Banks' Funding Structure and Pass-Through in the Euro Area

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Abstract

This paper investigates the interest rate pass-through of monetary policy as for the euro area by focusing on the role of banks' funding structure. We estimate the interest rate pass-through for loans to non-financial corporations by using bank-level balance sheet data. In doing so, we interact the response of lending rates with characteristics of the funding structure, and show that banks that rely more on bond issuance rather than the money market tend to be less responsive to policy changes. Finally, we test the presence of the asset-liability-management channel, and find that banks combining longer-term liabilities (higher bond shares) with longer fixation lending (higher share of loans with fixed rates) exhibit the most muted lending rate response to policy shocks.

Keywords: Monetary policy pass-trough, bank lending channel, bank's funding structure

JEL codes: C23, E44, E52, G21

1 Non-technical summary

Every time the European Central Bank sets policy rates, the intended effect on households and firms works largely through commercial banks. Banks decide how much interest to charge on new loans and how much interest to pay on deposits. The speed and extent to which a policy rate change is reflected in these banks' rates is known as interest rate pass-through. This matters for monetary policy because firm borrowing costs influence investment, production costs and prices, while deposit rates influence households' incentives to save and spend. In the euro area, where bank lending is a central source of finance for many firms, understanding this pass-through is especially important.

This paper studies why some euro area banks adjust lending and deposit rates more strongly than others after a policy rate change. The central idea is that a bank's funding structure matters. Banks fund themselves in different ways. Some rely more on short-term money market borrowing, which tends to reprice quickly when policy rates move. While, others rely more on longer-term bonds, whose costs are less immediately affected by short-term rate changes. These different funding models can shape the cost of providing new loans and therefore the rate that a bank chooses to charge borrowers. The paper also studies the link between the liability side of a bank's balance sheet - i.e., how the bank funds itself - and the asset side - i.e., the type of loans it grants. Banks that rely more on longer-term bond funding also tend to grant more loans with longer periods of fixed interest rates. This is consistent with a simple balance-sheet logic: a bank with more stable longer-term funding is in a better position to offer loans whose rates do not change quickly. Conversely, a bank that relies more on short-term market funding is more exposed to changes in short-term interest rates and may therefore adjust lending rates more promptly.

The empirical analysis uses monthly euro area aggregate data from 2001 to 2023. At the bank level, it uses ECB proprietary data on individual banks' interest rates and balance sheets from July 2007 to April 2023, covering 266 banks with at least two years of data. The paper focuses mainly on new loans to non-financial corporations, meaning firms outside the financial sector, and on overnight deposits.

The aggregate evidence shows that policy rate changes are passed through to firm lending rates, but not immediately and not completely. Only about 40 percent of the policy rate change is passed on to new firm loans on impact, 80 percent after three months. Rates on overnight deposits, especially household deposits, respond slowly and by a smaller amount. This means that the same policy rate move can have different effects across different products. The bank-level results show that these average patterns hide substantial differences across banks. Banks that rely more on money market funding tend to pass policy rate changes through to lending rates more strongly and more persistently. Banks with a larger share of bonds among their liabilities tend to adjust lending rates more slowly and by less. In fact, short-term market borrowing becomes more expensive soon after a policy rate increase, so banks that depend on it face a stronger and faster rise in funding costs. Longer-term bond funding partly shields banks from this immediate pressure, so the incentive to raise loan rates immediately is weaker.

The most muted pass-through is found among banks that combine a high share of bond funding with a high share of longer fixed-rate lending. This result points to an asset-liability-management channel of monetary transmission. Funding maturity and loan-rate fixation work together. Longer-term funding reduces the sensitivity of a bank's funding costs to short-term policy changes, while longer fixed-rate lending reduces the immediate sensitivity of the bank's loan revenues. Taken together, these features make the bank's posted lending rates less responsive to policy rate surprises.

The paper also uses a small macroeconomic model to assess why this matters beyond bank pricing itself. When the model is calibrated to match the estimated pass-through in the data, the effects of monetary policy on output and inflation are smaller than in a benchmark where bank rates move immediately and fully with the policy rate. In other words, assuming perfect pass-through can overstate the real and nominal effects of monetary policy.

The policy implication is that the transmission of ECB policy depends not only on the policy rate itself, but also on the structure of bank balance sheets. A policy rate change can have uneven effects across banks depending on whether they rely more on short-term market funding or on longer-term bond funding, and depending on whether they mainly issue floating-rate or fixed-rate loans. Monitoring these features can improve assessments of how strongly and how quickly monetary policy is reaching firms and households. It also helps explain why transmission may differ across banks even within the same currency union.

2 Introduction

This paper studies the role of bank's funding structure for defining the interest rate pass-through of monetary policy in the euro area. We do so by estimating the pass-through with bank-level data on interest rates and balance sheet items from the Eurosystem Individual Main Interest Rates (IMIR) and Balance Sheet Items (IBSI) databases. We document that cross-sectional heterogeneity in wholesale funding is systematically related to the dynamic response of both loan and deposit rates to policy shocks. Further, our findings point to the the presence of the asset-liability management channel as a key determinant of the transmission of monetary policy through the banking sector.

Our contribution relates to several strands of the empirical and theoretical literature. First, a substantial body of the literature documents incomplete and heterogeneous pass-through to bank lending and deposit pricing in the euro area. Considering lending to non-financial corporations, Altavilla et al. (2020a) shows the presence of heterogeneity in loan rate responses and a weakened mapping from policy to bank pricing since the sovereign debt crisis, while Albertazzi et al. (2021) studies the bank lending channel across conventional and unconventional episodes. Regarding the behaviour of deposit rates, Holton and Rodriguez d'Acri (2018) show that deposit pass-through fell markedly after the crisis, and Drechsler et al. (2017a, 2021) finds micro evidence linking banks' funding models and competitive conditions to stickiness in deposit rates and monetary transmission. Our study complements this evidence by providing bank-level pass-through estimates that explicitly condition on wholesale funding composition, jointly for loans and overnight deposits, over a sample that includes the most recent post-2022 tightening cycle. Second, heterogeneous effects of euro area monetary policy across jurisdictions and sectors have been documented in large multi-country empirical models by Mandler et al. (2022) and when considering financial fragmentation by Gagnon and Gimet (2023). With respect to them, our analysis unveils a balance-sheet channel of heterogeneity that operates *within* the cross-section of banks and that can coexist with country-level differences. We also link wholesale funding choices to loan maturity composition on the asset side (i.e., the asset-liability-management channel), providing a micro foundation for differences in the effective slope and timing of the pass-through. Finally, among others, Ottonello and Winberry (2020) exploit heterogeneity at the micro level to study transmission mechanisms of monetary policy. Relative to this literature, our novelty is to interact policy-induced dynamics with time-varying funding structure indicators from the bank-level balance sheet data, allowing the pass-through coefficients themselves to depend on wholesale funding wedges.

We estimate the interest pass-through via a Instrumental Variable Local Projection (IV-LP) model on a monthly database that includes bank's interest rates (for loans and deposits) as well as volumes of balance sheet items (assets and liabilities) for the sample 2001-2023. The conventional monetary policy shocks are instrument via high-frequency co-movements in interest rate surprises in a narrow window around ECB announcements, i.e., the "target" factor, as in Altavilla et al. (2019).[1] This empirical design builds on the best practice in external-instrument applied macroeconometrics (Jordà, 2005; Plagborg-Møller and Wolf, 2021).

First, we estimate aggregate pass-through benchmarks for the euro area, and show that, in line with prior evidence, loan rates for firms move rapidly with policy, while the pass-through to overnight deposit rates is lower and slower (Altavilla et al., 2020a; Holton and Rodriguez d'Acri, 2018). Then, to quantify the macro implications, we build a small-scale New Keynesian model with (i) Calvo price stickiness in goods markets (Calvo, 1983; Galí, 2015); (ii) a working-capital/cost channel whereby firms borrow in advance to pay wages, so the loan rate enters marginal costs (Christiano et al., 2005; Ravenna and Walsh, 2006); and (iii) monopolistically competitive intermediaries that set *deposit* and *loan* rate indices à la Calvo. The bank block generates sluggish aggregate loan and deposit rates that track—but do not one-for-one follow—the policy rate. We estimate the NK model based on empirical pass-through (via IRF-matching), and show that ignoring pass-through frictions leads to overstated output and inflation responses to policy shocks. This finding complements existing VAR-based evidence on the strength of transmission (Gertler and Karadi, 2015; Altavilla et al., 2019) by highlighting a structural wedge operating through bank pricing.

Next, we estimate bank-level impulse responses using Individual Main Interest Rates and Individual Balance Sheet Items panels and instrumented local projections. Importantly, we enhance IV-LP model by including an interaction structure in which the response of rates to the policy

[1] This identification approach is consistent with recent work emphasizing tight identification windows and careful separation of policy and information effects in the euro area (Jarociński and Karadi, 2020; Badinger and Schiman, 2023).

surprise is allowed to vary with pre-shock funding composition (i.e., percentages of net money-market debt and bonds outstanding over liabilities), measured at the bank level. Two robust facts emerge from this exercise: (i) banks more indebted on the money market exhibit higher and more persistent pass-through of policy to their loan rates; (ii) banks with larger bond shares in liabilities display attenuated and slower pass-through.

We hypothesize that the lower pass-through in the latter case maybe be linked to the the presence of the asset-liability-management channel dictating an interconnection between funding structure, assets composition, and rate-setting. Therefore, we test the presence of the asset-liability-management channel by further enhancing our analysis so to consider an additional dimension related to the assets composition of the banks, in particular we look at the of fixed-rate loans assets. Thus we jointly consider the banks liabilities (funding through bonds issuance) and assets (rate-fixation of loans) composition as determinants of the pass-through. The results of this exercise show that banks with balance sheets combining longer-term liabilities (higher bond shares) with longer fixation lending (higher share of loans with fixed rates) exhibit the smallest interest rate pass-through.

Overall, our findings point to the presence of a strong link between funding stability, asset maturity, and rate-setting in the euro area banking sector.[2] Stable longer-term funding reduces the sensitivity of marginal funding costs to short-term policy shocks, while a larger share of fixed-rate, longer-maturity assets dampens the marginal revenue sensitivity on the asset side. Both features lower the optimal reset of posted rates on impact. This mechanism is complementary to deposit market competition channels highlighted by Drechsler et al. (2017a, 2021) and to negative-rate frictions (Heider et al., 2019a). It also helps rationalize cross-sectional heterogeneity beyond country fragmentation (Mandler et al., 2022; Gagnon and Gimet, 2023).

The rest of the paper is organized as follow. Section 3 describes that aggregate and bank-level datasets. Section 4 explores empirical aggregate pass-through estimates and proposes a theoretical model to further rationale the estimates. Section 5 turns to bank-level estimates and the role of funding-structure for defining the pass-trough. Section 6 studies the relationship between the interest rate pass-through, the bank's funding structure and the asset-liability-management channel. Section 7 concludes.

[2]Notice that since we focus on rates to new loans we use maturity and rate-fixation interchangeably.

3 Data

3.1 Macro-financial Aggregates and Monetary Policy Surprises

We employ a monthly dataset of euro area aggregate indicators covering macroeconomics variables, finical indicators, interest rates (lending and deposits) and monetary policy surprises. The sample of aggregate data spans from January 2001 until April 2023.

Monetary policy surprises. We measure unexpected changes in the stance of monetary policy using the swap market surprises approach of Altavilla et al. (2019). Concretely, we use the Euro Area Monetary Policy event study Database (EA-MPD) and extract intra-day changes in euro area overnight index swap (OIS) rates around ECB policy communication and summarize them by the first principal component of the release-window surprises, which captures the "target" dimension of policy (policy rate/news component).

Marco-financial indicators. The set of aggregate time series (used as controls) follow standard practice. Specifically, it incudes the following monthly indicators: industrial production, consumer prices (HICP), an overnight short-term rate (ESTR/EONIA), a broad stock market index, a euro area corporate credit spread, a sovereign yield, and the ECB Composite Indicator of Systemic Stress (CISS) of Kremer et al. (2012).[3]

Bank aggregate data. We collect euro area aggregate banking sector data from the Main Interest Rate (MIR) and Balance Sheet Items (BSI) statistics. The MIR database reports statistics on interest rates applied by banks to deposits and loans (for both households and non-financial institutions). The database contains monthly figures for both interest rates and volumes. The BSI database reports aggregated (or consolidated) balance sheet items (assets and liabilities) of the euro area banking sector.[4]

[3]Regarding industrial production, we control for the rather abnormally large Covid-19 shocks by smoothing the observations between March 2020 and February 2022 via the Hodrick-Prescott (HP) filter, thus avoiding the presence of potential bias estimates of our Gaussian econometric framework (see Lenza and Primiceri, 2022).

[4]More information regarding the MIR and BSI datasets is provided in the ECB Data Portal: https://data.ecb.europa.eu/data/datasets.

3.2 Bank Level Dataset

Our bank-level analysis relies on two ECB proprietary datasets that are the micro counterparts of the public Main Interest Rate (MIR) and Balance Sheet Items (BSI) statistics.

Individual-MIR (IMIR). The IMIR reports monthly new-business interest rates charged/paid by each reporting institution, with a detailed breakdown by instrument, sector, and interest rate fixation horizon. On the loan side, IMIR distinguishes, inter alia, new loans to non-financial corporations (NFCs) and to households (including loans for house purchase), and it classifies contracts by initial rate-fixation buckets (e.g., up to 1 year, 1 to 5 years, over 5 years). Regarding the deposit side, IMIR provides rates on overnight deposits and time deposits, separately for households and NFCs. These granular new-business rates allow us to characterize both the level and the dynamic pass-through to posted loan and deposit prices at the bank level.

Individual-BSI (IBSI). The contains monthly/quarterly stocks by instrument, sector, and maturity for both assets and liabilities. On the liability side, we observe retail/wholesale deposits (by sector), money-market funding (e.g., interbank/market-based), and debt securities issued (bank bonds) among others. Regarding the asset side, we observe loans to households and NFCs and securities holdings, with maturity breakdowns. We exploit IBSI to construct two funding structure indicators—(i) money market indebtedness (net money market debt over total liabilities) and (ii) the share of bonds issued in total liabilities—and to proxy the asset-side interest rate sensitivity using the share of longer-fixation new loans.

The IMIR/IBSI panel we use spans from July 2007 to April 2023 and includes 266 reporting banks with at least two years of data. The balanced panel comprises 103 banks. Importantly, representativeness vis-à-vis aggregates is rather high. In particular, the sum of individual-bank volumes over the aggregate oscillates roughly between 40% and 65% for loans and deposits over 2007–2023, and the bank-level average response to policy closely tracks the aggregate response estimated on MIR/BSI, supporting external validity of our micro panel. In the baseline heterogeneity specifications, we assign banks to quartiles of the pre-shock funding indicators (money market indebtedness or bonds-issued share) and estimate group-specific responses. Our use of IMIR/IBSI databases follows and extends the approach in Altavilla et al. (2020a) who document heterogeneous pass-through in bank lending rates and emphasize bank-level drivers of incompleteness ("mending the broken link"). In our setting, the bank-level structure of funding (money-market vs. bonds) is measured directly from IBSI database, while loan/deposit pricing comes from IMIR database. Therefore we connect funding-side heterogeneity to loan pass-through within a unified IV-Local Projection framework. This micro-data design is complementary to aggregate euro area interest rate pass-through facts and is well suited to study the cross-sectional mechanisms highlighted in the literature (Altavilla et al., 2020a; Holton and Rodriguez d'Acri, 2018).

4 Aggregate Transmission and Pass-Through

In this section we study the interest rate pass-through of monetary policy at aggregate level. We do so by following a two steps approach. First, we estimate the responses of macro-financial indicators and interest rates to monetary policy shocks via a local projection econometric model. Second, we interpret the empirical response through the lens of a New Keynesian model featuring monopolistically competitive banks.

4.1 Estimating the Aggregate Pass-Through

We estimate the impulse response functions to a monetary policy shock in the euro area for the main macroeconomic aggregates as well as lending and deposit rates via the Instrumental Variable Local Projection (IV-LP) model (1)-(3). The model reads as follow.

$$IRF_h^{(Y,R,Z)} = \beta^{(Y,h)}/\beta^{(R)} \tag{1}$$

$$R_t = \alpha + \beta^{(R)} Z_t + \mathbf{\Gamma} \boldsymbol{X}_{t-1} + \varepsilon_{t+h}^{(R)} \tag{2}$$

$$Y_{t+h} = \alpha + \beta^{(Y,h)} \hat{R}_t + \mathbf{\Gamma} \boldsymbol{X}_{t-1} + \varepsilon_{t+h}^{(Y)} \tag{3}$$

The first stage of the IV approach is shown in (2), with the coefficient $\beta^{(R)}$ representing the variation in the policy rate R_t that is associated with a one standard deviation change in the instrument Z_t

(i.e., monetary policy shock instrument). The second stage (3) estimates $\beta^{(Y,h)}$ representing the response of variable Y_{t+h}, measured $h = 0, \ldots, H$ periods ahead to a variation in the policy rate R_t. Then, Equation (1) identifies the relative impulse response functions defined as the moving average (MA) coefficient for the reaction of a variable Y_t to a shock at any horizon h, rescaled by the MA coefficient for the reaction of the policy rate R_t to an unexpected monetary policy shock at time zero. This modelling choice restrains us of making any assumption on the information set spanned by the shock thus avoiding biases related the invertibility of the instrument as described in Stock and Watson (2018). Finally, the set of control variables $\boldsymbol{X}_{t-1}$ includes 12 lags of the dependent variable, log-level of industrial production, log-levels of HICP prices, the policy rate (ESTR, formerly EONIA), the log-level of stock market prices (STOXX500 index), corporate bond spreads (ICE BofA Euro High Yield Index Option-Adjusted Spread), long term sovereign bond yields (euro area 10-year index published by the OECD), and the CISS measure of money market distress (Kremer et al., 2012). The average lending rate on new loans to firms and deposit rates for households are obtained from the Main Interest Rates database published by the ECB. The data is monthly and the sample spans from January 2001 to October 2023.

The instrument for monetary policy shocks Z_t is based on the swap market surprises around monetary policy announcements from Altavilla et al. (2019). We consider swap contracts of duration up to one year, and compute the first principal component of surprises around the ECB's press release representing the "Target" component of the monetary policy shocks related to unexpected decisions on policy rates. Other components are interpreted as indicating timing, forward guidance, or Quantitative Easing . We focus on this first component with the aim of identifying the response to a conventional monetary policy shock.[5]

Figure 1 shows the estimated responses to a shock that raises the policy rate by 10 basis points for selected macro-financial indicators up to 1-year ahead.[6] The policy rate has a humped-shaped

[5] Jarociński and Karadi (2020) take a larger window for measuring market surprises (which includes both the press release and the announcement) with the objective of estimating central bank information shocks by imposing sign restrictions. This is not necessary in this context, as the press release refers only to changes in policy rates or actual activation of other policy tools, and does not contain explicit information on the state of the economy. Therefore choosing the narrow window to measure surprises related to conventional monetary policy allows to relax the identification restrictions.

[6] We limit our analysis to 1-year horizon because of the relatively short policy cycles for conventional monetary policy in the euro area, see Jarociński and Karadi (2020) and Badinger and Schiman (2023).

response, as documented also by Jarociński and Karadi (2020) and Badinger and Schiman (2023), significant at the 90% level until the one year horizon. Lending rates have a similar shape, though the response is more muted, thus indicating an imperfect pass-through. The response of inflation is also in line with the literature, with the first four months of stickiness, and then a persistent decrease. The response of industrial production is highly volatile, but negative for the first year, as expected.

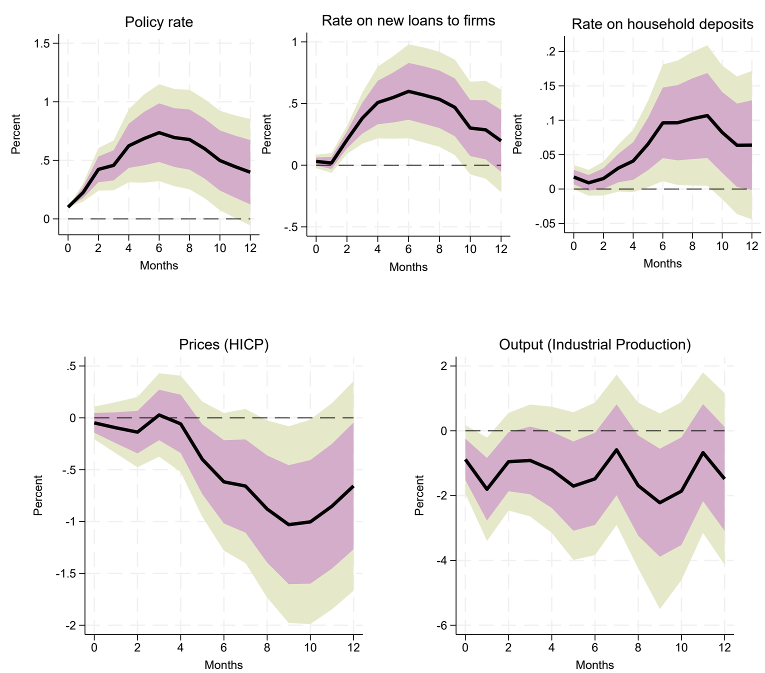

Figure 1: Responses to a 10 basis points monetary policy shock for the policy rate, lending rate to firms, HICP prices and industrial production. The shaded areas represent 68% and 90% confidence bands.

Interest rate pass-through. Based on the estimated model (1)-(3), the pass-through can be defined as the ratio of impulse response functions $PT_h^{(Y,R,Z)} \equiv IRF_h^{(Y,R,Z)}/IRF_h^{(R,R,Z)}$. This is also identified using the response of the policy rate R_{t+h} at different horizons $h = 0, \ldots, H$ as the first stage. Figure 2 shows the pass-through to volume-weighted lending rates for firms and deposit rates for households. The lending rate is defined as the average rate on new loans issued to non-financial corporations, an aggregate time series from the MIR dataset.[7] On impact, this

[7]Moreover, the lending rates for firms exclude revolving loans and overdrafts, convenience and extended credit card

seems to be transmitting changes in the policy rate at around 40% pass-through, meaning that for each 10 basis points of policy hike only 4 basis points are transmitted to new loans to firms. From the third month after the shock, though, the response of the firms lending rate is around 80% similar to the one of the policy rate. This could reflect a large share of contracts whose initial rate is based on an average of the banks' cost of funding, which could be proxied with an average of money market rates in the previous three months. Mechanisms of this kind, intrinsic in the contracts, could be underlying the fast convergence of firms' lending rates. Rates on household deposits, instead, feature a low pass-through below 20%, as visible from the right panel of Figure 2 and consistently with the literature on banks' market power on deposits (Drechsler et al., 2017a). Noting that deposit rates are for current accounts (which comprise around 80% of the deposits volume as of May 2023), this evidence could be suggestive of how the post-crisis full allotment/ample reserve system, quantitative easing, and negative rates have removed incentives for banks to compete for deposits. This is confirmed by Messer and Niepmann (2023) who show that the transmission to deposits has been particularly weak in the last tightening cycle, potentially due to the amount of liquidity in the banking system. Moreover, our sample includes years with negative rates, in which banks have not passed the rate cuts to households, but in part only to firms.

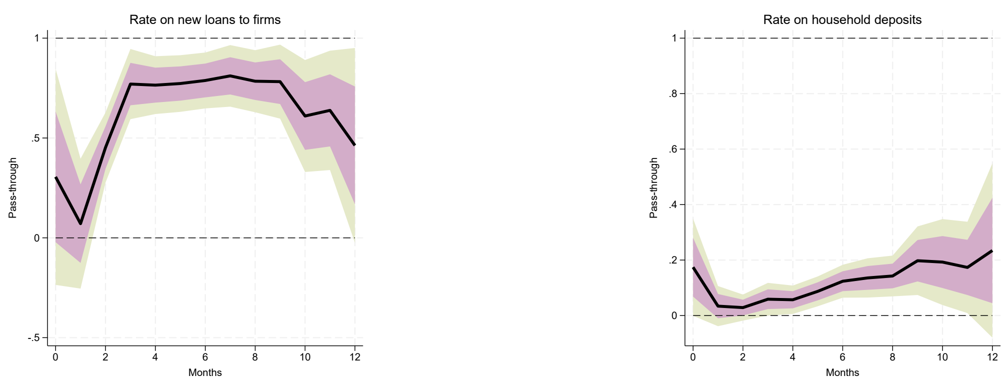

Figure 2: Interest rate pass-through for loans to firms (left) and deposits from households (right). Estimates are obtained with the aggregate data with series for the volume-weighted average lending rates on new loans to firms (non-financial corporations) and households current accounts for all euro area banks. The shaded areas represent 68% and 90% confidence bands.

debt, but include loans both with and without collateral and/or guarantees. Deposit rates refer to current account rates, and overnight deposits. The Appendix reports the volumes (Table A1 and Figure A1) and the pass-through (Figure A2 Figure A3) for loans and deposit to both households and firms distinguishing for short term credit and for term deposits.

4.2 A Model for the Imperfect Pass-Through

We build a otherwise standard New Keynesian model that allows to study how the imperfect pass-through of the policy rate to deposit and lending rates affects monetary transmission. The real side follows the standard NK setup with Calvo price stickiness (Calvo, 1983; Galí, 2015). Firms must finance their wage bill in advance, so the nominal interest rate enters marginal cost ("cost channel") as in Ravenna and Walsh (2006) and Christiano et al. (2005). Imperfect pass-through arises because monopolistically competitive financial intermediaries (banks) set both deposit and lending rates à la Calvo. In equilibrium, monetary policy transmits through two channels: (i) households' intertemporal margin via the deposit rate; and (ii) firms' marginal cost via the lending rate (working-capital channel). Monetary policy sets the short-term nominal rate via a Taylor rule with interest rate smoothing.

The banking sector. There is a continuum of monopolistically competitive banks that set rates à la Calvo in the deposit and loan markets. Let $\theta > 1$ be the elasticity of substitution across banks' products. Deposits demand from households and loans demand from firms aggregates with constant elasticity of substitution with individual demands $d_{j,t} = \left(r^D_{j,t}/R^D_t\right)^{-\theta} D_t$ and $l_{j,t} = \left(r^L_{j,t}/R^L_t\right)^{-\theta} L_t$. Banks can borrow from the central bank at the policy rate i_t to cover any funding gap $B_t = L_t - D_t$. Given demand conditions and the central bank rate, a rate-setting bank j maximizes discounted profits

$$\max_{\{r^L_{j,t}, r^D_{j,t}\}} \mathbb{E}_t \sum_{i=0}^{\infty} \omega_L^i \omega_D^i \, \Delta_{t,t+i} \frac{1}{P_{t+i}} \Big(\underbrace{r^L_{j,t}\, l_{j,t+i}}_{\text{loan revenue}} - \underbrace{r^D_{j,t+i}\, d_{j,t+i}}_{\text{deposit cost}} - \underbrace{i_{t+i}\big(l_{j,t+i} - d_{j,t+i}\big)}_{\text{refinancing cost}} \Big),$$

where ω_L and ω_D are the Calvo stickiness parameters and $\Delta_{t,t+i}$ is the household stochastic discount factor. The optimal reset loan rate is a constant markdown over a discounted average of marginal financing costs,

$$r^{L*}_{j,t} = \frac{\theta}{\theta - 1} \, \frac{\mathbb{E}_t \sum_{i \geq 0} \omega_L^i \, \Delta_{t,t+i} \, i_{t+i} \, (R^L_{t+i})^{\theta} \, L_{t+i}/P_{t+i}}{\mathbb{E}_t \sum_{i \geq 0} \omega_L^i \, \Delta_{t,t+i} \, (R^L_{t+i})^{\theta} \, L_{t+i}/P_{t+i}},$$

and analogously for deposits. Moreover, we model fixed rate loans as in Greenwald (2016), so that each period a portion $\phi = 1 - \frac{1}{\tau}$ of the outstanding loan is repaid, with τ representing the average maturity. Firms are assumed to borrow a portion γ of the wage bill through short-term loans at rate

$\hat{R}^{L,ST}$, which adjusts every period, and the rest of the wage bill from long-term (fixed-rate) loans at rate $\hat{R}^{L,LT}$. Banks' optimal response aggregates in the same way firms price setting does in the standard New Keynesian model, and linearizing around a zero-inflation steady state the equilibrium dynamics are described by:

$$\begin{cases} \text{IS curve:} \quad x_t = \mathbb{E}_t x_{t+1} - \frac{1}{\sigma}\left(\hat{R}_t^D - \mathbb{E}_t \pi_{t+1}\right), \\ \text{Phillips curve:} \quad \pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(\sigma+\eta)\, x_t + \kappa\left(\gamma \hat{R}^{L,ST} + (1-\gamma)\hat{R}^{L,LT}\right), \\ \text{Floating lending rate:} \quad \hat{R}_t^{L,ST} = \frac{1}{1+k_L+\beta}\left(\hat{R}_{t-1}^{L,ST} + k_L \hat{i}_t + \beta \mathbb{E}_t \hat{R}_{t+1}^{L,ST}\right), \\ \text{Fixed lending rate:} \; R^{\hat{L,LT}}{}_t = \frac{1}{1+k_L+\beta}\left(R^{\hat{L,LT}}{}_{t-1} + \left(\hat{i}_t - \sigma \hat{x}_t - \hat{\psi}_t\right) + \beta \mathbb{E}_t R^{\hat{L,LT}}{}_{t+1}\right), \\ \text{Deposit rate:} \quad \hat{R}_t^D = \frac{1}{1+k_D+\beta}\left(\hat{R}_{t-1}^D + k_D \hat{i}_t + \beta \mathbb{E}_t \hat{R}_{t+1}^D\right), \\ \text{Taylor rule:} \quad \hat{i}_t = \rho_i \hat{i}_{t-1} + \delta_x x_t + \delta_\pi \pi_t + z_t, \end{cases}$$

with $\hat{\psi}_t \equiv -\sigma(1-\phi\beta)\hat{x}_t - \phi\beta\mathbb{E}_t\pi_{t+1} + \phi\beta\mathbb{E}_t\hat{\psi}_{t+1}$. $\kappa \equiv (1-\beta\omega)\frac{1-\omega}{\omega}$, $k_L \equiv (1-\beta\omega_L)\frac{1-\omega_L}{\omega_L}$ and $k_D \equiv (1-\beta\omega_D)\frac{1-\omega_D}{\omega_D}$. The cost channel term $\kappa\left(\gamma\hat{R}^{L,ST} + (1-\gamma)\hat{R}^{L,LT}\right)$ is the key departure from the baseline New Keynesian Phillips Curve and is what makes policy trade-off stabilization of both x_t and π_t even in the absence of ad-hoc cost-push shocks. Moreover, the fact that household are not faced with the policy rate but with the deposit rate $\hat{R}_t^D$ also has important consequences when calibration the rate stickiness to the data: as the deposit rate adjusts sluggishly, the transmission of monetary policy through the Euler equation is attenuated. We calibrate the model via the Generalised Method of Moments to match the impulse responses obtained via an empirical VAR model.[8] Figure 3, show how this model can accurately match the responses of bank rates without

[8] Differently from the previous IV-LP approach, in this section we use responses obtained via an internal instrument VAR. The two approaches are equivalent in the large sample and both correctly identify the impulse response, as shown in Plagborg-Møller and Wolf (2022). However, the internal instrument VAR provides smoother multi-equation dynamics (and so related responses) that renders the GMM IRF-matching estimation of the NK model more efficient. The VAR model is estimated via OLS and it features 12 lags and a vector of endogenous variables endowed with the monetary policy surprises, log-level of industrial production (manufacturing), log-levels of HICP prices, the policy rate (ESTR, formerly EONIA), the log-level of stock market prices (STOXX500 index), corporate bond spread (ICE BofA Euro High Yield Index Option-Adjusted Spread), long-term sovereign bond yields (euro area 10-year index published by the OECD), the CISS measure of money market distress, the average lending rate for floating rates new loans to firms, the average lending rate for fixed-rate loans to firms, and the average deposit rate on household's current accounts. The sample used spans from January 2001 to April 2023. Finally, industrial production is smoothed with

sacrificing the reactions of the real variables. The model can, in fact, generate different levels of pass-through to match the data while maintaining a sensible calibration of the standard parameters.[9]

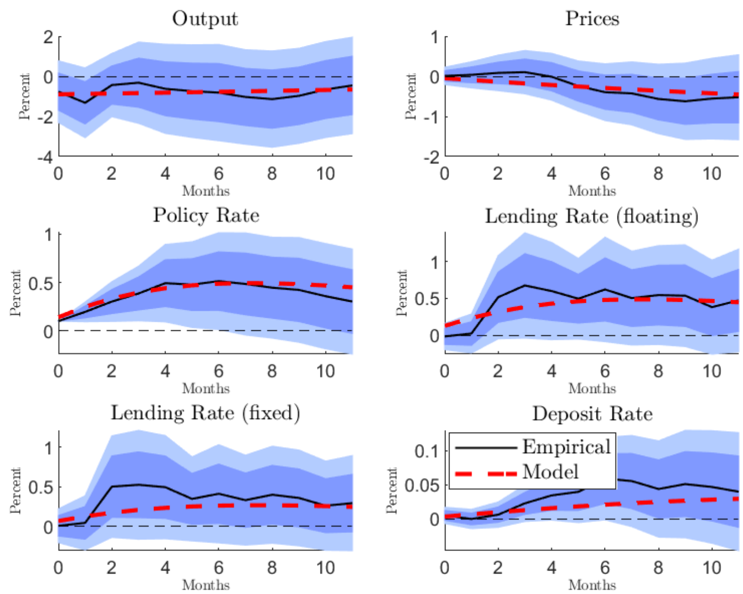

Figure 3: Responses to a 10 basis points monetary policy shock, empirical estimates and model simulation. The empirical responses are based on a internal instrument VAR, while the parameter of the NK model are estimated via the GMM IRF-matching approach. The shaded areas represent 68% and 90% confidence intervals for the VAR responses.

Based on this calibration, Figure 4 shows the impact of a one standard deviation monetary policy shock on output and inflation according to the NK model with all the estimated parameters, including the rates stickiness (i.e., estimated pass-through) and according to the same model but imposing flexible rates in the calibration (i.e., perfect pass-through). The response of both variables is substantially more muted in the model with estimated stickiness, with output reacting around one percentage point less to monetary policy and inflation around two basis points less. This quantitative wedge complements the aggregate findings shown in the previous section, making evident how the imperfect pass-through has sizeable implications on the impact of monetary policy.[10]

the Hodrick-Prescott (HP) filter between March 2020 and February 2021 so to control for the Covid-19 shocks.

[9]More details on the estimated parameters are reported in the Appendix A8 (Table A2).

[10]These findings also complement other euro area estimates of incomplete pass-through (e.g., Altavilla et al., 2020b; Holton and Rodriguez d'Acri, 2018; Boeckx et al., 2020) and the deposit-franchise/negative-rates mechanisms that rationalize persistent bank-rate stickiness (Drechsler et al., 2017a; Heider et al., 2019b).

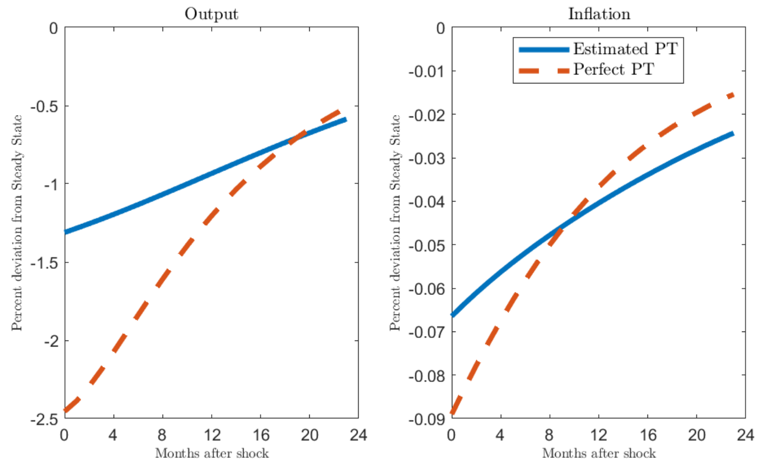

Figure 4: Model simulation with flexible (Perfect PT) and sticky rates (Estimated PT). Responses to a 1-standard deviation monetary policy shock for output and inflation based on the model featuring perfect pass-through (red dashed lines) and imperfect pass-through (blue solid lines).

This model allows to study the relevance of the intermediaries for the transmission of monetary policy by estimating the Calvo parameters for the rate setting equations and the average duration of the long-term loans. These parameters allow to match the empirical evidence, and to simulate the impact of monetary policy shocks on the real economy. While the model includes loans of different maturities, it does not describe banks with different sources of wholesale funding, and including this dimension could lead to an even clearer description of banks incentives in asset-liability management and rate setting.

5 Bank-Level Estimates

The analysis on aggregate data indicates that the response of lending rates is about 40% of the one of the policy rate on impact, reaching 80% after three months. As heterogeneities could play a large role at the bank-level, in this section we consider data from the Individual Main Interest Rates and Individual Balance Sheet Items databases of the ECB, which include information on a representative sample of around 260 banks. In doing so we test the consistency of the aggregate findings reported in the previous section, and then we further explore the role of bank's funding structure for determining the interest rate pass-through.

5.1 Aggregate vs. Bank Level Pass-Through

First we study the representativeness of bank-level data covering around 260 banks (IMIR/IBSI database) with respect to the aggregate data (MIR/BSI database) sample. To do so, we estimate a common response using the same first stage as with the aggregate specification in Equation (2) (instrumenting the policy changes with the swap market surprises) but with the following bank-level specification for the second stage:

$$Y_{i,t+h} = \alpha_i + \beta^{(Y,h)}\hat{R}_t + \mathbf{\Gamma}\boldsymbol{X}_{i,t-1} + \varepsilon^{(Y)}_{i,t+h}. \tag{4}$$

Where banks are indexed by i and the dependent variable $Y_{i,t+h}$ indicates the bank-specific lending rate at any future time $t + h$. The dependent variable $Y_{i,t+h}$ is assumed to depend on a bank-fixed effect α_i, a common response to $\beta^{(Y,h)}$ to changes in the policy rate ΔR_t, and the response to the control variables (both at aggregate and bank level) $\mathbf{\Gamma}\boldsymbol{X}_{i,t-1}$. As for the set of aggregate level control variables, we use the same specification than in Section 4, and hence the monetary policy shock identification (first IV stage) also remains unchanged. Regarding the bank level controls, we include variables describing the composition of the balance sheet (one period before the shock) from the IBSI database. In particular, we consider the following volumes as share of total assets: retail loans, retail deposits, money market credit and debt, and capital. The data is monthly and the sample spans from July 2007 to April 2023.

Figure 5 shows the average response of lending and deposit rates to a monetary policy shock across the bank-level sample. Standard errors are clustered by bank and time following Driscoll and Kraay (1998) for dealing with both differences in variability within the cross section as well as possible serial correlation. Responses are significant across almost all the projection horizon of 1-year, in line with the results from the aggregate data. The size of the responses is similar to those reported in Section 4, with **the response of deposit rates being much lower than that for lending rates**, confirming also the results on the interest rate pass-through for these two assets.

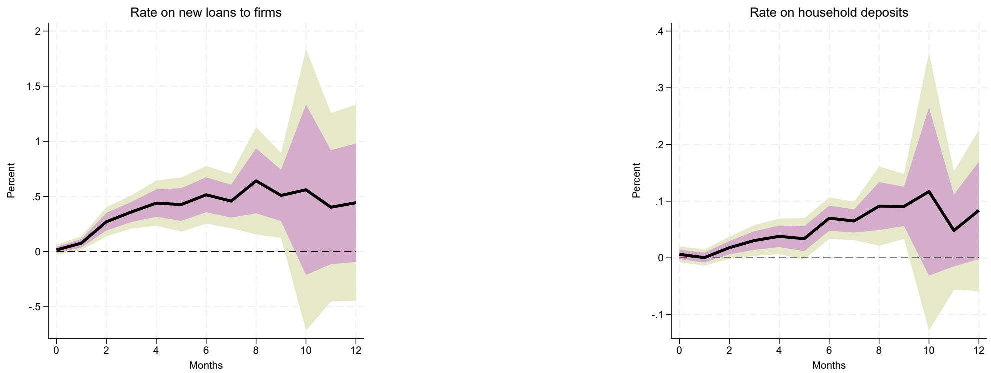

Figure 5: Average responses to a 10 basis points monetary policy shock for lending rates (left) and deposit rates (right). The lending rates are for loans to firms (non-financial corporations), and deposit rates are for household current accounts. The standard errors are clustered at bank and year level. The shaded areas represent 68% and 90% confidence intervals.

5.2 Heterogeneity in Funding structure

To study the role bank's funding structure for determining the pass-through we follow the empirical approach of Cloyne et al. (2023). In particular, we consider the interaction between the response of the lending rate to (instrumented) changes of the policy rate and a categorical variable representing individual bank's characteristic. Hence the specification for the second stage reads as follow.

$$Y_{i,t+h} = \alpha_i + \sum_{g=1}^{G} \beta_g^{(h)} I_{[W_{i,t-1} \in g]} \hat{R}_t + \sum_{g=1}^{G} \alpha_g^{(h)} I_{[W_{i,t-1} \in g]} + \Gamma X_{i,t-1} + \varepsilon_{i,t+h} \tag{5}$$

Where W_t is a set of bank characteristics, and the indicator function takes value 1 if the bank-specific $W_{i,t-1}$ belongs to a certain quantile g of that characteristic. This way the response to the monetary policy shock is interacted with a dummy variable that indicates the position of the bank in the distribution according to some characteristic of choice before the shock. In our analysis we consider the wholesale funding structure as a potential source of heterogeneity in the response of lending rates.[11] This because, for example, if a bank is more indebted on the money market and has less

[11]The main analysis focuses on the reaction of lending rates since the literature suggests that the deposit rates are rather sticky so less reactive to changes in monetary policy (see Drechsler et al., 2017b, Messer and Niepmann, 2023). Importantly, the findings reported in this section are confirmed when we consider the reaction of deposit rate for households. Appendix A4 reports these findings.

stable funding opportunities due to low bond issuance, we expect a higher response of lending rates as the bank is more exposed to variations in the short term interbank rates. Our focus on the wholesale funding structure is supported by recent findings in theoretical literature, see, among others, Drechsler et al. (2017b), Infante and Vardoulakis (2021), Ahnert et al. (2019), and He and Milbradt (2016). We provide a more thoroughly discussion of this choice at the end of this section.

Because funding structure enters the specification through lagged characteristics, contemporaneous adjustments in banks' funding composition in response to the shock do not mechanically drive the estimated heterogeneity. An additional concern is that funding structure may be correlated with country-level factors, such as sovereign risk, banking market structure, or regulatory differences. In our setting, bank fixed effects absorb time-invariant cross-country differences for a given bank, while aggregate controls include euro area sovereign yields, corporate spreads, and systemic stress indicators. Therefore, our estimates should be interpreted as within-sample bank heterogeneity conditional on common macro-financial conditions, not as a full decomposition of country-specific transmission channels.

Next, we proceed by assigning banks to groups according to the quartiles of the distribution of indebtedness in the money market obtained from the IBSI dataset. Figure 6 shows the response of lending rates by banks with low (first quartile) net levels of net credit in the money market, with respect to banks with high (fourth quartile) levels of net credits. Differently from the previous section, the standard errors are clustered at bank level only due to the more constrained information set. The response of indebted banks is higher on impact and persistently higher for some months until they both start converging to zero, indicating a stronger pass-through for banks that have more liabilities tied to money market rates.

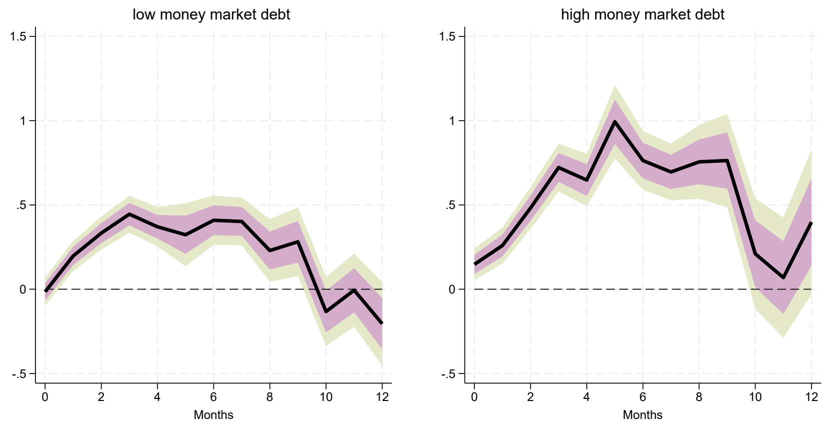

Figure 6: Response of lending rates to a 10 basis points monetary policy shock, interacted with net money market debt as a share of total liabilities. The left (right) column shows the response of banks with a net level of credit in the money market located in the lower 25th quantile (upper 75th quantile) of the cross-bank distribution. The standard errors are clustered at bank level. The shaded areas represent 68% and 90% confidence bands.

Considering the marginal cost of funding, for a bank issuing new loans, we might categorise wholesale funding mainly into very short term liquidity (coming wither from the central bank or from the money market) and longer term, fixed rate, liquidity, which comes from the issuance of bonds. Figure 7 shows the response of lending rates by banks with low (first quartile) bond issuance levels relative to their total liabilities with respect to banks with high bond issuance levels (fourth quartile). The response of banks with less liabilities in the bond market is higher on impact and persistently higher for two years, indicating a stronger pass-through. This shows how bond issuances can insure banks from the rates variations in the money market, and make their lending rates less sensitive as well.

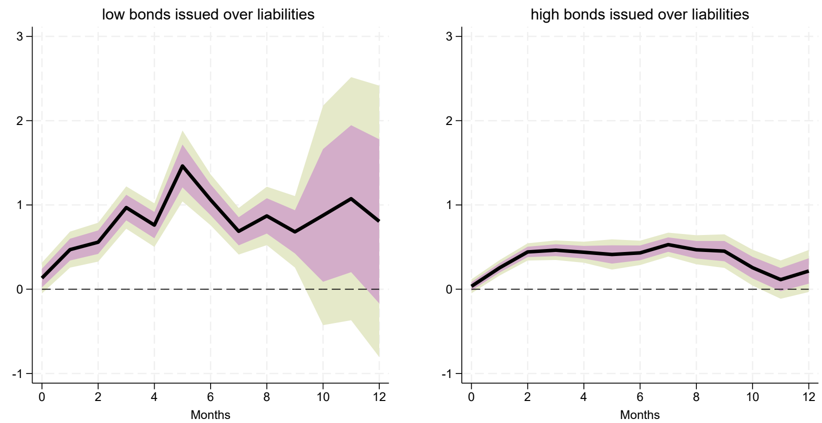

Figure 7: Response of lending rates to a 10 basis points monetary policy shock, interacted with quartiles of bonds issued as a share of total liabilities. The left (right) column shows the response of banks with a bond issuance levels (relative to their total liabilities) located in the lower 25th quantile (upper 75th quantile) of the cross-bank distribution. The standard errors are clustered at bank level. The shaded areas represent 68% and 90% confidence bands.

These findings give evidence indicating that banks that rely more on the money market as a funding source and less on the bond market, tend to transmit changes in the policy rate to rates on new loans more promptly. When considering the determinants of the different funding structures, banks might chose their wholesale funding strategy as part of more comprehensive asset-liability management practices. Therefore, in Section 6 we explore asset-liability-management channel.

Our empirical analysis indicates that wholesale funding structure is a source of heterogeneity for the pass-through and relates to a number of findings documented in the recent theoretical literature. First, wholesale funding is naturally "marginal" and market-priced. In environments where deposit markets feature market power and deposits provide convenience services (Drechsler et al., 2017b), deposit rates adjust imperfectly to policy, so the relevant variation in the marginal cost of funds arises disproportionately through market-priced liabilities and balance sheet adjustments, making wholesale dependence a natural determinant of heterogeneous pass-through. Second, wholesale funding is distinctive because it embeds rollover and run-type fragility: a central theme in the theory is that wholesale markets can tighten abruptly through strategic complementarities and collateral market dynamics, generating a state-contingent shadow cost of funds that differs sharply across banks depending on their reliance on (un)secured short-term wholesale funding (Infante and Vardoulakis, 2021; Schmidt et al., 2016; Ahnert et al., 2019). Third, maturity within wholesale funding is a canonical propagation margin. Debt-maturity theory indicates that short-maturity funding must be rolled over and reprices frequently with short-term rates, while longer-maturity bond funding insulates effective funding costs in the short run and reduces immediate refinancing exposure; this directly rationalizes distinguishing money market wholesale funding from bond funding in empirical work on pass-through (He and Milbradt, 2016; Ahnert et al., 2019).[12] Moreover, evidence of sudden bank-level wholesale funding "dry-ups" provides an empirical counterpart consistent with these mechanisms and reinforces the relevance of wholesale funding structure for heterogeneous transmission (Pérignon et al., 2018). Taken together, these connected arguments imply that wholesale funding composition—and specifically the money market versus bond funding split—is not merely another balance sheet proxy, but a theoretically grounded determinant of cross-sectional differences in the speed and strength of pass-through (Bocola, 2016).

Finally, wholesale funding is a sizable component of the balance sheet of euro area banks, with bonds and money market funding adding up to at least 24.8% and at most 37.5% of total assets of the aggregate euro area banking sector balance sheet between 2003 and 2023.[13] This further supports our analysis indicating that access to different forms of wholesale funding is a primary characteristic of a bank's asset-liability management, and it plays a role in shaping the incentives to issue different assets that transmit policy rate changes differently. In the same period, the sum of household and non-financial corporations deposits ranges from 20.8% to 33.2%. However, given that deposits are rarely the marginal source of funding when issuing new loans, it might be that they play less of a role as a determinant for assets pass-through. In fact, we document evidence supporting this hypothesis in the Appendix A3.

[12] Since bond issuances are a large share of total liabilities, it would be relevant to also explore the maturity dimension within bond issuance as well, though currently the IBSI dataset does not provide this information. Therefore we leave this aspect of the analysis for future work.

[13] Money market credit, in particular, has ranged from 14.1% to 20.8% of total assets. Figure A1 illustrates the evolution of the overall balance sheet of euro area banks through the sample. These figures, extracted from the public BSI database, are in line with other studies in the literature like Vazquez and Federico (2015) who consider a set of European and US banks before the crisis, and Altavilla et al. (2020b) that studies the IMIR banks until 2017.

6 The Asset-Liability-Management Channel

Next, we investigate whether differences in the wholesale funding structure are related to characteristics of the assets side of the balance sheet. In particular, when analysing the bank-level data we notice that banks that rely more on bond issuance tend to issue more fixed rate loans. This pattern is clearly observed in Figure 8 relating the share of bonds with respect to total liabilities as compared with the share of loans to firms with a rate fixation longer than five years over total loans to firms.

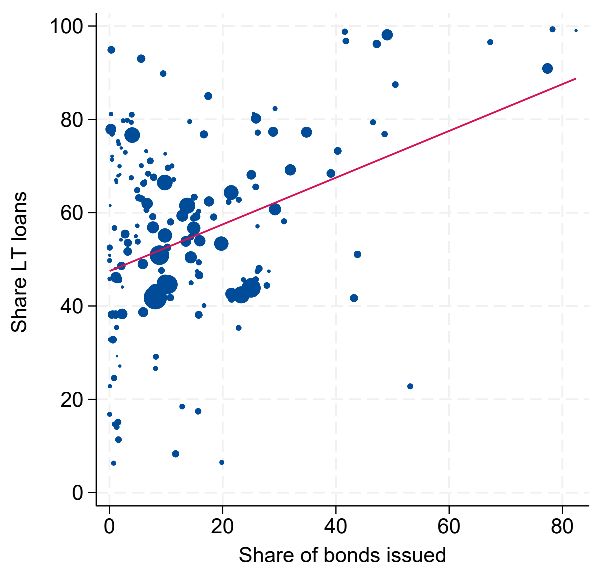

Figure 8: Scatter plot of the mean share of bonds issued (x-axis) and mean share of loans to firms with fixed rate for more than five years (y-axis). Each dot represents a bank, with sizes reflecting the size of the balance sheet in terms of total assets. The red solid line depicts the fitted regression line.

This evidence suggests that banks adjust their wholesale funding structure depending on the demand for fixed or variable loans they face, or that vice versa they tend to issue longer term loans if they have more favourable borrowing conditions in the bond market. This pattern is consistent with the asset-liability-management channel dictating that longer-term, more stable funding insulates marginal funding costs from short-rate shocks; while a larger stock of fixed-rate, long-fixation assets dampens the marginal revenue sensitivity, lowering incentives for optimal on-impact repricing. Moreover, as longer-term assets bring a term premium in their price, it is plausible that they might correlate less with short term money market rates and therefore transmit conventional monetary policy less. Therefore, we next investigate whether this feature of the assets is relevant by using additional dimension from the IMIR dataset, i.e., the banks share of loans with fixed-rate.

Loans rate fixation as bank-specific characteristic. So far we have considered the average lending rate per bank, however the dataset also includes (cross-bank) average rates for three different fixation periods of: up to 1-year, more than 1 year and up to 5 years, and more than 5 years. Therefore all loans with remaining fixation of the interest within a certain bucket (fixation period) are used to compute an average rate for that maturity bucket. Notice that we use maturity and fixation interchangeably in this context as we refer to rates to new loans. Figure 9 shows the response (to a monetary policy shock) of the average (across all the banks) loans rate with different fixation periods obtained via the IV-LP model specification featuring bank fix effects in Equation (4).

Figure 9: Response of lending rates to a monetary policy shock for (cross-bank) average rates per interest rate fixation period. Estimates follow the specification with bank fixed effects, with the dependent variable being a different average rate per each rate-fixation horizon bucket. The shaded areas represent 68% and 90% confidence intervals.

Because pass-through differs by initial rate-fixation horizon, a bank-specific average lending-rate response may depend on its mix of fixed- versus floating-rate originations. In Appendix A5 we show that indeed this is the case as for the euro area banks. We therefore treat the share of fixed-rate loans issued as a time-varying, bank-specific characteristic—capturing persistent demand patterns linked to sectoral or regional specialisation—rather than as a purely contract-level trait. This grouping is less restrictive than assigning banks to fixed categories ex-ante, since incentives to issue fixed-rate loans vary across banks and over time. Moreover, asset characteristics can shape liability management through maturity matching.

Testing the asset-liability-management channel. We then estimate the IV-LP model specification allowing for heterogeneity across banks in Equation (5) by jointly sorting by the bond share on the liability side and the fixed-rate loans share on the asset side. In line with the asset–liability interaction discussed above, Figure 10 shows that banks combining longer-term liabilities (higher bond shares) with longer-fixation lending (higher share of loans with fixed rates for more than five years) display the most muted lending rate response to policy shocks, whereas those with short-term wholesale funding (low bonds) and predominantly short-fixation lending exhibit the strongest pass-through.

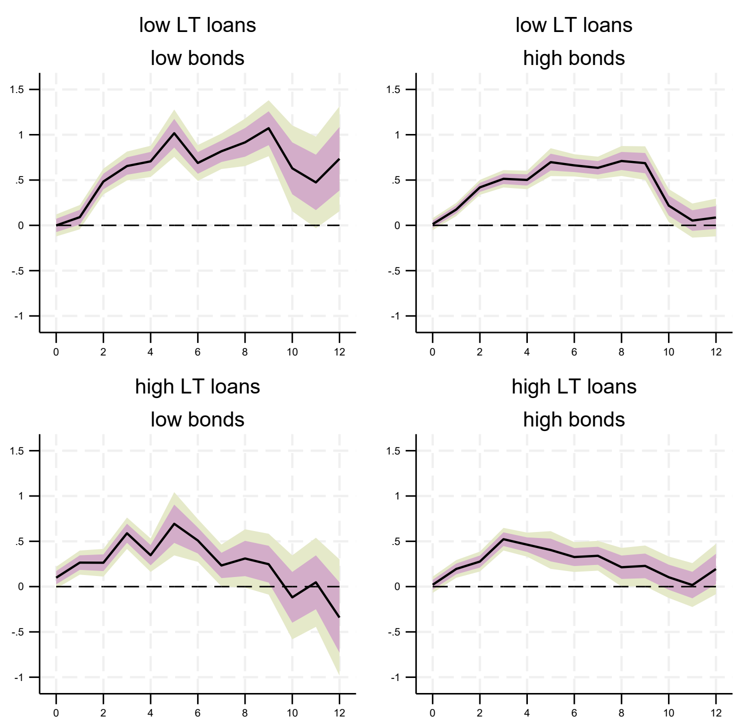

Figure 10: Response of lending rate to a monetary policy shock for multidimensional groups. Groups are defined on whether the share of fixed rate loans (LT loans) issued and the share of bonds issued lie above or below the sample median. The standard errors are clustered at bank level. The shaded areas represent 68% and 90% confidence intervals.

This multidimensional analysis refines the earlier single-dimension results reported in Section 5 and shows that, consistent with the presence of the asset–liability management, funding maturity and asset maturity operate as complementary margins of attenuation, thus reducing both the sensitivity of marginal funding costs and the sensitivity of loan revenues to short-rate movements. These patterns align with euro area evidence on heterogeneous and incomplete monetary policy pass-through—especially the role of funding models and maturity structure in dampening transmission (e.g., Altavilla et al., 2020b; Holton and Rodriguez d'Acri, 2018)—and complement the deposit competition mechanisms emphasized for the U.S. economy by Drechsler et al. (2017a) and Drechsler et al. (2021). In our setting, the interaction of elevated bond financing and long-fixation lending reconciles the relatively quick aggregate pass-through to firm loans with the cross-sectional dispersion at the bank level. Moreover, these findings further motivates the sticky loan/deposit rate block of our NK model where imperfect pass-through attenuates output and inflation responses as shown in Section 4.2.

Importantly, these results are confirmed when considering deposit rates and a battery of robustness checks reported in the Appendix, including alternative cut-offs for fixed-rate lending, a balanced panel, and a specification in which banks are assigned to time-invariant groups based on their average balance sheet characteristics.[14]

7 Conclusions

This paper studies the role of banks' funding structures for defining the interest rate pass-through of monetary policy in the euro area. We do so by estimating IV local projections on a panel of bank-level data including interest rates and balance sheet items volumes. We document three facts. First, at the aggregate level, policy shocks transmit rapidly to loan rates for non-financial corporations, while pass-through to overnight deposit rates is lower and slower. Second, at the bank level, the strength and timing of pass-through vary systematically across banks. In particular, institutions more reliant on money market funding exhibit larger and more persistent responses of both loan and

[14]The latter exercise is particularly informative about the robustness of our identification strategy, as it shows that the main interaction patterns are not driven mechanically by banks switching groups across different monetary policy environments over time. In this sense, the baseline findings do not appear to be an artifact of reclassification during the negative rate, QE, or post-2022 tightening episodes, even though a full regime-specific estimation is an interesting avenue to be explored in future work.

deposit rates, while banks with a higher share of bonds issued—and correspondingly longer maturity assets—adjust more gradually. Third, the asset-side maturity mix helps rationalize these differences, i.e., a larger fraction of long-fixation loans is associated with a more muted adjustment of average lending rates following policy shocks.

We interpret these findings through a small New Keynesian model with sticky rate setting and a cost channel for firms. Calibrated to match the empirical pass-through profiles, the model implies that imperfect pass-through attenuates the effects of monetary policy on output and inflation relative to a benchmark with perfect and immediate transmission through bank rates.

The main implications of our research are twofold. First, transmission heterogeneity in terms of funding structures acts as a structural source of dispersion in interest rate pass-through, beyond cross-country factors. In environments with larger shares of money market funding, policy-induced movements in bank rates propagate more strongly and earlier. Secondly, evaluations of the stance of monetary policy that abstract from bank-rate stickiness risk overstates real and nominal effects. Incorporating empirically disciplined pass-through wedges can align model-based assessments with observed dynamics in the data. Moreover, liability composition and asset maturity jointly shape the effective sensitivity of posted rates.

Our analysis also faces limitations and could lead the way to further research. In particular, we focus on conventional policy surprises only, and hence we abstract from targeted credit measures and balance sheet policies except insofar as they affect funding variables. The heterogeneity is modelled through interactions and grouping, and therefore we do not claim causal effects of funding structure on pass-through beyond the event study variation in policy shocks. Two extensions appear most useful. First, tracing the maturity ladder on both sides of the balance sheet at finer horizons could improve the mapping from empirical estimates to model parameters. Second, allowing for state dependence across regimes (e.g., negative interest rate periods) would add potential non-linearities over time in deposits and reserves remuneration to our linear (time-invariant) framework used here.

Overall, our findings indicate that banks' funding structure are a first-order determinant of the speed and completeness of monetary transmission. Accounting for these factors improves both factual description and policy analysis of the euro area transmission mechanism of monetary policy.

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Appendix of the paper "Banks' Funding Structure and Pass-Through in the Euro Area" by Guido Spanò and Juan Manuel Figueres

A1 Banking System Balance Sheet

Asset	Volume May 2023	Growth from July 2007
Loans to Hh	6,586	3%
Current Accounts Hh	5,276	78%
Loans to Firms	4,997	-10%
Current Accounts Firms	2,369	76%
Term Deposits Hh	1,315	-37%
Term Deposits Firms	645	5%
Short Term Credit to Firms	565	-28%
Short Term Credit to Hh	194	-26%

Table A1: Loans and deposit volumes at euro area commercial banks from the ECB Balance Sheet Items (BSI) database. Volumes in current EUR Billions, growth rates in real terms. Term deposits refer to deposits with agreed maturity, and short term credit is revolving loans and overdrafts, convenience and extended credit card debt.

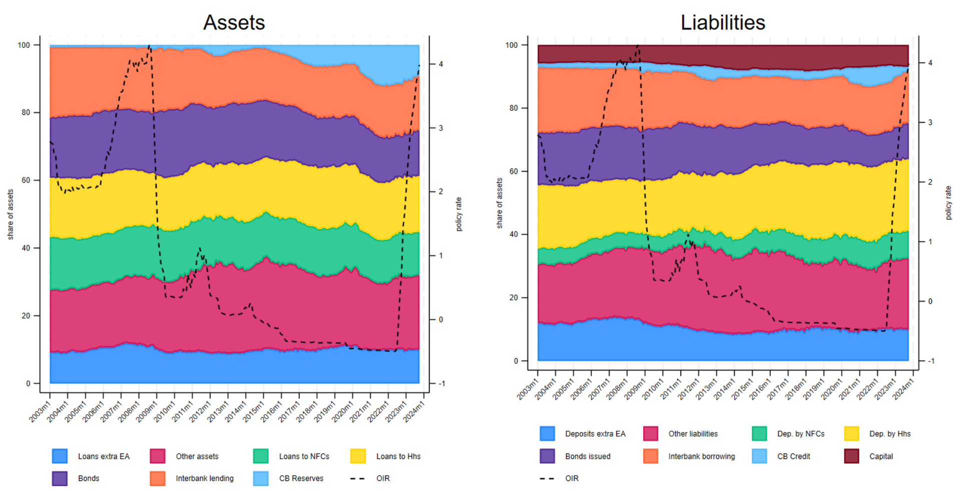

Figure A1: Evolution of the aggregate balance sheet of the euro area banking sector through the sample, based on the BSI database. The share of total assets per category is on the left axis in percentage points, while the overnight interest rate (OIR) is on the right axis.

A2 Interest Rate Pass-through for Different Assets

Figures A2 and A3 document the aggregate interest pass-through for all the assets available in the MIR database including rates on loans to firms, loans to households, firms current accounts, households current accounts, firms term deposits, households term deposits, firms short-term deposits, and households short-term deposits.

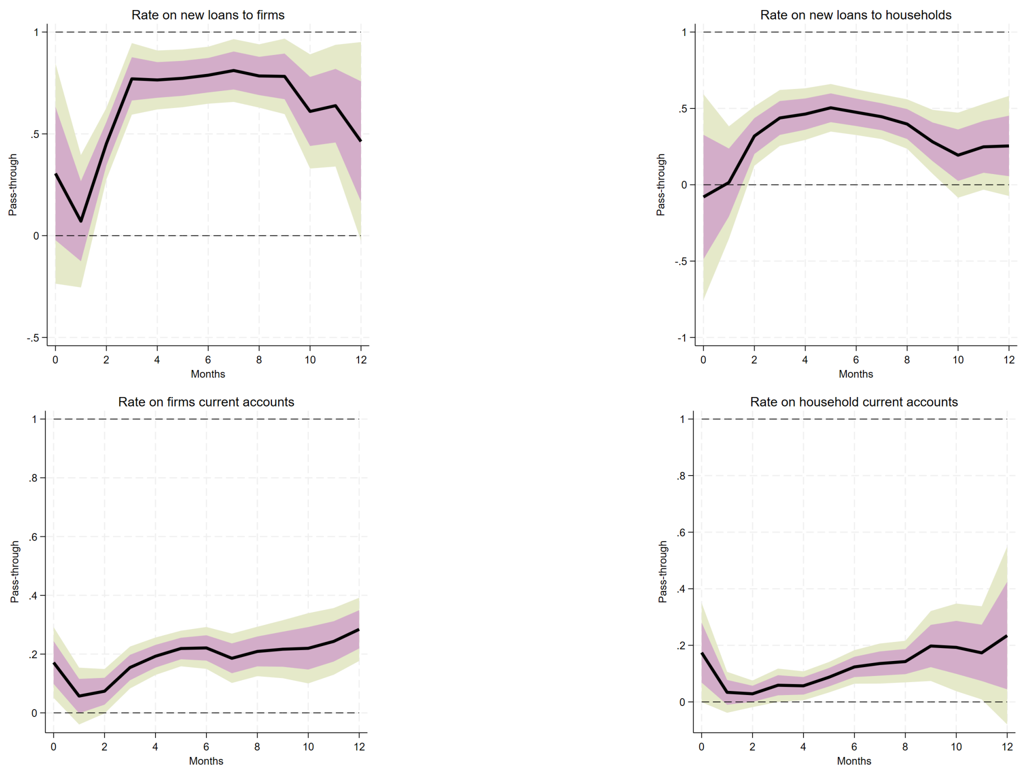

Figure A2: Interest rate pass-through for different assets with interest rates available in the MIR database. Estimates are obtained with the aggregate data with series for the volume-weighted average rates. The shaded areas represent 68% and 90% confidence bands.

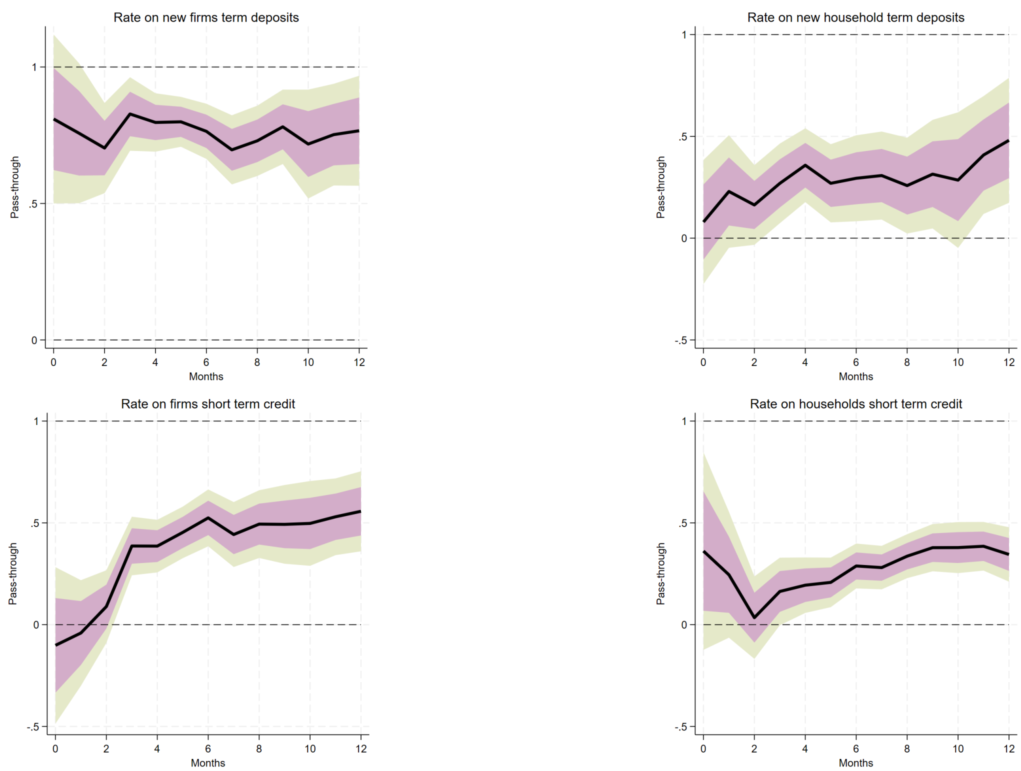

Figure A3: Interest rate pass-through for different assets with interest rates available in the MIR database. Estimates are obtained with the aggregate data with series for the volume-weighted average rates. The shaded areas represent 68% and 90% confidence bands.

A3 Pass-through Conditional on Deposits

Figures A4, A5, and A6 suggest that, while deposit reliance is not irrelevant for the transmission of policy shocks, it is not the main margin through which cross-sectional differences in lending rate pass-through arise in our sample.

When interacting the response of lending rates with the share of deposits in the balance sheet, banks with a higher share of deposits seem to display a slightly stronger response at some horizons, as shown in Figure A4. Even though the volume of deposits might affect the response of the lending rate when taken unconditionally, this effect fades when including other sources of funding in the exercise. In particular, Figure A5 shows the responses of the lending rate for groups of banks with different levels of deposit shares conditional on being above or below median in terms of bonds share. Conditional on the wholesale funding characteristic, grouping according to deposits almost does not alter the responses.

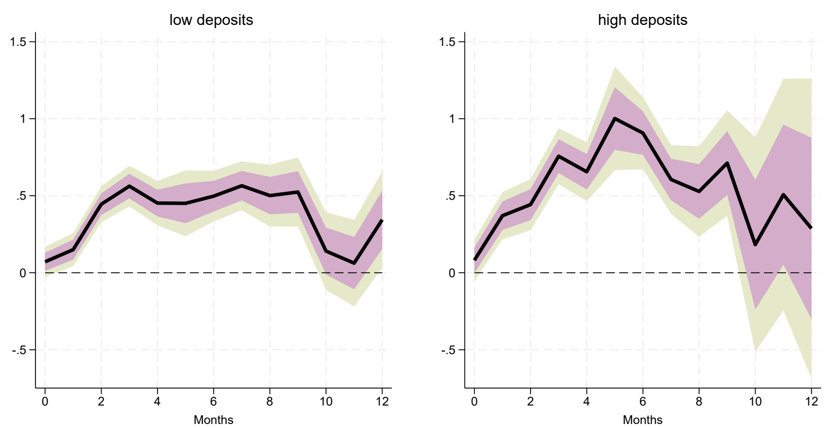

Figure A4: Response of lending rates to a 10 basis points monetary policy shock, interacted with quartiles of household and non financial corporations deposits as a share of total liabilities. The left (right) column shows the response of banks with a deposit level (relative to their total liabilities) located in the lower 25th quantile (upper 75th quantile) of the cross-bank distribution. The shaded areas represent 68% and 90% confidence bands.

Once banks are jointly sorted by deposit shares and bond issuance, the dominant source of heterogeneity is clearly the bond funding dimension: within both the low-deposit and high-deposit groups, banks with low bond funding exhibit a materially stronger and more persistent pass-through than banks with elevated bond funding; differently, for a given level of bond issuance, the additional grouping defined by deposit shares delivers rather muted differences in responses. Figure A6 confirms these results by jointly considering the deposit share and the share money market debt (instead of bond issuance).

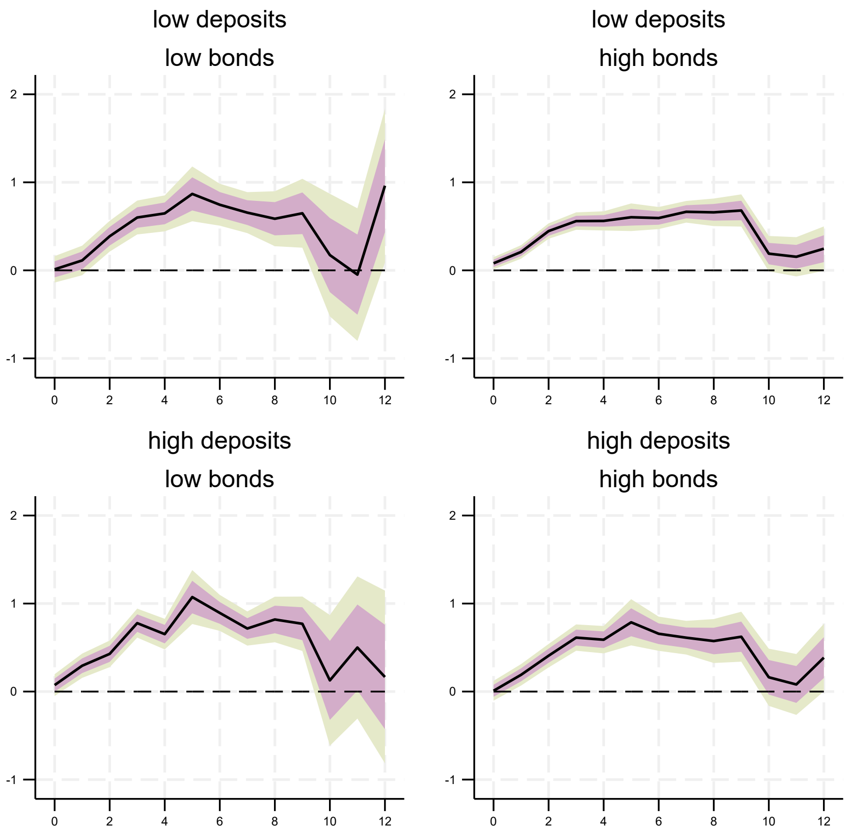

Figure A5: Response of lending rate to a monetary policy shock for multidimensional groups. Groups are defined on whether the share of deposits and the share of bonds issued lie above or below the median. The shaded areas represent 68% and 90% confidence intervals.

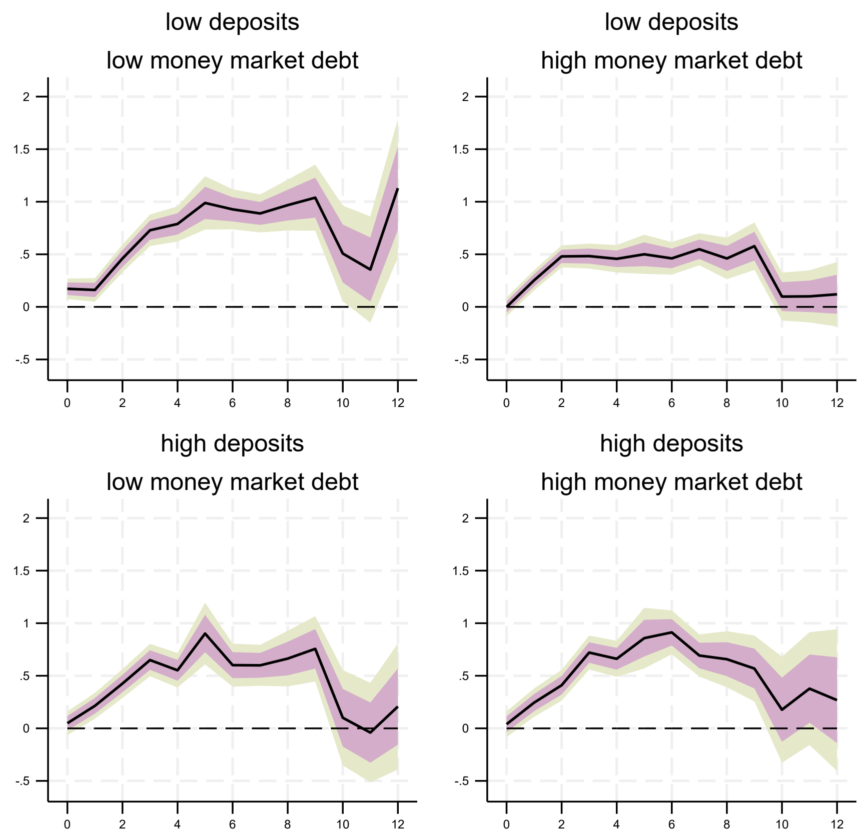

Figure A6: Response of lending rate to a monetary policy shock for multidimensional groups. Groups are defined on whether the share of deposits and the share of money market debt lie above or below the median. The shaded areas represent 68% and 90% confidence intervals.

We conclude that, conditional on wholesale funding composition, deposit reliance has a marginal explanatory power for the response of lending rates. This pattern suggests that the relevant marginal cost channel operates primarily through wholesale funding, in particular through the distinction between funding structures that rely relatively more on liabilities repriced at short horizons and those that are more insulated by longer-term bond funding. Such an interpretation is in line with the literature emphasising that market-priced wholesale liabilities are the natural margin through which policy shocks affect banks' marginal funding costs, whereas deposits are partly shielded by market power, convenience services, and sluggish repricing (Drechsler et al., 2017a, 2021). This finding is also consistent with theories of debt maturity and rollover risk, according to which longer-term bond funding reduces immediate exposure to short rate fluctuations, thereby muting the incentive to reprice lending rates on impact (He and Milbradt, 2016; Ahnert et al., 2019). Overall, this evidence reinforces the main message of our study, i.e., although deposits might matter for balance sheet structure, the wholesale funding margin—and especially the availability of bond funding—appears to be the most important determinant of heterogeneity in lending rate pass-through across euro area banks.

A4 Deposit Pass-Through and Wholesale Funding Structure

Similarly to lending rates, the pass-through to deposit rates for households is also affected by the composition of banks' funding structure. Figures A7 and A8 show that banks with different funding structures adjust deposit rates differently following a monetary policy shock.

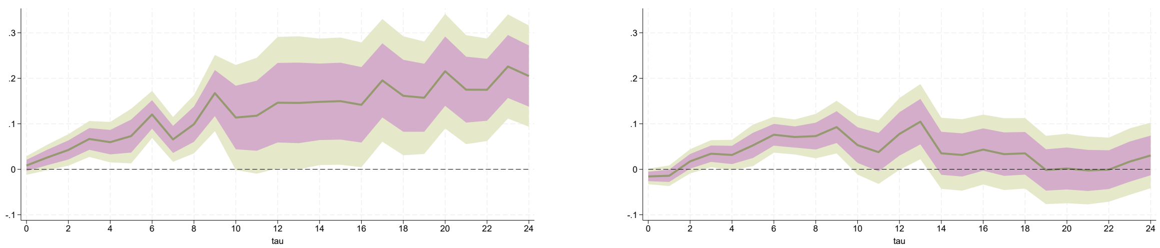

Figure A7: Response of deposit rates for households to a 10 basis points monetary policy shock, interacted with net money market debt as a share of total liabilities. The left (right) column shows the response of banks with a net level of credit in the money market located in the lower 25th quantile (upper 75th quantile) of the cross-bank distribution. The shaded areas represent 68% and 90% confidence bands.

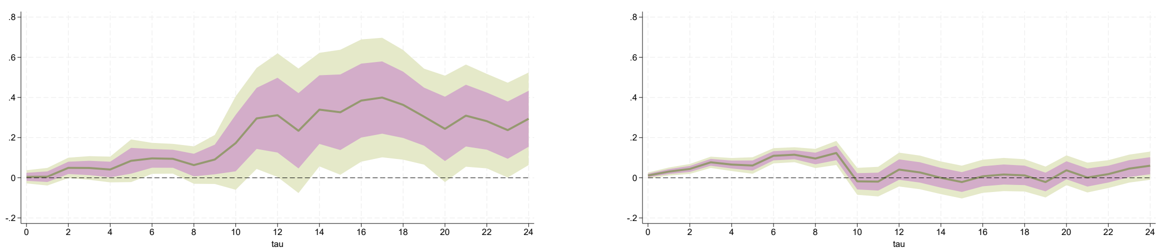

Figure A8: Response of deposit rates for households to a 10 basis points monetary policy shock, interacted with quartiles of bonds issued as a share of total liabilities. The left (right) column shows the response of banks with a bond issuance levels (relative to their total liabilities) located in the lower 25th quantile (upper 75th quantile) of the cross-bank distribution. The shaded areas represent 68% and 90% confidence bands.

A5 Bank Groups by Loans Fixation

Even though the maturity is a characteristic of the asset, each bank might face different elasticities of demand for different type of loans. Or alternatively, some ease of access to longer term funding might incentivise the bank to provide fixed loans. Therefore the share of fixed-rate loans could also be considered as a characteristic of the bank. Following this perspective we estimate the IV-LP specification in Section 5.2 with groups based on the issuance of fixed loans, as shown in Figure A9 and A10. Theses findings indicate that the pass-through differs by initial rate-fixation horizon, therefore a bank-specific average lending rate response depends on its mix of fixed- versus floating-rate origination.

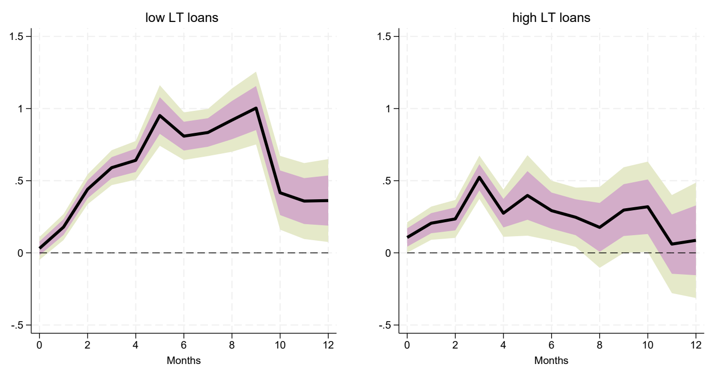

Figure A9: Response of lending rates to a 10 basis points monetary policy shock, interacted with quartiles of the share of loans with interest rate fixed for more than five years. The shaded areas represent 68% and 90% confidence bands.

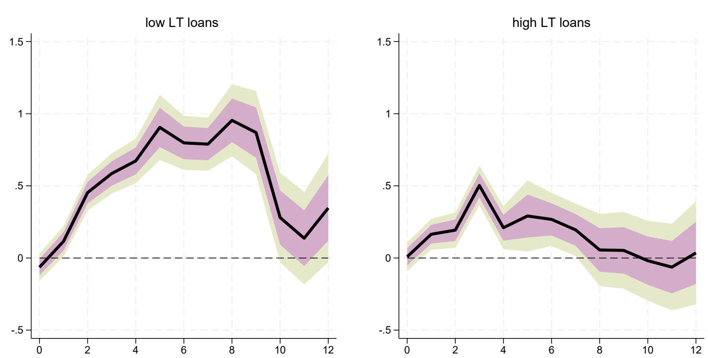

Figure A10: Response of lending rates to a 10 basis points monetary policy shock, interacted with quartiles of the share of loans with interest rate fixed for more than one year. The shaded areas represent 68% and 90% confidence bands.

A6 Balanced Panel

Since a high number of mergers has taken place across of our 2022-2023 sample, we consider whether the main relationships we estimate hold also in a balanced panel. Figure A11 confirms the interaction on both the assets and liabilities side as in the main results for the balanced panel of 103 banks that are always present over the sample.

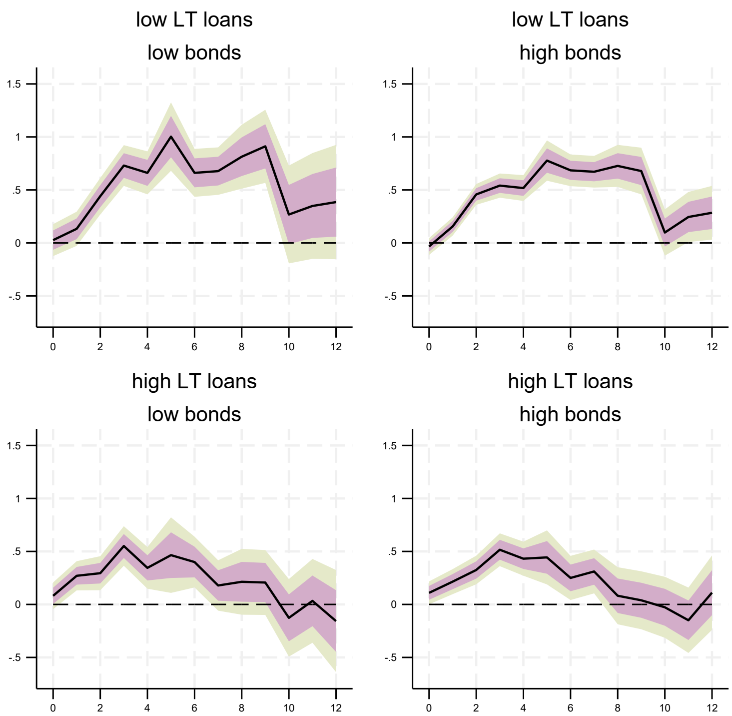

Figure A11: Balanced panel. Response of lending rate to a monetary policy shock for multidimensional groups. Groups are defined on whether the share of fixed rate loans (LT loans) issued and the share of bonds issued lie above or below the median. The shaded areas represent 68% and 90% confidence intervals.

A7 Fixing Groups

Figure A12 shows the same interaction as in the IV-LP model of Section 5.2, but with groups based on averages of the characteristics for each bank. This way, banks don't change group through the sample, and the result can be considered as depending on some banks characteristics rather than some systematic changes in market condition or business models through the time series. Actually, if results were dependent by the fact that in some years fixed loans or bond issuances were predominant, then results wouldn't hold once fixing groups per bank. Figure A12 shows that the banks that on average have issued more variable rate loans and haven't used bond issuances (top-left panel), those are the banks that transmit most of the policy change to average lending rates. Vice-versa for longer-term oriented banks in the bottom-right panel. These results confirm the robustness of our baseline findings.

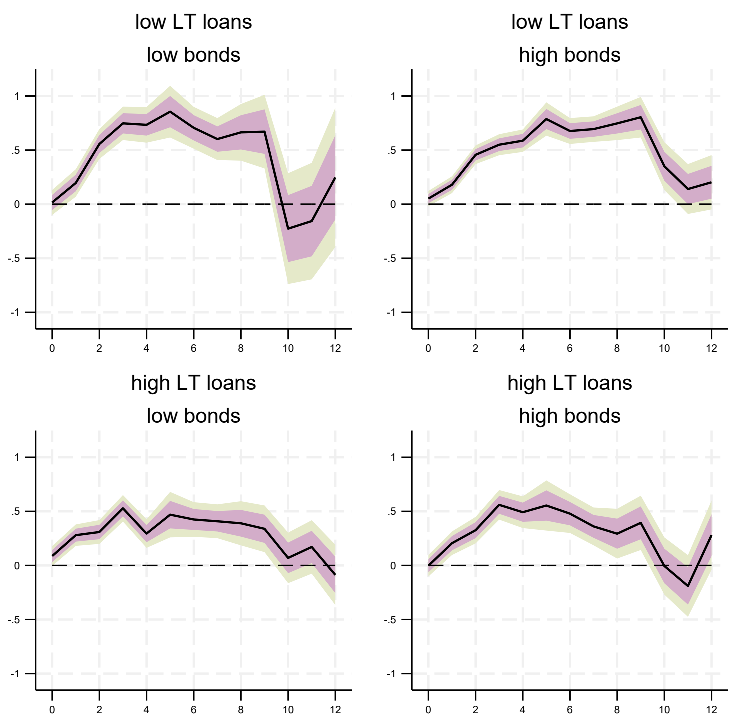

Figure A12: Long term assets vs. liabilities above and below the median. Response of lending rates to a 10 basis points monetary policy shock. The shaded areas represent 68% and 90% confidence bands.

A8 Model Calibration

Table A2 shows the estimated parameters, corresponding to the impulse response matching exercise in section 4.2. The estimates largely follows standard New Keynesian practice for preferences and policy, while leading to strong nominal rigidities in goods and bank rates to replicate the empirically observed interest rate pass-through dynamics. The discount factor is set to $\beta = 0.990$, which is high for a literal monthly model but is commonly used in empirical NK applications when the focus is on matching medium-run dynamics rather than pinning down pure time preference; in this context, β mainly affects the slope and persistence of the IS relation and helps reproduce the observed gradual adjustment of real activity. Risk aversion $\sigma = 2.5$ lies within the conventional macroeconomic range (typically between 1 and 3), while the inverse Frisch elasticity $\eta = 1.23$ (Frisch elasticity of about 0.8) is also standard in medium-scale NK models and ensures a realistic labor supply response at the monthly horizon. Nominal rigidities are central to the GMM fit: the Calvo parameter for goods prices, $\omega = 0.978$, implies very persistent price adjustment at monthly frequency and a correspondingly flat Phillips curve, consistent with the muted and delayed inflation responses estimated in the data. Deposit rate stickiness is even stronger, with $\omega^D = 0.981$, capturing the empirically documented sluggish and incomplete pass-through from policy rates to retail deposits. By contrast, lending rate stickiness is much lower, $\omega^L = 0.321$, allowing lending rates to react quickly to monetary shocks, in line with the estimated impulse responses for loan rates. Monetary policy parameters are broadly consistent with inertial Taylor rules estimated at high frequency: interest rate smoothing $\rho_I = 0.900$ implies substantial persistence in the policy rate, the inflation coefficient $\delta_\pi = 1.313$ satisfies the Taylor principle, and the output-gap coefficient $\delta_x = 0.990$ reflects a non-negligible stabilization motive once variables are measured at monthly frequency. The persistence of the monetary policy shock, $\rho_v = 0.923$, is high but typical in GMM-based IRF matching exercises, while the innovation variance $\sigma_v = 0.023$ mainly reflects the normalization required to fit the magnitude of the empirical responses. Finally, the loan contract parameters—the average maturity of fixed-rate loans $\tau = 37.2$ months and the fixed-rate share $\gamma = 0.477$—are economically plausible for the euro area and are key to matching the hump-shaped and gradual adjustment of lending rates observed in the data.

	Description	Estimate
β	Subjective discount factor	0.990
σ	Risk aversion	2.500
η	Inverse Frisch elasticity	1.230
ω	Price stickiness	0.978
ω^D	Deposit rate stikiness	0.981
ρ^I	Persistence of monetary policy	0.900
δ_π	Taylor rule response to π_t	1.313
δ_x	Taylor rule response to x_t	0.990
σ^v	Variance of monetary policy shock	0.023
ρ^v	Persistence of m.p. shock	0.923
τ	Avg. maturity of fixed rate loans (months)	37.224
ω^L	Lending rate stikiness	0.321
γ	Share of fixed rate loans	0.477

Table A2: Estimated model parameters with GMM to match the VAR impulse responses presented in Section 4.2.

Running the simulation for a monetary policy shock, it becomes evident that using a model with only variable rate loans with respect to a model with floating loans does not significantly affect the real responses. Figure A13 shows that the main difference is observed in prices. This is due to the fact that only firms have access to loans in this model, therefore the additional feature of a term structure is reflected directly only through the Phillips Curve, and not via the Euler Equation. The coefficient k for the Phillips Curve tends to be very small, as in fact the intertemporal motive tends to drive most of the response in representative agent NK models.

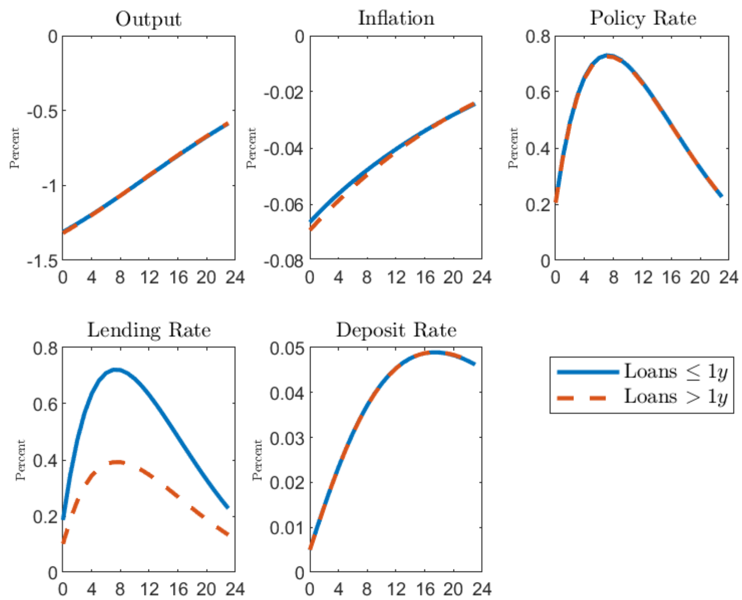

Figure A13: Simulation with only short term loans and a model with only long term loans (cut-off one year). The reactions of the lending rates are different, but the response of output does not seem to change, and only the path of inflation is affected due to the fact that lending rates appear only in the Phillips Curve.

Even though differences in the real effect is small in this setup, this extension opens the door to the modelling of mortgages with fixed rates, for which rates on new mortgages adjust with stickiness to match the estimated pass-through. As mortgage repayment impact the households' budget constraint (and potentially housing preferences affect the optimality conditions as well), having sticky mortgage rates in a model of this type could generate a sizeable wedge in the transmission of monetary policy to output and inflation.