Monetary Policy, Bank Heterogeneity and the Marginal Propensity to Lend

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Abstract

There is substantial heterogeneity in the response of banks to monetary policy. In a model with heterogeneous banks, I show that banks with more deposit market power are more exposed to monetary policy and can have either a lower or a higher marginal propensity to lend (MPL), defined as the increase in lending after a transitory increase in deposits. I provide evidence that banks with more market power experience a larger decline in deposits after an increase in the policy rate and have a lower MPL, which leads to *dampening* of monetary policy.

1 Introduction

A large literature documents substantial heterogeneity in the response of bank lending to monetary policy. Several papers such as Kashyap and Stein (1995, 2000) and Kishan and Opiela (2000) find that smaller banks, with relatively low capital and less liquid balance sheets are more responsive to monetary policy. More recently, Dreschler et al (2018) find that banks that raise deposits in more concentrated local markets reduce lending by more after a monetary tightening. However, there is not much evidence on the aggregate implications of bank heterogeneity. This paper studies the role of bank heterogeneity in the monetary transmission. It presents a model and provides evidence that support a *dampening* of monetary policy due to bank heterogeneity in deposit market power.

The main contribution of this paper is to provide empirical estimates of the aggregate implications of bank heterogeneity in the monetary transmission mechanism and a theoretical model to explain the main results. Specifically, this paper studies the role of heterogeneity in deposit market power to explain the heterogeneous responses of deposits to monetary policy at the bank-level and its implications for the responses of bank lending at the aggregate level. This work complements the literature on banking and monetary policy by showing that bank heterogeneity in deposit market power leads to *dampening* in the response of bank lending to monetary policy through the deposits channel.

Empirically, I use the sensitivity of the deposit spread, defined as the difference between the policy rate and the nominal interest rate on deposits, to the policy rate as an indicator of deposit market power. Banks with more market increase their deposit deposit spreads relatively more after an increase in the policy rate. I find that banks with a higher sensitivity of their deposit spread experience a larger decline in deposits after an increase in the policy rate and have a lower marginal propensity to lend, defined as the increase in lending after a transitory increase in deposits. Then, banks that experience a larger decline in deposits are the ones who contract lending relatively *less* after an increase in the policy rate. These facts imply that bank heterogeneity in deposit market power *dampens* monetary policy.

I develop a three period model with heterogeneous banks. In this model, banks have two assets, bonds and loans, and one liability, deposits. Banks face a bank-specific demand for deposits and set a deposit spread that is decreasing in the elasticity of deposits but increasing in the policy rate. Banks with a lower elasticity of deposits find optimal to set a relatively lower deposit rate (higher deposit spread) and increase the interest rate on deposit by *less* after an increase in the policy rate. Banks supply loans in a competitive market, they decide how much to lend at $t = 0$, and only a fraction $0 < \delta < 1$ of loans matures after one period, which implies that an increase in the policy rate at $t = 1$ lowers the consumption of bankers in $t = 1$ because they are unable to reoptimize a fraction of their balance sheet. However, banks have deposit market power, which implies that their deposit spreads are increasing in the policy rate. Then, an increase in the policy rate in $t = 1$ increases consumption in $t = 1$ due to profits from deposits. If δ is sufficiently low, consumption in $t = 1$ will decline after an increase in the policy rate in $t = 1$. Hence, more lending implies a lower consumption in $t = 1$, while more market power implies a higher consumption in $t = 1$ after an increase in the policy rate in that period.

If there is a transitory increase in deposits, i.e. an increase in deposits only at $t = 0$, banks will experience higher profits from deposits and therefore higher consumption in the future $t = 1$. A higher consumption lowers the marginal utility of consumption, which makes banks more tolerant to interest rate risk.

Hence, banks find optimal to increase lending to increase their exposure to interest rate risk. The marginal propensity to lend (MPL) changes with deposit market power through three channels: more market power increases MPL through two channels but reduces it through the other channel. In the *first channel*, the increase in future consumption due to higher deposits today would be larger for banks with more market power, which leads to a bigger decline in the marginal utility of consumption and makes banks more tolerant to interest rate risk. This leads to a bigger increase in lending. In the *second channel*, banks with more market power have a *higher* sensitivity of future consumption c_1 to changes in the future interest rate i_1, which implies a higher sensitivity of the marginal utility of consumption to changes in the policy rate. Then, a given increase in deposits has a small effect on making banks more tolerant to interest rate risk, which implies a *lower* increase in lending for banks with more market power. In the *third channel*, banks with more deposit market power enjoy relatively higher consumption. Then, a unit increase in lending is relatively less costly for banks with more market power, i.e. the added risk due to an increase in lending is lower given that consumption is relatively higher. Hence, banks with more deposit market power would increase lending relatively more after a transitory increase in deposits.

Outline. Section 2 presents a general framework to study bank heterogeneity and monetary policy. Section 3 presents the main empirical results. Section 4 presents robustness checks and estimates for the role of bank heterogeneity in the monetary transmission. Section 5 presents a simple model with long-term lending and deposit market power. Section 6 presents some alternative models and Section 7 concludes.

2 Bank Heterogeneity: A general framework

In this section, I provide a general framework to study the aggregate implications of bank heterogeneity in the response of bank lending to monetary policy through the deposits channel.

2.1 Marginal Propensity to Lend

Assume banks have an optimal lending policy given by:

$$l_{jt} = f_j(d_{jt}, i_t, \omega^l_{jt}, \mathbb{E}_t d_{t+\tau}, \mathbb{E}_t i_{t+\tau}) \tag{1}$$

where d_{jt} is the amount of deposits from bank j in period t, i_t is the nominal policy rate, and l_{jt} is the stock of loans from bank j in period t, ω^l_{jt} are bank-characteristics, $\mathbb{E}_t d_{t+\tau}$ and $\mathbb{E}_t i_{t+\tau}$ are the expected future path of deposits and interest rate with $\tau > 0$, and the function f_j is bank-specific.

A **transitory** increase in deposit funding is an increase in d_t keeping *constant* the expected future path of deposits $\mathbb{E}_t d_{t+\tau}$.

Definition: Marginal Propensity to Lend (MPL) is defined as the increase in lending after a *transitory* increase in deposits.

$$MPL_j = \frac{\partial l_{jt}}{\partial d_{jt}} = \frac{\partial f_j}{\partial d_{jt}} \tag{2}$$

If there is an increase in the policy rate today i_t, keeping constant $\mathbb{E}_t i_{t+\tau}$ for all $\tau > 0$, the *total* effect of monetary policy on lending l_{jt} is given by:

$$\frac{\mathrm{d}l_{jt}}{\mathrm{d}i_t} = \underbrace{\frac{\partial f_j}{\partial d_{jt}}}_{MPL_j} \frac{\mathrm{d}d_{jt}}{\mathrm{d}i_t} + \frac{\partial f_j}{\partial i_{jt}} \tag{3}$$

In percentage terms, we have

$$\frac{\mathrm{d}l_{jt}}{\mathrm{d}i_t}\frac{1}{l_{jt}} = \underbrace{\frac{\partial f_j}{\partial d_{jt}}\frac{d_{jt}}{l_{jt}}}_{\lambda_j^d} \underbrace{\frac{\mathrm{d}d_{jt}}{\mathrm{d}i_t}\frac{1}{d_{jt}}}_{\text{Exposure of deposits}} + \underbrace{\frac{\partial f_j}{\partial i_{jt}}\frac{1}{f_j}}_{\lambda_j^i} \tag{4}$$

where λ_j^d is the elasticity of loans with respect to deposits and λ_j^i is the semi-elasticity of loans with respect to the policy rate for bank j.

Then, we define aggregate lending L_t and deposits D_t as follows:

$$L_t = \sum_j l_{jt} \quad D_t = \sum_j d_{jt} \tag{5}$$

Then the total change in *aggregate* lending and deposits after an increase in the policy rate i_t is given by:

$$\frac{\mathrm{d}L_t}{\mathrm{d}i_t}\frac{1}{L_t} = \sum_j \frac{\mathrm{d}l_{jt}}{\mathrm{d}i_t}\frac{1}{l_{jt}} \underbrace{\frac{l_{jt}}{L_t}}_{\text{relative size}} \quad \text{and} \quad \frac{\mathrm{d}D_t}{\mathrm{d}i_t}\frac{1}{D_t} = \sum_j \frac{\mathrm{d}d_{jt}}{\mathrm{d}i_t}\frac{1}{d_{jt}} \underbrace{\frac{d_{jt}}{D_t}}_{\text{relative size}} \tag{6}$$

Then, we can find the response of aggregate lending to the policy rate.

$$\frac{\mathrm{d}L_t}{\mathrm{d}i_t} = \left[\underbrace{\sum_j \frac{\partial f_j}{\partial d_{jt}} \frac{d_{jt}}{D_t}}_{\text{Aggregate MPL}} + \underbrace{\sum_j \underbrace{\frac{\partial f_j}{\partial d_{jt}}}_{MPL_j} \left(\frac{\frac{\mathrm{d}d_{jt}}{\mathrm{d}i_t}}{\frac{\mathrm{d}D_t}{\mathrm{d}i_t}} - \frac{d_{jt}}{D_t} \right)}_{\text{Covariance: MPL and Exposure of deposits}} \right] \frac{\mathrm{d}D_t}{\mathrm{d}i_t} + \sum_j \frac{\partial f_j}{\partial i_{jt}} \tag{7}$$

An increase in the policy rate lowers deposits and the decline in deposits lowers bank lending through two channels. First, bank lending decreases due to an aggregate marginal propensity to lend. Second, bank heterogeneity can either amplify or dampen the response of loans to changes in the policy rate. If the covariance term in equation (7) is positive, then bank heterogeneity amplifies monetary policy because banks with a higher MPL are those with a higher exposure of deposits, i.e. $|\frac{\mathrm{d}d_j}{d_j}| > |\frac{\mathrm{d}D}{D}|$. Similarly, there is dampening of monetary policy if those banks with a higher MPL have a lower exposure of deposits, which implies a negative covariance term.

Bank heterogeneity is relevant for the aggregate response of loans to monetary policy only if the covariance term in equation (7) is different from zero. If the exposure of deposits to monetary policy is the same for all banks, i.e. we have $\frac{\mathrm{d}d_j}{d_j} = \frac{\mathrm{d}D}{D}$, the covariance term is zero. In this case, MPL heterogeneity is not relevant for the aggregate response of loans. Similarly if MPL_j is the same for all banks, then the covariance term is zero and heterogeneity in the exposure of deposits to monetary policy has no effect on aggregate lending.

In percentage terms, the response of aggregate bank lending to changes in the policy rate can be expressed as follows:

$$\frac{\mathrm{d}L_t}{\mathrm{d}i_t}\frac{1}{L_t} = \left[\lambda^d + \sum_j MPL_j \frac{D_t}{L_t}\left(\frac{\frac{\mathrm{d}d_{jt}}{\mathrm{d}i_t}}{\frac{\mathrm{d}D_t}{\mathrm{d}i_t}} - \frac{d_{jt}}{D_t}\right)\right]\frac{\mathrm{d}D_t}{\mathrm{d}i_t}\frac{1}{D_t} + \sum_j \lambda_j^i \frac{l_{jt}}{L_t} \tag{8}$$

where λ^d is the aggregate elasticity of loans with respect to deposits and λ^i is the aggregate semi-elasticity of loans with respect to the policy rate.

$$\lambda^d = \sum_j \lambda_j^d \frac{l_{jt}}{L_t} \quad \text{and} \quad \lambda^i = \sum_j \lambda_j^i \frac{l_{jt}}{L_t} \tag{9}$$

2.2 Deposits

Assume banks want to maximize profits from deposits $d_j(i_j^d, i)$, where i_j^d is the nominal interest rate on deposits and i is the policy rate. Then, banks' problem is the following:

$$\max_{i_j^d} \quad (i - i_j^d) d_j(i_j^d, i) \tag{10}$$

First order condition is given by:

$$(i - i_j^d)\frac{\partial d_j}{\partial i_j^d} - d_j = 0 \tag{11}$$

Then if we define $\varepsilon_j^d = \frac{\partial d_j}{\partial i_j^d}\frac{i_j^d}{d_j} > 0$, we have the following condition:

$$\frac{i - i_j^d}{i_j^d}\varepsilon_j^d = 1 \tag{12}$$

Then the optimal deposit spread is given by:

$$i - i_j^d = \frac{1}{1 + \varepsilon_j^d} i \tag{13}$$

Then, a lower elasticity ε_j^d increases the deposit spread. Moreover, if we assume that ε_j^d is independent of i_j^d, the indirect effect of the policy rate i through the deposit rate on deposits, which is a measure of the exposure of deposits to monetary policy, is given by:

$$\left(\frac{\partial d_j}{\partial i_j^d}\frac{\partial i_j^d}{\partial i}\right)\frac{i}{d_j} = \frac{\partial d_j}{\partial i_j^d}\frac{i_j^d}{d_j}\frac{\partial i_j^d}{\partial i}\frac{i}{i_j^d} = \varepsilon_j^d\left(1 + \frac{1}{1+\varepsilon_j^d}\frac{\partial \varepsilon_j^d}{\partial i}\frac{i}{\varepsilon_j^d}\right) \tag{14}$$

If the elasticity of deposits is independent of the policy rate, i.e. $\frac{\partial \varepsilon_j^d}{\partial i} = 0$, then an increase in the policy rate *increases* deposits and this increment is larger for banks with a higher elasticity of deposits ε_j^d .

$$\left(\frac{\partial d_j}{\partial i_j^d}\frac{\partial i_j^d}{\partial i}\right)\frac{i}{d_j} = \varepsilon_j^d \tag{15}$$

Since an increase in the policy rate leads to a decline in deposits in the data, the *total* response of deposits to an increase in the policy rate i can be express as follows:

$$\frac{\mathrm{d}d_j}{\mathrm{d}i}\frac{i}{d_j} = \underbrace{\left(\frac{\partial d_j}{\partial i_j^d}\frac{\partial i_j^d}{\partial i}\right)\frac{i}{d_j}}_{\text{micro exposure}} + \underbrace{\frac{\partial d_j}{\partial i}\frac{i}{d_j}}_{\text{macro exposure}} = \underbrace{\varepsilon_j^d}_{\text{micro exposure}} - \underbrace{\theta_j}_{\text{macro exposure}} \tag{16}$$

where $\theta_j > 0$, then from equation (16), banks with more market power (a lower ε_j^d) are more exposed to monetary policy, i.e. the decline in deposits after an increase in the policy rate i is bigger, if θ_j is independent of ε_j^d or $1 > \frac{\partial \theta_j}{\partial \varepsilon_j^d}$.

The aggregate response of deposits D is given by:

$$\frac{\mathrm{d}D}{\mathrm{d}i}\frac{i}{D} = \varepsilon^d - \theta < 0 \tag{17}$$

where $\varepsilon^d = \sum_j \varepsilon_j^d \frac{d_j}{D}$ and $\theta = \sum_j \theta_j \frac{d_j}{D}$. An increase in the policy rate reduces bank deposits if and only if $\theta > \varepsilon^d$. This implies that some banks might experience an *increase* in deposits after a contractionary policy if and only if the elasticity of deposits is sufficiently high, i.e. $\theta_j < \varepsilon_j^d$.

2.3 Implications

The aggregate response of loans to an increase in the policy rate i_t is given by:

$$\frac{\mathrm{d}L_t}{\mathrm{d}i_t}\frac{1}{L_t} = \left[\underbrace{\lambda^d}_{>0} + \underbrace{\sum_j MPL_j \frac{D_t}{L_t}\left(\frac{\varepsilon_j^d - \theta_j}{\varepsilon^d - \theta} - 1\right)\frac{d_{jt}}{D_t}}_{\text{Amplification: } >0}\right]\frac{\varepsilon^d - \theta}{i} + \sum_j \lambda_j^i \frac{l_{jt}}{L_t} \tag{18}$$

The role of bank heterogeneity is captured by this covariance:

$$\sum_j MPL_j \frac{D_t}{L_t}\left(\frac{\varepsilon_j^d - \theta_j}{\varepsilon^d - \theta} - 1\right)\frac{d_{jt}}{D_t} \tag{19}$$

Given that an increase in the policy rate reduces bank deposits, i.e. $\theta > \varepsilon^d$, we have the following result: If banks with a high MPL_j have a relatively high elasticity of deposits ε_j^d, then monetary policy is dampened by bank heterogeneity. This dampening requires that banks with *less* deposit market power have a *higher* MPL, given that $1 > \frac{\partial \theta_j}{\partial \varepsilon_j^d}$.

3 Empirical Results

In this section, I estimate the role of bank heterogeneity in the response of loans to changes in the policy rate. To compute the marginal propensity to lend, I follow a procedure similar to Blundell, Pistaferri, and Preston (2008), and Auclert (2019). First, regress the log of loans and the log of deposits on predetermined bank characteristics. Then, compute the residuals of these regressions and call them $\tilde{l}_{jt}$ and $\tilde{d}_{jt}$, respectively. Finally, group banks into k bins according to their deposit market power and estimate MPL within each bin:

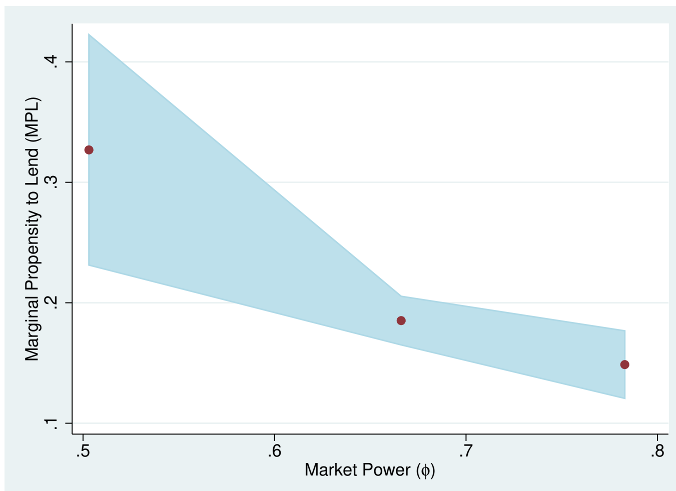
$$\widehat{MPL}_k = \underbrace{\frac{\text{Cov}_k(\Delta\tilde{l}_t, \Delta\tilde{d}_{t+1})}{\text{Cov}_k(\Delta\tilde{d}_t, \Delta\tilde{d}_{t+1})}}_{\widehat{\lambda}^d_k} \frac{l_k}{d_k} \tag{20}$$

where l_k and d_k denote average loans and average deposits, respectively, in bin k, $\widehat{MPL}_k$ is an estimate of MPL for banks in bin k, and $\widehat{\lambda}^d_k$ is an estimate of the elasticity of loans with respect to a transitory change in deposits for banks in bin k. The sensitivity of the deposit spread $i - i^d_j$ with respect to the policy rate i is used as an indicator of deposit market power. According to equation (13), this sensitivity is increasing in deposit market power (decreasing in the elasticity of deposits). Using bank-level data from U.S. Call Reports, I estimate the following regression:

$$\Delta(i_t - i^d_{jt}) = \alpha_j + \phi_j \Delta i_t + \Gamma' X_t + \nu_{jt} \tag{21}$$

where $\Delta(i_t - i^d_{jt})$ is the change in the deposit spread of bank j from date $t-1$ to t, Δi_t is the change in the Fed Funds target rate from $t-1$ to t, and X_t is a set of control variables which includes two lags of GDP growth. Banks with a higher ϕ_j have a higher sensitivity of their deposit spread with respect to the policy rate, which is an indicator of more deposit market power. Then, I group banks into $K = 3$ bins according to their ϕ_j and compute $\widehat{MPL}_k$ within each bin following equation (20).

Figure 1: Marginal Propensity to Lend and market power



Notes: This figure plots the Marginal Propensity to Lend MPL_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{MPL}_k$.

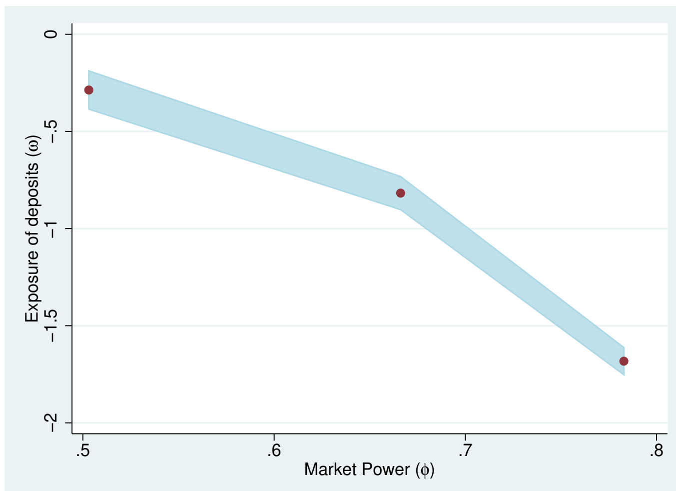
Figure 1 shows that the marginal propensity to lend MPL_k is decreasing with deposit market power ϕ_k, i.e. banks with more deposit market power increase lending by relatively *less* after a *transitory* increase in deposits.

To compute the exposure of deposits within each bin, I estimate the following regression for each bin k:

$$\Delta \log d_{j(k)t} = \alpha_{j(k)} + \omega_k \Delta i_t + \Gamma_k' X_t + \nu_{j(k)t} \tag{22}$$

where $\Delta \log d_{j(k)t}$ is the change in the log of deposits of bank j in bin k from date $t-1$ to t, and X_t is a set of control variables which includes two lags of GDP growth. Banks with a more negative ω_k have a higher exposure of deposits to changes in the policy rate.

Figure 2: Exposure of deposits and market power



Notes: This figure plots the exposure of deposits ω_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{\omega}_k$.

Figure 2 shows that exposure of deposits is increasing with deposit market power, ϕ_k, i.e. the decline in deposits after an increase in the policy rate is bigger for banks with more market power. This empirical result is consistent with equation (16).

Figure 1 and 2 shows that banks with more deposit market power have a lower MPL and a higher exposure of deposits to changes in the policy rate. This implies that bank heterogeneity in deposit market power *dampens* monetary policy by reducing the aggregate effect of a transitory change in deposits on bank lending.

The response of aggregate lending to monetary policy can be expressed as follows:

$$\frac{\mathrm{d}L}{\mathrm{d}i}\frac{1}{L} = \Bigg[\underbrace{\sum_k \widehat{\lambda}^d_k \frac{l_k}{L}}_{\widehat{\lambda}^d} + \underbrace{\sum_k \widehat{MPL}_k \left(\frac{\widehat{\omega}_k}{\widehat{\omega}} - 1\right)\left(\frac{d_k}{D}\right)\frac{D}{L}}_{\text{Covariance: MPL and exposure of deposits}} \Bigg]\widehat{\omega} + \sum_k \widehat{\lambda}^i_k \frac{l_k}{L} \tag{23}$$

where $\widehat{\omega}$ is an estimate of the aggregate response of deposits to monetary policy and $\widehat{\lambda}^d_k$ is an estimate of the elasticity of loans with respect to a transitory change in deposits for banks in bin k, and l_k, d_k is the sum of loans and deposits in each bin k, respectively.

An estimate of the aggregate elasticity of loans with respect to a transitory change in deposits $\widehat{\lambda}^d$ is given by:

$$\widehat{\lambda}^d = \sum_k \widehat{\lambda}^d_k \frac{l_k}{L} = \frac{\mathrm{Cov}_k(\Delta l_t, \Delta d_{t+1})}{\mathrm{Cov}_k(\Delta d_t, \Delta d_{t+1})}\frac{l_k}{L} = 0.24 \quad \text{with} \quad l_k = \sum_{j \in k} l_j \tag{24}$$

which implies that a transitory decline of 1% in deposits reduces bank lending by 0.24% contemporaneously without taking into account bank heterogeneity. The covariance term in (23) is different from zero if bank heterogeneity in deposit market power is relevant for the aggregate response of bank lending to monetary policy. An estimate of the covariance term in (23) is the following:

$$\underbrace{\sum_k \widehat{MPL}_k \left(\frac{\widehat{\omega}_k}{\widehat{\omega}} - 1\right)\left(\frac{d_k}{D}\right)}_{-0.05} \underbrace{\frac{D}{L}}_{1.00} = -0.05 \tag{25}$$

$$\text{with} \quad \widehat{\omega} = \sum_k \widehat{\omega}_k \frac{d_k}{D} \quad , \quad d_k = \sum_{j \in k} d_j \quad , \quad \widehat{MPL}_k = \widehat{\lambda}^d_k \frac{l_k}{d_k}$$

Then, if we take into account bank heterogeneity, we find that a transitory 1% decline in deposits reduces bank lending by 0.19% on impact. Hence, bank heterogeneity in deposit market power reduces the aggregate effect of a transitory change in deposits on bank lending by 20.8%.

The main implication of these results is that bank heterogeneity in deposit market power *dampens* monetary policy through the deposits channel.

4 Additional Empirical Results

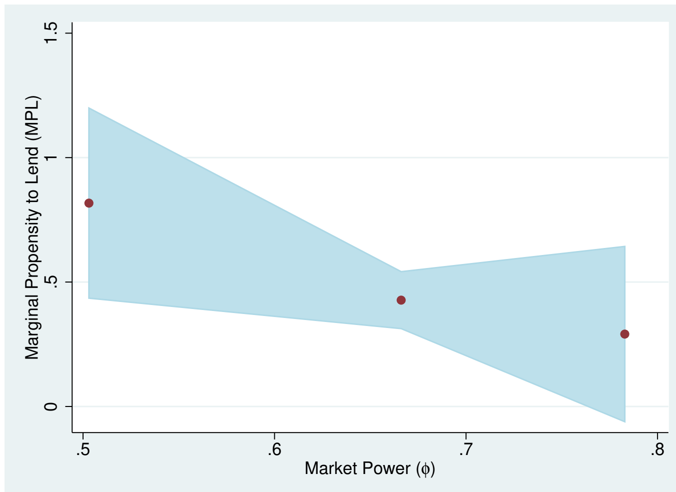
Since the distribution of banks assets is highly skewed, the empirical results from previous section can be biased. In this section I provide three robustness checks: First, I use weighted regressions to compute the marginal propensity to lend and the exposure of deposits. Second, I study the role of bank heterogeneity within a set of large banks in terms of assets. Third, I restrict my estimates within a set of big banks in terms of their number of branches.

4.1 Weighted regressions

In this section, I use weighted regressions to compute MPL_k and the exposure of deposits ω_k. The marginal propensity to lend is weighted by the share of loans in $t-1$ and the exposure of deposits is weighted by the share of deposits in $t-1$. The number of groups will be $K = 3$ according to the distribution of ϕ_j from (21).

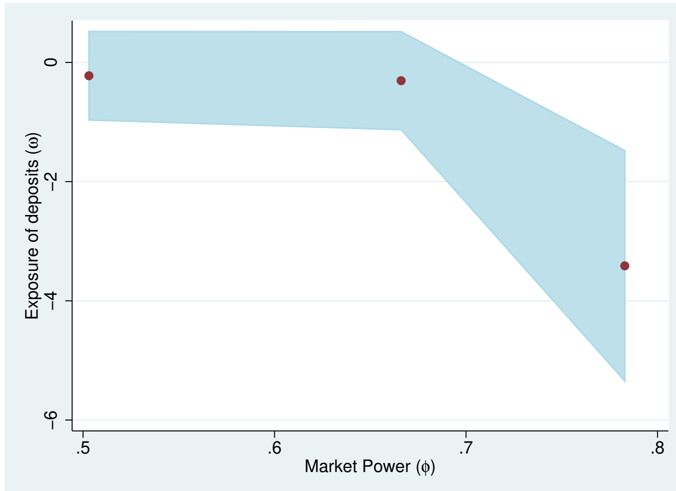
Figure 3 shows that there is negative relationship between the marginal propensity to lend MPL_k and deposit market power ϕ_k, i.e. banks with a higher MPL have a lower deposit market power. This result is similar to the one from figure 1, where I use unweighted regressions.

Figure 3: Marginal Propensity to Lend and market power



Notes: This figure plots the Marginal Propensity to Lend MPL_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{MPL}_k$.

Figure 4: Exposure of deposits and market power



Notes: This figure plots the exposure of deposits ω_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{\omega}_k$.

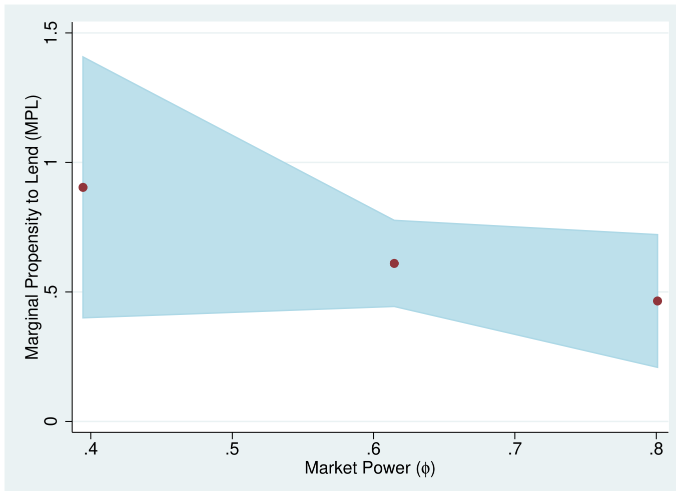
Figure 4 shows that exposure of deposits is increasing with deposit market power, ϕ_k, i.e. the decline in deposits after an increase in the policy rate is bigger for banks with more deposit market power. This result is similar to the one from figure 2.

Using weighted regressions, I find that banks with more market power have a higher exposure of deposits and a lower marginal propensity to lend. This implies that bank heterogeneity in deposit market power *dampens* monetary policy.

4.2 Large banks

As an additional robustness check, I compute MPL_k and ω_k only for the top 1% banks (in terms of assets). If bank heterogeneity in deposit market power is relevant for the aggregate behavior of bank lending, it should be relevant to explain the cross-sectional differences between big banks.

Figure 5: Marginal Propensity to Lend and market power

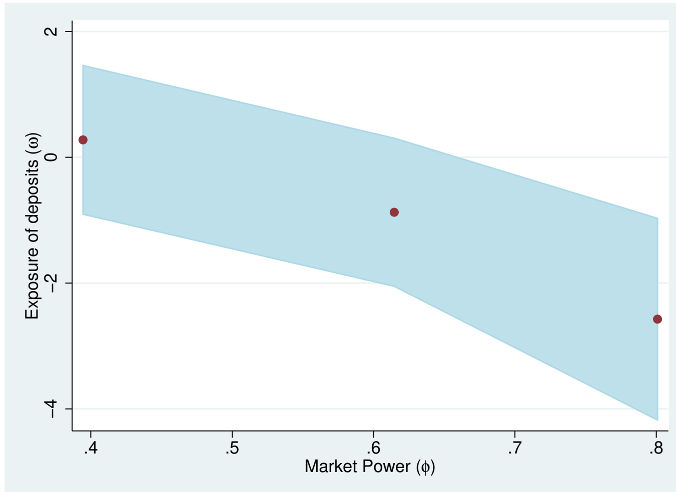


Notes: This figure plots the Marginal Propensity to Lend MPL_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{MPL}_k$.

Figure 5 shows that big banks with a lower deposit market power increase lending by more after a transitory increase in deposits. However, boostrap confidence intervals show that the relationship between MPL and exposure of deposits is weakly negative.

Figure 6 shows that big banks with more market power also experience a larger decline in deposits after an increase in the Fed funds rate. Therefore, bank heterogeneity in deposit market power can explain the different responses of big banks to monetary policy.

Figure 6: Exposure of deposits and market power



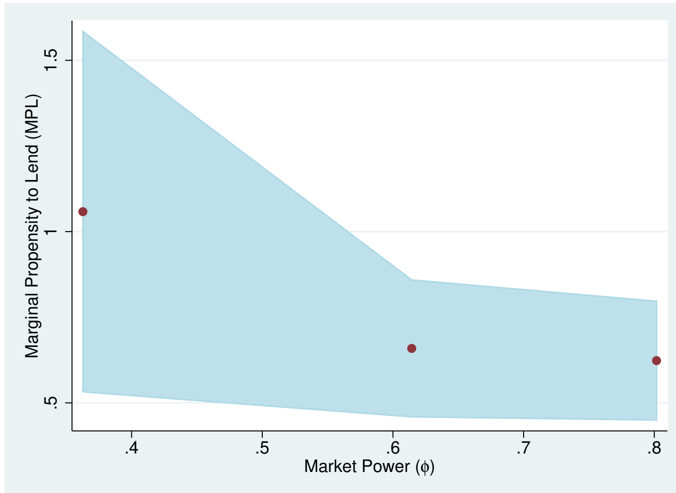
Notes: This figure plots the exposure of deposits ω_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{\omega}_k$.

Big banks with more market power have a higher exposure of deposits to changes in the policy rate and a *weakly* lower marginal propensity to lend. Then, we have a weakly negative covariance between MPL and exposure of deposits within the set of largest banks in terms of assets, which leads to *dampening* of monetary policy.

4.3 Branches

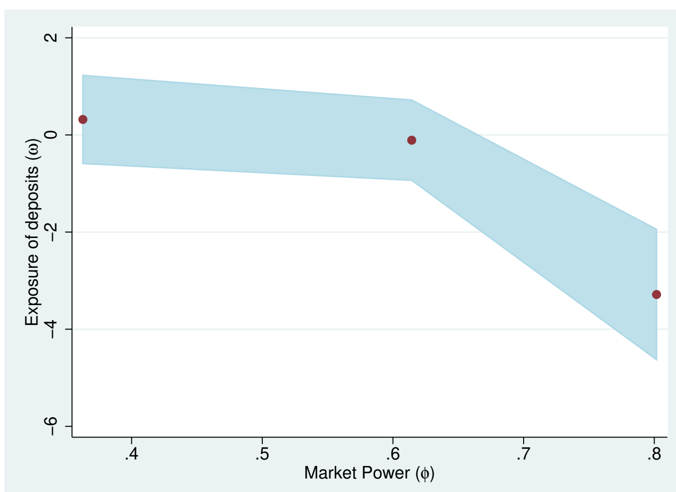
I compute MPL_k and ω_k for the top 1% banks in terms of number of branches (more than 100 branches on average). Figure 7 shows that there is a *weakly* negative relationship between MPL and market power among this group of banks.

Figure 7: Marginal Propensity to Lend and market power



Notes: This figure plots the Marginal Propensity to Lend MPL_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{MPL}_k$.

Figure 8: Exposure of deposits and market power



Notes: This figure plots the exposure of deposits ω_k and an indicator of deposit market power ϕ_k for each bin k. The shaded area is the 95% bootstrap confidence interval for $\widehat{\omega}_k$.

Figure 8 shows that banks with the highest number of branches have an exposure of deposits that is increasing in their deposit market power.

Banks with the highest number of branches have a marginal propensity to lend that is decreasing in their deposit market power while their exposure of deposits is increasing. Then, among this group of banks, bank heterogeneity in deposit market power *weakly dampens* monetary policy.

4.4 The role of bank heterogeneity

In this section, I provide estimates of the covariance between exposure of deposits and the marginal propensity to lend for three different groups of banks. The first group includes all banks, the second group includes only top 1% in terms of assets, and the third group includes only banks with more than 100 branches on average (top 1% in terms of number of branches). For the first group, weighted regressions are considered. The IV regression for the marginal propensity to lend is weighted by the share of loans and the regression for the exposure of deposits is weighted by the share of deposits. For the last two groups, only unweighted regressions are considered. The number of bins is $K = 3$ according to the distribution of ϕ_j from (21).

Equation (23) can be expressed as follows:

$$\frac{\mathrm{d}L}{\mathrm{d}i}\frac{1}{L} = \left[\widehat{\lambda}^d + \widehat{\mathcal{C}}\right]\widehat{\gamma} + \widehat{\lambda}^i \qquad (26)$$

where $\widehat{\mathcal{C}} = \sum_k \widehat{MPL}_k\left(\frac{\widehat{\gamma}_k}{\widehat{\gamma}} - 1\right)\left(\frac{d_k}{D}\right)\frac{D}{L}$. For the first group (all banks) with weighted regressions, we have $\widehat{\lambda}^d = 0.56$ and $\widehat{\mathcal{C}} = -0.22$ (Table 1). Then, a decline of 1% in deposits reduces bank lending by 0.35% on impact, which implies that bank heterogeneity in deposit market power reduces the response of aggregate bank lending by 39.3%. However, the covariance term is not highly significant[1]. When using unweighted regressions, the aggregate response of lending goes from 0.35% to 0.19% and the covariance term is negative and highly significant. In this case bank heterogeneity in deposit market power reduces the aggregate response of lending by 20.8%.

Table 1: Estimates for different set of banks (bootstrap)

	λ^d	$\mathcal{C}$	$\lambda^d + \mathcal{C}$	$\frac{\mathcal{C}}{\lambda^d}$
All banks (weighted)	0.56	-0.22	0.35	-39.3%
	$[0.42, 0.70]$	$[-0.50, 0.07]$	$[-0.02, 0.71]$	
All banks	0.24	-0.05	0.19	-20.8%
	$[0.22, 0.26]$	$[-0.08, -0.03]$	$[0.17, 0.20]$	
Large banks	0.53	-0.13	0.40	-24.5%
	$[0.38, 0.67]$	$[-0.41, 0.15]$	$[0.11, 0.69]$	
High No of branches	0.65	-0.14	0.51	-21.5%
	$[0.55, 0.74]$	$[-0.37, 0.10]$	$[0.29, 0.74]$	

Notes: This table shows the estimates of λ^d and $\mathcal{C}$ for different set of banks. In brackets: 95% confidence intervals.

The estimates for the second and third group are similar to the estimates for the first group when we use weighted regressions. This is not surprising given the highly skewed distribution of bank assets. In both cases, the covariance term is negative and not highly significant. Then, Table 1 shows that bank heterogeneity in deposit market power *does not amplify* monetary policy. Moreover, it most likely *dampens* the response of bank lending to changes in the policy rate.

[1]It would be significant if we use 86% confidence intervals.

5 A simple model

In this section, I develop a three-period model to study the implications of interest rate risk and deposit market power for the monetary transmission mechanism. Banks engage in maturity transformation and expose themselves to interest rate risk by providing fixed-rate two-period loans and collecting deposits (one-period funding). Each bank faces a bank-specific demand for deposits and an aggregate demand for loans. Therefore, banks enjoy deposit market power but they are competitive in the loans market. Bankers maximize the expected present discounted value of their utility from consumption in $t = 1$ and $t = 2$. The implications of the model would be similar if we assume that banks maximize the expected present discounted value of their dividends subject to a convex dividend adjustment cost similar to Jermann and Quadrini (2012), Begenau (2020), and Polo (2020)[2].

Bank balance sheet. There are three periods $t = 0, 1, 2$. Bankers have two assets, bonds b and loans l and only one liability, deposits d. A fraction δ of outstanding loans becomes due in period $t = 1$ and bankers consume only in $t = 1, 2$. For simplicity, prices of consumption goods are equal to one in both periods $t = 1, 2$. Bank balance sheets in $t = 0, 1, 2$ are given by:

[2]The assumption in those papers is that banks incurs a convex cost if dividends deviate from a target level.

$$
\begin{aligned}
b_0 + l_0 &= d_0 \\
b_1 + (1-\delta)l_0 &= d_1 + (e_1 - c_1) \qquad (27) \\
c_2 &= e_2
\end{aligned}
$$

where e_1 and c_1 are bank equity and consumption in $t = 1$, respectively. In $t = 2$, the consumption of bankers is equal to their equity, i.e. $c_2 = e_2$. In period $t = 0$, banks collect deposits d_0 and decide to invest in bonds b_0 and in loans l_0. In $t = 1$, a fraction δ of outstanding loans is due, banks collect deposits d_1, decide how much to consume c_1 and use profits from loans and deposits in $t = 0$ to decide how much to invest in bonds b_1. The last period, banks consume their equity.

Cash Flows. At the beginning of period $t = 1$, banks receive income from loans and bonds and pay an interest on deposits. Cash flows at the beginning of period $t = 1$ are:

$$
CF_1 = \underbrace{(\delta + i_0^l)l_0}_{\text{loan payments}} + \underbrace{(1 + i_0)b_0}_{\text{bond payments}} - \underbrace{(1 + i_0^d)d_0}_{\text{deposit payments}} \qquad (28)
$$

where i_t^l, i_t, i_t^d are the nominal interest rates on loans, bonds and deposits in period t, respectively and the nominal interest rate on bonds is also the monetary policy rate. Banks receive interest income on loans $i_0^l l_0$ and a fraction δ of outstanding principal l_0, interest income on bonds $i_0 b_0$ and the principal repayment b_0, and pay interest on deposits $i_0^d d_0$ and repay the principal d_0. Similarly, cash flows at the beginning of period $t = 2$ are:

$$CF_2 = \underbrace{(1 + i_0^l)(1 - \delta)l_0}_{\text{loan payments}} + \underbrace{(1 + i_1)b_1}_{\text{bond payments}} - \underbrace{(1 + i_1^d)d_1}_{\text{deposit payments}} \tag{29}$$

Banks receive interest income on outstanding loans $i_0^l(1 - \delta)l_0$ and the repayment of outstanding principal $(1 - \delta)l_0$, interest income on bonds $i_1 b_1$ and the principal repayment b_1, and pay interest on deposits $i_1^d d_1$ and repay the principal d_1. Then, bank's balance sheets at $t = 1$ and $t = 2$ can be expressed as follows:

$$\begin{aligned} b_1 + c_1 &= d_1 + CF_1 \\ c_2 &= CF_2 \end{aligned} \tag{30}$$

Banks decide how much to invest in bonds b_1 and to consume c_1 using cash flows from the beginning of period CF_1 and collecting deposits d_1. These decisions generate cash flows the following period, CF_2 and determine consumption of bankers in that period.

Equity. In this model, bank equity is equal to retained earnings. In $t = 1$, equity is equal to the sum of profits from loans $(i_0^l - i_0)l_0$ and profits from deposits $(i_0 - i_0^d)d_0$. The next period, equity is equal to profits from outstanding loans $(i_0^l - i_1)(1 - \delta)l_0$, profits from deposits $(i_1 - i_1^d)d_1$ and profits from bonds financed by equity $(1 + i_1)(e_1 - c_1)$.

$$\begin{aligned} e_1 &= (i_0^l - i_0)l_0 + (i_0 - i_0^d)d_0 \\ e_2 &= (i_0^l - i_1)(1 - \delta)l_0 + (i_1 - i_1^d)d_1 + (1 + i_1)(e_1 - c_1) \end{aligned} \tag{31}$$

Interest rate risk. If $i^l_0 > i_0$, investing in loans increases equity in the first period e_1 but it exposes equity (and consumption) in the second period e_2 (c_2) to interest rate risk. Loans l_0 earn a fixed interest rate i^l_0. Then, if interest rate increases in the second period such that $i^l_0 < i_1$, bank equity in that period would be decreasing in the amount of loans l_0. Hence, the spread between i^l_0 and i_0 should compensate for the interest rate risk.

Bank Problem. In period $t = 1$, bankers decide how much to consume c_1, c_2 and the amount of deposits d_1, conditional on the amount of outstanding loans $(1-\delta)l_0$. They solve the following optimization problem:

$$\max_{c_2,c_1,d_1} \quad \log(c_1) + \beta\,\mathbb{E}_1 \log(c_2) \tag{32}$$

subject to

$$c_2 = (i^l_0 - i_1)(1-\delta)l_0 + (i_1 - i^d_1)d_1 + (1+i_1)(e_1 - c_1)$$

The optimality conditions for consumption c_1 and deposits d_1 are below. Consumption c_2 is determined by the constraint in (32)

$$\begin{aligned} c_2 &= \beta(1+i_1)c_1 \\ i_1 - i^d_1 &= \frac{1}{1+\varepsilon^d} i_1 \end{aligned} \tag{33}$$

where $\varepsilon^d = \frac{\partial d}{\partial i^d}\frac{i^d}{d} > 0$. The deposit spread is increasing in the policy rate if we assume that the elasticity of deposits ϵ^d is constant. Moreover, banks with more market power (lower elasticity) have a deposit spread that is more sensitive to the policy rate i_1. Consumption c_1 is determined by the Euler equation and can be expressed as follows:

$$c_1 = \frac{(i_1 - i_1^d)d_1}{(1+i_1)(1+\beta)} + \left[\frac{(i_0^l - i_1)(1-\delta)}{(1+i_1)(1+\beta)} + \frac{(i_0^l - i_0)}{(1+\beta)}\right] l_0 + \frac{(i_0 - i_0^d)d_0}{(1+\beta)} \tag{34}$$

Consumption c_1 is increasing in profits from deposits and it is decreasing in the policy rate i_1 is δ is sufficiently low. Also, if the interest rate i_1 is sufficiently high, a higher amount of loans l_0 leads to a lower consumption c_1.

Bankers don't consume in $t = 0$. In this period, they decide how much to lend l_0 and the amount of deposits d_0. The amount of bonds b_0 is determined by the balance sheet constraint. They solve the following optimization problem:

$$\max_{l_0, d_0} \quad \mathbb{E}_0 \log(c_1) \tag{35}$$

$$\text{subject to} \quad (34)$$

The optimality conditions for loans l_0 and deposits d_0 are the following:

$$\mathbb{E}_0\left[\frac{1}{c_1}\left(\frac{(i_0^l - i_1)(1-\delta)}{1+i_1} + (i_0^l - i_0)\right)\right] = 0 \tag{36}$$

$$i_0 - i_0^d = \frac{1}{1+\varepsilon^d} i_0$$

The deposit spread $i_0 - i_0^d$ is increasing in the policy rate i_0 and it is larger and more sensitive to the policy rate for banks with more market power (lower ϵ^d). The interest rate on loans i_0^l is increasing in the policy rate i_0 and the spread $i_0^l - i_0$ should be sufficiently large to compensate for the interest rate risk associated with fixed-rate loans. A higher interest rate i_1 increases the cost of funding i_1^d and reduces the amount of deposits d_1, then banks need to reduce their investment in bonds b_1 and their consumption c_1 to finance their outstanding loans $(1-\delta)l_0$. Consumption in $t=1$ can be expressed as follows:

$$c_1 = \gamma_1^d d_1 + \gamma^l l_0 + \gamma_0^d d_0 \tag{37}$$

where:

$$\gamma_1^d = \frac{1}{1+\epsilon^d}\frac{i_1}{(1+i_1)(1+\beta)} \quad , \quad \gamma_0^d = \frac{1}{1+\epsilon^d}\frac{i_0}{(1+\beta)}$$

$$\gamma^l = \frac{(i_0^l - i_1)(1-\delta)}{(1+i_1)(1+\beta)} + \frac{(i_0^l - i_0)}{(1+\beta)}$$

Then, the optimality condition for loans l_0 can be expressed as follows:

$$\mathbb{E}_0\left[\frac{\gamma^l}{c_1}\right] = 0 \tag{38}$$

Marginal Propensity to Lend. It is defined as the increase in lending l_0 after a transitory increase in deposits, i.e. an increase in d_0[3]. To find the marginal propensity to lend, we can use the optimality condition for loans and take the derivative with respect to d_0

$$\mathbb{E}_0\left[\frac{\gamma^l}{c_1^2}(\gamma^l MPL + \gamma_0^d)\right] = 0 \tag{39}$$

where $MPL = \frac{\partial l_0}{\partial d_0}$ is the marginal propensity to lend. Then, we can find an expression for MPL

[3]A permanent increase in deposits occurs when deposits today and tomorrow increase by one unit, i.e. $\Delta d_0 = \mathbb{E}_0 \Delta d_1 = 1$

$$MPL = \frac{-\mathbb{E}_0\left[\frac{\gamma^l}{c_1^2}\right]}{\mathbb{E}_0\left[\left(\frac{\gamma^l}{c_1}\right)^2\right]}\gamma_0^d = \frac{\text{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{-1}{c_1}\right)}{\text{Var}_0\left(\frac{\gamma^l}{c_1}\right)}\gamma_0^d > 0 \tag{40}$$

Notice that $\mathbb{E}_0\left[\frac{\gamma^l}{c_1^2}\right] = \mathbb{E}_0\left[\frac{\gamma^l}{c_1}\frac{1}{c_1}\right] = \text{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{1}{c_1}\right) < 0$ because an increase in the interest rate i_1 increases losses from maturity transformation (lower $\frac{\gamma^l}{c_1}$), which reduces future consumption (lower c_1). Then, we can conclude that MPL is strictly positive. The intuition goes as follows: an increase in deposits d_0 increases consumption c_1 due to higher profits from deposits, which decreases the marginal utility of consumption and makes banks more tolerant to interest rate risk. Then, banks find optimal to increase their exposure to interest rate risk by increasing lending l_0.

In the empirical section, we found that banks with more market power have a lower marginal propensity to lend. In this model, market power can either increase or decrease the marginal propensity to lend. More market power increases MPL due to higher γ_0^d and lower variance term in equation (40) but it reduces MPL by lowering the covariance term.

$$\begin{aligned}\frac{\mathrm{d}MPL}{\mathrm{d}(\frac{1}{1+\epsilon^d})} = \frac{\text{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{-1}{c_1}\right)}{\text{Var}_0\left(\frac{\gamma^l}{c_1}\right)}\frac{i_0}{1+\beta}\Bigg[1 &+ \frac{2}{1+\epsilon^d}\frac{\text{Cov}_0\left(\frac{1}{c_1}, \frac{\gamma^l}{c_1^2}\frac{\mathrm{d}c_1}{\mathrm{d}(1/(1+\epsilon^d))}\right)}{\text{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{-1}{c_1}\right)} \\ &+ \frac{2}{1+\epsilon^d}\frac{\text{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{\gamma^l}{c_1^2}\frac{\mathrm{d}c_1}{\mathrm{d}(1/(1+\epsilon^d))}\right)}{\text{Var}_0\left(\frac{\gamma^l}{c_1}\right)}\Bigg]\end{aligned} \tag{41}$$

First channel: An increase in deposits d_0 increases consumption c_1, and the increase is larger for banks with more market power (lower elasticity of deposits).

Since marginal utility is decreasing in consumption, higher consumption reduces the marginal utility of consumption and makes banks relatively more tolerant to interest rate risk. Then, banks with more market power find optimal to increase their exposure to interest rate risk by increasing their lending relatively more.

Second channel: Banks experience a decline in deposits after an increase in the policy rate, which implies that the increase in profits from deposits after an increase in i_1 is bigger for banks with *less* market power (lower deposit spreads). Moreover, banks with more market power invest relatively more in loans. Then, banks with more deposit market power experience a bigger decline in consumption c_1 after an increase in i_1, and a given increase in deposits d_0 has a smaller effect on making banks more tolerant to interest rate risk, which leads to a lower increase in lending l_0. In this case, the covariance between the losses from maturity transformation and the marginal utility of consumption, i.e. $\mathrm{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{1}{c_1}\right)$, is lower for banks with more market power because consumption is *more* sensitive to changes in i_1 while $\frac{\gamma^l}{c_1}$ is less sensitive. Hence, we have:

$$\mathrm{Cov}_0\left(\frac{1}{c_1}, \frac{\gamma^l}{c_1^2}\frac{\mathrm{d}c_1}{\mathrm{d}(1/(1+\epsilon^d))}\right) < 0 \tag{42}$$

Third channel: An increase in lending increases interest rate risk and banks with more market power enjoy relatively *higher* consumption c_1. Then, a unit increase in lending implies a relatively *lower* cost for banks with more market power, i.e. the added risk due to an increase in lending is lower given that consumption c_1 is relatively higher, which implies a higher marginal propensity to lend. Banks with more market power will increase lending relatively *more* after an increase in deposits d_0 because a given increase in lending will increase their exposure to interest rate risk relatively less. In this case, the variance of the losses from maturity transformation, i.e. $\mathrm{Var}_0\left(\frac{\gamma^l}{c_1}\right)$, is lower for banks with more market power because their marginal utility of consumption $\frac{1}{c_1}$ is relatively lower. Hence, we have:

$$\mathrm{Cov}_0\left(\frac{\gamma^l}{c_1}, \frac{\gamma^l}{c_1^2}\frac{\mathrm{d}c_1}{\mathrm{d}(1/(1+\epsilon^d))}\right) > 0 \tag{43}$$

Deposit market power *increases* the sensitivity of consumption c_1 to changes in the policy rate i_1. Hence, if the increase in this sensitivity due to market power is sufficiently large, the marginal propensity to lend would be *decreasing* in deposit market power. In this case, bank heterogeneity in deposit market power *dampens* monetary policy, consistent with the empirical results from previous sections.

Some additional testable implications of this model are the following:

Profits from deposits and market power. Banks with more market power experience a bigger decline in deposits after an increase in the policy rate, which leads to lower profits from deposits. Then, an increase in the policy rate increases profits from deposits but this increase is *lower* for banks with more deposit market power.

Bank equity and market power. Given that banks face the same interest rate on loans and loan maturity, banks with more market power will experience a *bigger* decline in equity after an increase in the policy rate.

Bonds and market power. Banks with more market power experience a larger decline in bonds after an increase in the policy rate. If MPL is decreasing in deposit market power, the decline in bonds would be bigger.

Finally, the demand for loans and deposits are not modelled explicitly. Only a few assumptions are needed to derive the main results in the paper.

Demand for loans. The model assumes that banks supply loans in a competitive market. Then, the interest rate on loans, which is the same for all banks, is sufficient to study the implications of bank heterogeneity.

Demand for deposits. The model assumes that the level of deposits is initially[4] the same for all banks. The demand for deposits is bank-specific and it increases with the interest on deposits (constant elasticity of deposits) and decreases with the interest on bonds (policy rate). In general, deposits decline after an increase in the policy rate. In a microfounded model, a higher monetary policy rate would increase the opportunity cost of holding deposits. Additionally, if the demand for deposits depends on aggregate income and/or consumption, a higher interest rate would decrease deposits further.

6 Alternative models

In this section, I present alternative models to study the role of deposit market power and interest rate risk management in the monetary transmission.

[4] As the interest rate changes, the level of deposits across banks can change but the level is the same at i_0

6.1 A model with financially constrained banks

Folowing Gertler and Karadi (2011), we can assume that banks have a probability equal to ρ to continue being a banker next period $t = 1$. They maximize their expected terminal wealth.

$$\begin{aligned}
& V_0 = \max_{l_0, d_0} \mathbb{E}_0 \Lambda_{0,1} [(1-\rho) n_1 + \rho V_1] \\
\text{s.t.} \quad & n_1 = (i_0^l - i_0) l_0 + (i_{-1}^l - i_0)(1-\delta) l_{-1} + (i_0 - i_0^d) d_0 \\
& V_0 \geq \lambda \Big[l_0 + (1-\delta) l_{-1} \Big] \\
& V_1 = \max_{d_1} \mathbb{E}_1 \Lambda_{1,2} \Big[(i_0^l - i_1)(1-\delta) l_0 + (i_1 - i_1^d) d_1 + (1 + i_1) n_1 \Big]
\end{aligned} \tag{44}$$

where $\Lambda_{t,t+1}$ is the stochastic discount factor between t and $t+1$. Then, constrained lending can be expressed as follows:

$$l_0 = \Gamma_{-1}^l l_{-1} + \Gamma_0^d d_0 + \mathbb{E}_0 \left[\Gamma_1^d d_1 \right] \tag{45}$$

where:

$$\begin{aligned}
\Gamma_{-1}^l &= \frac{\frac{(1-\rho)(i_{-1} - i_0)(1-\delta)}{1+i_0} - \lambda(1-\delta)}{\lambda - \frac{i_0^l - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left(\frac{i_0^l - i_1}{1+i_1} \right)(1-\delta)} \\
\Gamma_0^d &= \frac{\frac{i_0 - i_0^d}{1+i_0}}{\lambda - \frac{i_0^l - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left(\frac{i_0^l - i_1}{1+i_1} \right)(1-\delta)} \\
\Gamma_1^d &= \frac{\rho \Lambda_{0,1} \left(\frac{i_1 - i_1^d}{1+i_1} \right)}{\lambda - \frac{i_0^l - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left(\frac{i_0^l - i_1}{1+i_1} \right)(1-\delta)}
\end{aligned}$$

In this case, the marginal propensity to lend is $\frac{\partial l_0}{\partial d_0} = \Gamma_0^d$. Since the stochastic discount factor is independent of bank-specific variables, a higher deposit spread, $i_0 - i_0^d$ leads to a higher MPL. Therefore, in this model banks with *more* deposit market power have a higher MPL, which is *inconsistent* with empirical evidence from previous sections.

If the financial constraint is not binding, then we have:

$$\frac{(i_0^l - i_0)}{1 + i_0} + \rho(1 - \delta)\mathbb{E}_0\Lambda_{0,1}\frac{(i_0^l - i_1)}{1 + i_1} = 0 \tag{46}$$

If lending is unconstrained, the first order condition will pin down the interest rate on loans but the level of loans and the marginal propensity to lend is undetermined. If banks have market power in the loans market, then the level of loans will be determined but it would be unrelated to the level of deposits, which implies $MPL = 0$.

In this model, MPL is increasing in deposit market power when banks are financially constrained. If banks are not financially constrained, then MPL would be undetermined because the utility of bankers is linear in their wealth. Moreover, if we assume that banks have loan market power, MPL would be equal to zero. To generate a strictly positive MPL, we need a concave utility function over wealth or a binding financial constraint.

6.2 A model with dividend adjustment costs

Banks maximize the expected present discounted value of their dividends div_t and incur quadratic dividend adjustment costs $f(div_t)$ similar to Jermann and

Quadrini (2012), Begenau (2020), and Polo (2020). They solve the following problem:

$$
\begin{aligned}
V_0 &= \max_{l_0,d_0} \mathbb{E}_0\Lambda_{0,1}div_1 + \mathbb{E}_0\Lambda_{0,2}div_2 \\
&\text{subject to} \\
e_1 &= (i^l_0 - i_0)l_0 + (i^l_{-1} - i_0)(1-\delta)l_{-1} + (i_0 - i^d_0)d_0 - div_1 - f(div_1) \\
div_2 &= (i^l_0 - i_1)(1-\delta)l_0 + (i_1 - i^d_1)d_1 + (1+i_1)e_1 - f(div_2) \\
V_1 &= \max_{div_1,div_2,d_1} div_1 + \mathbb{E}_1\Lambda_{1,2}div_2 \\
f(div_t) &= \frac{\kappa}{2}(div_t - \bar{div})^2
\end{aligned}
\tag{47}
$$

where $\Lambda_{t,t+1}$ is the stochastic discount factor between t and $t+1$. Then, the first order condition for loans is:

$$
\mathbb{E}_0\left[\frac{\Lambda_{0,1}}{1+\kappa(div_1 - \bar{div})}\left(\frac{(i^l_0 - i_1)(1-\delta)}{(1+i_1)} + (i^l_0 - i_0)\right)\right] = 0 \tag{48}
$$

where:

$$
\begin{aligned}
div_1 + f(div_1) = &\left[\frac{(i^l_0 - i_1)(1-\delta) + (i^l_0 - i_0)(1+i_1)}{2+i_1}\right]l_0 + \left[\frac{i_1 - i^d_1}{2+i_1}\right]d_1 \\
&+ \left[\frac{(1+i_1)(i_0 - i^d_0)}{2+i_1}\right]d_0 + \left[\frac{(1+i_1)(i^l_{-1} - i_0)(1-\delta)}{2+i_1}\right]l_{-1}
\end{aligned}
\tag{49}
$$

Equation (48) is similar to equation (38). The only difference is that banks use the stochastic discount factor to discount future cash flows and maximize the present value of dividends subject to quadratic adjustment costs. Then, similar to (38) it is possible to derive a marginal propensity to lend and to study how it changes with deposit market power.

7 Conclusion

This paper contributes to the literature on banking and monetary policy by providing estimates of the aggregate implications of bank heterogeneity in deposit market power and a model to rationalize the main results. Empirically, I find that banks with more market power have a higher exposure of deposits to changes in the policy rate and a lower marginal propensity to lend, which leads to *dampening* of monetary policy. The same conclusion holds under different robustness checks.

I present a model where banks have market power in deposits and provide fixed-rate long-term loans, exposing themselves to interest rate risk. Banks with more deposit market power set a higher deposit spread and increase their spread by *more* after an increase in the policy rate. Banks with more market power have a lower elasticity of deposits, which implies that the decline in deposits after a monetary tightening is larger for banks with more deposit market power.

The marginal propensity to lend can either increase or decrease with deposit market power. In the first channel, the increase in future consumption due to higher deposits would be larger for banks with more market power, which makes banks more tolerant to interest rate risk. This leads to a bigger increase in lending. In the second channel, banks with more market power have a *higher* sensitivity of consumption to changes in the policy rate, which implies that a given increase in deposits has a small effect on making banks more tolerant to interest rate risk.

This implies a lower increase in lending. In the third channel, banks with more deposit market power enjoy relatively higher consumption. Then, the added risk due to an increase in lending is relatively lower, which implies a higher increase in lending. The marginal propensity to lend would be decreasing in deposit market power if an increase in market power leads to a sufficiently large increase in the sensitivity of consumption to changes in the policy rate.

The main contribution of this paper is to provide empirical estimates of the aggregate implications of bank heterogeneity in the monetary transmission mechanism and a theoretical model to explain the main results. Specifically, this paper studies the role of heterogeneity in deposit market power to explain the heterogeneous responses of deposits to monetary policy at the bank-level and its implications for the responses of bank lending at the aggregate level. This work complements the literature on banking and monetary policy by showing that bank heterogeneity in deposit market power leads to *dampening* in the response of bank lending to monetary policy through the deposits channel.

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Appendix

A Data

In this paper, I use quarterly bank-level data 1994-2007 from U.S. Call Reports. Data comes from Drechsler, Savov, and Schnabl (2018).

Loans l_t. Total Loans. Loan Growth ($\Delta \log l_t \times 100$) is winsorized at the 1% level.

Deposits d_t. Total Deposits. Deposit Growth ($\Delta \log d_t \times 100$) is winsorized at the 1% level.

Interest rate on deposits i_t^d. Interest expenses on deposits divided by total deposits and multiplied by 100.

Policy rate i_t. Fed funds target rate from FRED.

Deposit Spread $i_t - i_t^d$. The first difference $\Delta(i_t - i_t^d)$ is winsorized at the 1% level.

GDP growth X_t. From FRED.

B Identification of the Marginal Propensity to Lend

In this section, I explain the methodology to identify the marginal propensity to lend. Following Blundell, Pistaferri, and Preston (2008) and Auclert (2019), we assume that the dynamics of log deposits can be explained by a set of bank characteristics, and permanent and transitory components.

$$\log d_t = X'_{t-1}\beta + \log d_t^P + \log d_t^T \tag{50}$$

where X_{t-1} is a vector of lagged bank-level controls[5], $\log d_t^P$ is the permanent component and $\log d_t^T$ is the transitory component. The permanent component follows a martingale process and the transitory component follows a white noise process.

$$\log d_t^P = \log d_{t-1}^P + \varepsilon_t^P$$
$$\log d_t^T = \varepsilon_t^T$$

where ε_t^P and ε_t^T are serially uncorrelated. Then, the unexplained change in log deposits is:

$$\Delta\tilde{d}_t = \varepsilon_t^P + \Delta\varepsilon_t^T \tag{51}$$

where $\tilde{d}_t = \log d_t - X'_{t-1}\beta$. Following Blundell, Pistaferri, and Preston (2008) and Auclert (2019), the unexplained change in log loans can be expressed as follows:

$$\Delta\tilde{l}_t = \chi^d\,\varepsilon_t^P + \lambda^d\,\varepsilon_t^T + \xi_t \tag{52}$$

where χ^d measures the impact of permanent deposit shocks on lending and λ^d captures the impact of transitory deposit shocks on bank lending, and ξ_t represents unexpected changes in lending independent of deposit shocks. We

[5]It includes the liquidity ratio, bank leverage, the wholesale funding ratio, and log assets.

are interested in the marginal propensity to lend, which is equal to λ^d multiply by the ratio of loans over deposits. Identification of λ^d is possible if we run an instrumental variable regression of $\Delta\tilde{l}_t$ on $\Delta\tilde{d}_t$ using $\Delta\tilde{d}_{t+1}$ as an instrument. The estimate, denoted as $\hat{\lambda}^d$, is the following:

$$\hat{\lambda}^d = \frac{\text{Cov}(\Delta\tilde{l}_t, \Delta\tilde{d}_{t+1})}{\text{Cov}(\Delta\tilde{d}_t, \Delta\tilde{d}_{t+1})} \tag{53}$$

Using the stochastic processes for $\Delta\tilde{l}_t$ and $\Delta\tilde{l}_t$, we can find that the IV estimate precisely identifies λ^d.

$$\text{Cov}(\Delta\tilde{l}_t, \Delta\tilde{d}_{t+1}) = -\lambda^d \text{Var}(\varepsilon_t^T) \tag{54}$$

$$\text{Cov}(\Delta\tilde{d}_t, \Delta\tilde{d}_{t+1}) = -\text{Var}(\varepsilon_t^T) \tag{55}$$

The ratio of these covariances is equal to λ^d. Then, we can estimate the marginal propensity to lend as follows:

$$\widehat{MPL} = \hat{\lambda}^d \times \frac{l}{d} \tag{56}$$

where l and d denote average loans and average deposits.