.015)	(0.015)
$Herf_{t-1} \times \Delta eonia_t$				0.000
				(0.007)
$Herf_{t-1} \times eonia_{t-1}$				0.003*
				(0.001)
$Herf_{t-1} \times ir_{t-1}$				−0.006***
				(0.002)
Fixed effects	Bank	Bank	Bank	Bank
Other controls	Yes	Yes	Yes	Yes
N	5,658	5,350	5,350	5,350
R-squared	0.257	0.247	0.249	0.251

Notes: Models (1) - (4) use the FE estimator. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 13: Alternative estimators

	(1)	(2)	(3)	(4)
Δir_{t-1}	−0.237***	−0.237***	−0.333***	−0.315***
	(0.013)	(0.013)	(0.013)	(0.013)
$Herf_{t-1}$	0.026***	0.026***	0.000	−0.062***
	(0.010)	(0.010)	(0.004)	(0.019)
$Size_{t-1}$	−0.081	−0.081	0.041	−0.003
	(0.113)	(0.113)	(0.034)	(0.036)
$Liquidity_{t-1}$	0.007***	0.007***	0.002*	0.004***
	(0.002)	(0.002)	(0.001)	(0.001)
Imp_{t-1}	0.020***	0.020***	0.013***	0.010**
	(0.006)	(0.006)	(0.004)	(0.005)
$\Delta eonia_t$	0.693***	0.693***	0.680***	0.617***
	(0.116)	(0.116)	(0.120)	(0.124)
$eonia_{t-1}$	0.075***	0.075***	0.046	0.069
	(0.024)	(0.024)	(0.030)	(0.042)
ir_{t-1}	−0.118***	−0.118***	−0.016	−0.069***
	(0.022)	(0.022)	(0.017)	(0.019)
$Herf_{t-1} \times \Delta eonia_t$	0.000	0.000	−0.002	−0.001
	(0.007)	(0.007)	(0.007)	(0.008)
$Herf_{t-1} \times eonia_{t-1}$	0.003*	0.003*	−0.002	−0.001
	(0.001)	(0.001)	(0.001)	(0.004)
$Herf_{t-1} \times ir_{t-1}$	−0.006***	−0.006***	0.002*	0.002
	(0.002)	(0.002)	(0.001)	(0.002)
$Size_{t-1} \times \Delta eonia_t$	0.010	0.010	−0.001	0.028
	(0.064)	(0.064)	(0.065)	(0.065)
$Size_{t-1} \times eonia_{t-1}$	0.044***	0.044***	0.015	0.010
	(0.014)	(0.014)	(0.012)	(0.013)
$Size_{t-1} \times ir_{t-1}$	−0.027*	−0.027*	−0.021**	−0.005
	(0.015)	(0.015)	(0.010)	(0.011)
$Liquidity_{t-1} \times \Delta eonia_t$	0.005*	0.005*	0.005*	0.005
	(0.003)	(0.003)	(0.003)	(0.003)
$Liquidity_{t-1} \times eonia_{t-1}$	0.002***	0.002***	0.000	0.001**
	(0.001)	(0.001)	(0.000)	(0.001)
$Liquidity_{t-1} \times ir_{t-1}$	−0.002***	−0.002***	−0.001***	−0.002***
	(0.001)	(0.001)	(0.000)	(0.000)
$Imp_{t-1} \times \Delta eonia_t$	−0.034***	−0.034***	−0.036***	−0.032***
	(0.010)	(0.010)	(0.010)	(0.011)
$Imp_{t-1} \times eonia_{t-1}$	−0.002	−0.002	0.002	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	−0.003***	−0.003***	−0.002***	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
GB_t	0.016***	0.016***		
	(0.004)	(0.004)		
Un_t	0.022***	0.022***		
	(0.004)	(0.004)		
$HICP_t$	0.047***	0.047***		
	(0.007)	(0.007)		
Constant	0.035	−0.127	0.027	0.353**
	(0.103)	(0.129)	(0.108)	(0.158)
Fixed effects	Bank	Bank	Year	$Country \times Year$
N	5,350	5,350	5,350	5,350
R-squared	0.251	0.255	0.199	0.228

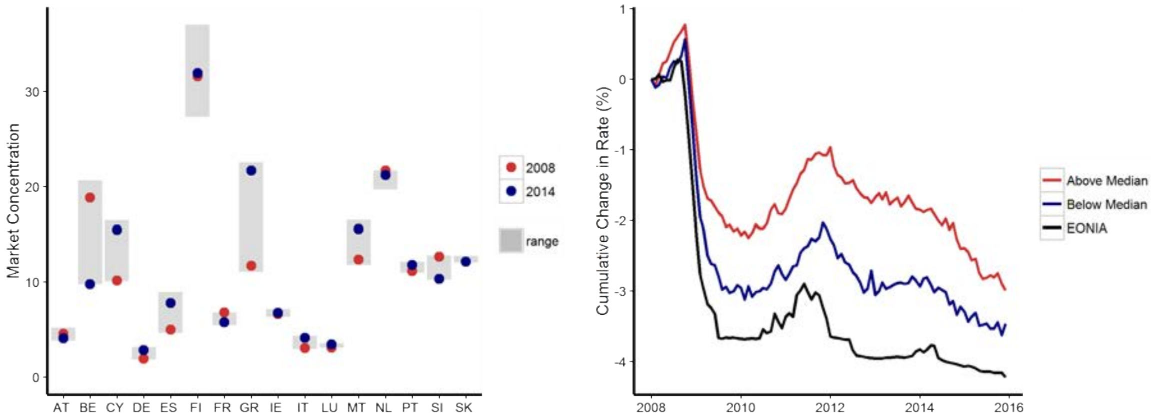
Notes: Model (1) is estimated using the FE estimator. Models (2)-(4) are estimated using Pooled OLS. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Table 14: Robustness to specification of macroeconomic variables

	(1)	(2)	(3)
Δir_{t-1}	−0.237***	−0.268***	−0.245***
	(0.013)	(0.013)	(0.013)
Imp_{t-1}	0.020***	0.018***	0.018***
	(0.006)	(0.006)	(0.006)
$\Delta eonia_t$	0.693***	0.611***	0.575***
	(0.116)	(0.119)	(0.118)
$eonia_{t-1}$	0.075***	0.018	0.073***
	(0.024)	(0.022)	(0.024)
ir_{t-1}	−0.118***	−0.067***	−0.120***
	(0.022)	(0.022)	(0.022)
$Imp_{t-1} \times \Delta eonia_t$	−0.034***	−0.036***	−0.031***
	(0.010)	(0.010)	(0.010)
$Imp_{t-1} \times eonia_{t-1}$	−0.002	0.001	−0.003
	(0.002)	(0.002)	(0.002)
$Imp_{t-1} \times ir_{t-1}$	−0.003***	−0.002	−0.003**
	(0.001)	(0.001)	(0.001)
GB_t	0.016***		0.017***
	(0.004)		(0.004)
ΔGB_t		0.012	0.023**
		(0.011)	(0.011)
Un_t	0.022***		0.025***
	(0.004)		(0.004)
ΔUn_t		0.052	−0.027
		(0.032)	(0.034)
$HICP_t$	0.047***		0.045***
	(0.007)		(0.007)
$\Delta HICP_t$		0.242***	0.234***
		(0.038)	(0.038)
Constant	0.035	0.173*	0.061
	(0.103)	(0.102)	(0.103)
Fixed effects	Bank	Bank	Bank
Liquidity	Yes	Yes	Yes
Bank size	Yes	Yes	Yes
Market concentration	Yes	Yes	Yes
N	5,350	5,350	5,350
R-squared	0.251	0.240	0.257

Notes: Models (1) - (3) use the FE estimator. Standard errors are in parentheses and significance level displayed as *p<0.1; **p<0.05; ***p<0.01

Figure 6: Market concentration and pass-through



References

Altavilla, Carlo, Fabio Canova, and Matteo Ciccarelli, "Mending the broken link: heterogeneous bank lending and monetary policy pass-through," Working Paper Series 1978, European Central Bank November 2016.

Annaert, Jan, Marc De Ceuster, Patrick Van Roy, and Cristina Vespro, "What determines Euro area bank CDS spreads?," *Journal of International Money and Finance*, 2013, *32* (C), 444–461.

Aristei, David and Manuela Gallo, "Interest rate pass-through in the Euro area during the financial crisis: A multivariate regime-switching approach," *Journal of Policy Modelling*, March-April 2014, *36* (2), 273–295.

Avouyi-Dovi, Sanvi, Guillaume Horney, and Patrick Sevestre, "The stability of short-term interest rates pass-through in the euro area during the financial market and sovereign debt crises," *Journal of Banking & Finance*, 2017, *79* (C), 74–94.

Balgova, Maria, Michel Nies, and Alexander Plekhanov, "The Economic Impact of Reducing Non-Performing Loans," *European Bank for Reconstruction and Development Working Paper Series*, 2016, *193.*

Banerjee, Anindya, John W. Galbraith, and Juan Dolado, "Dynamic Specification and Linear Transformations of the Autoregressive-Distributed Lag Model," *Oxford Bulletin of Economics and Statistics*, February 1990, *52* (1), 95–104.

Benbouzid, Nadia, Sushanta K. Mallick, and Ricardo M. Sousa, "An international forensic perspective of the determinants of bank CDS spreads," *Journal of Financial Stability*, 2017, *33* (C), 60–70.

Berrospide, Jose M. and Rochelle M. Edge, "The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean?," *International Journal of Central Banking*, December 2010, *6* (34), 1–50.

Borio, Claudio and Haibin Zhu, "Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?," *Journal of Financial Stability*, 2012, *8* (4), 236–251.

Brei, Michael, Leonardo Gambacorta, and Goetz von Peter, "Rescue packages and bank lending," *Journal of Banking & Finance*, 2013, *37* (2), 490–505.

Ciccarelli, Matteo, Angela Maddaloni, and Jos-Luis Peydr, "Heterogeneous transmission mechanism: monetary policy and financial fragility in the eurozone," *Economic Policy*, 2014, *28* (75), 459–512.

_ , _ , and _ , "Trusting the Bankers: A New Look at the Credit Channel of Monetary Policy," *Review of Economic Dynamics*, October 2015, *18* (4), 979–1002.

Constâncio, Vitor, "Resolving Europes NPL burden: challenges and benefits," 2017.

Cucinelli, Doriana, "The Impact of Non-Performing Loans on Bank Lending Behaviour: Evidence from the Italian Banking Sector," *Eurasian Journal of Business and Economics*, 2015, *8*, 59–71.

de Bondt, Gabe, "Retail bank interest rate pass-through: new evidence at the euro area level," Working Paper Series 0136, European Central Bank April 2002.

Deli, Yota D. and Iftekhar Hasan, "Real effects of bank capital regulations: Global evidence," *Journal of Banking & Finance*, 2017, *82* (C), 217–228.

Freixas, Xavier and Jean-Charles Rochet, *Microeconomics of Banking, 2nd Edition*, Vol. 1 of *MIT Press Books*, The MIT Press, 2008.

Frey, Giliola and Matteo Manera, "Econometric Models OF Asymmetric Price Transmission," *Journal of Economic Surveys*, 2007, *21* (2), 349–415.

Gambacorta, Leonardo, "How do banks set interest rates?," *European Economic Review*, July 2008, *52* (5), 792–819.

_ and Paolo Emilio Mistrulli, "Bank Heterogeneity and Interest Rate Setting: What Lessons Have We Learned since Lehman Brothers?," *Journal of Money, Credit and Banking*, 06 2014, *46* (4), 753–778.

Graeve, Ferre De, Olivier De Jonghe, and Rudi Vander Vennet, "Competition, transmission and bank pricing policies: Evidence from Belgian loan and deposit markets," *Journal of Banking & Finance*, January 2007, *31* (1), 259–278.

Hannan, Timothy H. and Allen N. Berger, "The Rigidity of Prices: Evidence from the Banking Industry," *The American Economic Review*, 1991, *81* (4), 938–945.

Holton, Sarah and Costanza Rodriguez d'Acri, "Jagged cliffs and stumbling blocks: interest rate pass-through fragmentation during the Euro area crisis," Working Paper Series 1850, European Central Bank 2015.

_ and Fergal McCann, "Sources of the Small Firm Financing Premium: Evidence from Euro Area Banks," *Research Technical Paper, Central Bank of Ireland*, 2016, (09/RT/16).

Hristov, Nikolay, Oliver Hlsewig, and Timo Wollmershuser, "The interest rate pass-through in the Euro area during the global financial crisis," *Journal of Banking & Finance*, 2014, *48* (C), 104–119.

Illes, Anamaria, Marco Lombardi, and Paul Mizen, "Why Did Bank Lending Rates Diverge from Policy Rates aftre the Financial Crisis," *BIS Working Paper Series*, 2015, *No. 486.*

Jiménez, Gabriel, Steven Ongena, José-Luis Peydró, and Saurina Jesús, "Credit Supply and Monetary Policy: Identifying the Bank Balance- Sheet Channel with Loan Applications," *American Economic Review*, 2012, *102* (5), 2301–2326.

Jorda, Oscar, Moritz Schularick, and Alan M. Taylor, "When Credit Bites Back," *Journal of Money, Credit and Banking*, 2013, *45*, 3–28.

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

Kashyap, Anil K. and Jeremy C. Stein, "The Impact of Monetary Policy on Bank Balance Sheets," *Carnegie Rochester Conference Series on Public Policy*, 1995, *42*, 151–195.

_ and _ , "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?," *The American Economic Review*, 2000, *90* (3), 407–428.

_ , _ , and David W. Wilcox, "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance," *American Economic Review*, March 1993, *83* (1), 78–98.

Kishan, Ruby P. and Timothy P. Opiela, "Bank Size, Bank Capital, and the Bank Lending Channel," *Journal of Money, Credit and Banking*, 2000, *32*, 121–141.

Kwan, Simon H. and Robert A. Eisenbeis, "An Analysis of Inefficiencies in Banking," *Journal of Banking and Finance*, 1995, *19*, 733–734.

Lovreta, Lidija and Zorica Mladenovi, "Do the stock and CDS markets price credit risk equally in the long-run?," *The European Journal of Finance*, 2018, *0* (0), 1–28.

Marotta, Giuseppe, "Structural Breaks in the Lending Interest Rate Pass-Through and the Euro," *Economic Modelling*, 2009, *26* (1), 191–205.

Peek, Joe and Eric S. Rosengren, "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States," *American Economic Review*, 2000, *90*, 30–45.

_ and _ , "Unnatural Selection: Perverse Incentives and the Misallocation of Credit in Japan," *American Economic Review*, 2005, *95*, 1144–1166.

Peltzman, Sam, "Prices Rise Faster than They Fall," *Journal of Political Economy*, June 2000, *108* (3), 466–502.

Ritz, Robert and Ansgar Walther, "How do Banks Respond to Increased Funding Uncertainty," *Journal of Finanical Intermediation*, 2015, *24* (3).

Ruthenberg, David and Yoram Landskroner, "Loan pricing under Basel II in an imperfectly competitive banking market," *Journal of Banking & Finance*, 2008, *32* (12), 2725–2733.

Sander, Harald and Stefanie Kleimeier, "Convergence in euro-zone retail banking? What interest rate pass-through tells us about monetary policy transmission, competition and integration," *Journal of International Money and Finance*, April 2004, *23* (3), 461–492.

Stineman, Russell W., "A consistently well-behaved method of interpolation," *Creative Computing*, 1980, *6* (7), 54–57.

van Leuvensteijn, Michiel, Christoffer Kok Srensen, Jacob A. Bikker, and Adrian A.R.J.M. van Rixtel, "Impact of bank competition on the interest rate pass-through in the euro area," *Applied Economics*, April 2013, *45* (11), 1359–1380.

Wang, Alan T., "A reexamination on the effect of bank competition on bank non-performing loans," *Applied Economics*, 2018, *0* (0), 1–9.

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