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 $\delta$ 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.

4
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:

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

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 $t$, $\omega_{jt}$ 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.

$$MPL_j = \frac{\partial l_{jt}}{\partial d_{jt}} = \frac{\partial f_j}{\partial d_{jt}}$$
If there is an increase in the policy rate today $i_t$, keeping constant $E_t i_{t+\tau}$ for all $\tau > 0$, the total effect of monetary policy on lending $l_{jt}$ is given by:

$$\frac{dl_{jt}}{di_t} = \frac{\partial f_j}{\partial d_{jt}} \frac{dd_{jt}}{di_t} + \frac{\partial f_j}{\partial i_{jt}}$$

(3)

In percentage terms, we have

$$\frac{dl_{jt}}{di_t} \frac{1}{l_{jt}} = \frac{\partial f_j}{\partial d_{jt}} \frac{dd_{jt}}{di_t} \frac{1}{l_{jt}} + \frac{\partial f_j}{\partial i_{jt}} \frac{1}{f_j}$$

(4)

where $\lambda^d_j$ is the elasticity of loans with respect to deposits and $\lambda^i_j$ 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:

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

(5)

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

$$\frac{dL_t}{di_t} \frac{1}{L_t} = \sum_j \frac{dl_{jt}}{di_t} \frac{1}{l_{jt}} \frac{l_{jt}}{L_t} \quad \text{and} \quad \frac{dD_t}{di_t} \frac{1}{D_t} = \sum_j \frac{dd_{jt}}{di_t} \frac{1}{d_{jt}} \frac{d_{jt}}{D_t}$$

(6)

Then, we can find the response of aggregate lending to the policy rate.
\[
\frac{dL_t}{dt} = \left[ \sum_j \frac{\partial f_j}{\partial d_{jt}} d_{jt} \right] + \left[ \sum_j \frac{\partial f_j}{\partial d_{jt}} \left( \frac{dd_{jt}}{dt} d_{jt} - \frac{d_{jt}}{dt} D_t \right) \right] \frac{dD_t}{dt} + \sum_j \frac{\partial f_j}{\partial i_{jt}} (7)
\]

Covariance: MPL and Exposure of deposits

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. \(|\frac{dd_j}{dj}| > |\frac{dD}{D}|\). Similarly, there is damping 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 \(\frac{dd_j}{dj} = \frac{dD}{D}\), 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:
\[
\frac{dL_t}{dt} \frac{1}{L_t} = \left[ \lambda^d + \sum_j MPL_j \frac{D_t}{L_t} \left( \frac{dd_i}{dt} - \frac{d_j}{dt} \right) \right] \frac{dD_t}{dt} \frac{1}{D_t} + \sum_j \lambda^d_j \frac{L_t}{L_t} \tag{8}
\]

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

\[
\lambda^d = \sum_j \lambda^d_j \frac{L_t}{L_t} \quad \text{and} \quad \lambda^i = \sum_j \lambda^i_j \frac{L_t}{L_t} \tag{9}
\]

2.2 Deposits

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

\[
\max_{i^d_j} (i - i^d_j) d_j(i^d_j, i) \tag{10}
\]

First order condition is given by:

\[
(i - i^d_j) \frac{\partial d_j}{\partial i^d_j} - d_j = 0 \tag{11}
\]

Then if we define \(\varepsilon^d_j = \frac{\partial d_j}{\partial i^d_j} \), we have the following condition:

\[
\frac{i - i^d_j}{i^d_j} \varepsilon^d_j = 1 \tag{12}
\]

Then the optimal deposit spread is given by:

\[
i - i^d_j = \frac{1}{1 + \varepsilon^d_j} i \tag{13}
\]
Then, a lower elasticity $\varepsilon^d_j$ increases the deposit spread. Moreover, if we assume that $\varepsilon^d_j$ is independent of $i^d_j$, 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:

$$
\left( \frac{\partial d_j}{\partial i^d_j} \frac{\partial i^d_j}{\partial i} \right) \frac{i}{d_j} = \frac{\partial d_j}{\partial i^d_j} \frac{i}{d_j} \frac{\partial i^d_j}{\partial i} = \varepsilon^d_j \left( 1 + \frac{1}{1 + \varepsilon^d_j} \frac{\partial \varepsilon^d_j}{\partial i} \right)
$$

(14)

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

$$
\left( \frac{\partial d_j}{\partial i^d_j} \frac{\partial i^d_j}{\partial i} \right) \frac{i}{d_j} = \varepsilon^d_j
$$

(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:

$$
\frac{dd_j}{di} \frac{i}{d_j} = \left( \frac{\partial d_j}{\partial i^d_j} \frac{\partial i^d_j}{\partial i} \right) \frac{i}{d_j} + \frac{\partial d_j}{\partial i} \frac{i}{d_j} = \varepsilon^d_j - \frac{\theta_j}{\varepsilon^d_j}
$$

(16)

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

The aggregate response of deposits $D$ is given by:

$$
\frac{dD}{di} \frac{i}{D} = \varepsilon^d - \theta < 0
$$

(17)
where $\varepsilon^d = \sum_j \varepsilon_j^d d_j^D$ and $\theta = \sum_j \theta_j^d d_j^D$. 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:

$$
\frac{dL_t}{di_t} \frac{1}{L_t} = \left[ \chi^d > 0 + \sum_j MPL_j \frac{D_t}{L_t} \left( \frac{\varepsilon_j^d - \theta_j}{\varepsilon^d - \theta} - 1 \right) \frac{d_j^t}{D_t} \right] \frac{\varepsilon^d - \theta}{i} + \sum_j \lambda_j^i \frac{l_j^t}{L_t} \tag{18}
$$

The role of bank heterogeneity is captured by this covariance:

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

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 $\varepsilon_j^d$, 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:

\[
\hat{MPL}_k = \frac{\text{Cov}_k(\Delta \tilde{l}_t, \Delta \tilde{d}_{t+1})}{\text{Cov}_k(\Delta \tilde{d}_t, \Delta \tilde{d}_{t+1})} \frac{l_k}{d_k} \tag{20}
\]

where \( l_k \) and \( d_k \) denote average loans and average deposits, respectively, in bin \( k \), \( \hat{MPL}_k \) is an estimate of MPL for banks in bin \( k \), and \( \hat{\lambda}_d^k \) 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 \( t \), \( \Delta i_t \) 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 $\phi_j$ 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 $\phi_j$ and compute $\hat{MPL}_k$ within each bin following equation (20).

**Figure 1**: Marginal Propensity to Lend and market power

![Figure 1](image_url)

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

Figure 1 shows that the marginal propensity to lend $MPL_k$ is decreasing with deposit market power $\phi_k$, 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 $k$:

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

(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 $\omega_k$ have a higher exposure of deposits to changes in the policy rate.

**Figure 2:** Exposure of deposits and market power

![Figure 2](image-url)

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

Figure 2 shows that exposure of deposits is increasing with deposit market power, $\phi_k$, 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:

\[
\frac{dL}{di} L = \left[ \sum_k \hat{\lambda}_d^{d_k} L \right] + \sum_k \hat{MPL}_k \left( \frac{\hat{\omega} - 1}{\hat{\omega}} \right) \left( \frac{d_k}{D} \right) \frac{D}{L} + \sum_k \hat{\lambda}_i^{l_k} L \quad (23)
\]

where \( \hat{\omega} \) is an estimate of the aggregate response of deposits to monetary policy and \( \hat{\lambda}_d \) 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 \( \hat{\lambda}_d \) is given by:

\[
\hat{\lambda}_d = \sum_k \hat{\lambda}_d^{l_k} L = \frac{\text{Cov}_k(\Delta l_t, \Delta d_{t+1}) l_k}{\text{Cov}_k(\Delta d_t, \Delta d_{t+1}) L} = 0.24 \quad \text{with} \quad l_k = \sum_{j \in k} l_j \quad (24)
\]

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:

\[
\sum_k \hat{MPL}_k \left( \frac{\hat{\omega} - 1}{\hat{\omega}} \right) \left( \frac{d_k}{D} \right) \frac{D}{L} = -0.05 \quad (25)
\]

with \( \hat{\omega} = \sum_k \hat{\omega}_k \frac{d_k}{D} \), \( d_k = \sum_{j \in k} d_j \), \( \hat{MPL}_k = \hat{\lambda}_d^{l_k} d_k \)
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 $\omega_k$. 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 $\phi_j$ from (21).

Figure 3 shows that there is negative relationship between the marginal propensity to lend $MPL_k$ and deposit market power $\phi_k$, 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 $\phi_k$ for each bin $k$. The shaded area is the 95% bootstrap confidence interval for $\hat{MPL}_k$. 
Figure 4: Exposure of deposits and market power

Figure 4 shows that exposure of deposits is increasing with deposit market power, $\phi_k$, 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 $\omega_k$ 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**

![Figure 5: Marginal Propensity to Lend and market power](image)

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

Figure 5 shows that big banks with a lower deposit market power increase lending by more after a transitory increase in deposits. However, bootstrap 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.
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 $\omega_k$ 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 $\phi_k$ for each bin $k$. The shaded area is the 95% bootstrap confidence interval for $\hat{MPL}_k$.

Figure 8: Exposure of deposits and market power

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

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 $\phi_j$ from (21).

Equation (23) can be expressed as follows:

$$\frac{dL}{di} \frac{1}{L} = \left[ \hat{\lambda}^d + \hat{C} \right] \hat{\gamma} + \hat{\lambda}^i$$

(26)

where $\hat{C} = \sum_k MPL_k \left( \hat{\gamma}_k - 1 \right) \left( \frac{\partial_k}{D} \right) \frac{P}{L}$. For the first group (all banks) with weighted regressions, we have $\hat{\lambda}^d = 0.56$ and $\hat{C} = -0.22$ (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)

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

Notes: This table shows the estimates of \(\lambda^d\) and \(\hat{C}\) 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).

 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 $\delta$ 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:

---

2The assumption in those papers is that banks incurs a convex cost if dividends deviate from a target level.
\[b_0 + l_0 = d_0\]
\[
b_1 + (1 - \delta)l_0 = d_1 + (e_1 - c_1)\]  \hfill (27)
\[
c_2 = e_2\]

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 \(\delta\) 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:

\[
CF_1 = (\delta + i_l^l)l_0 + (1 + i_b^b)b_0 - (1 + i_d^d)d_0 \hfill (28)
\]

where \(i_l^l, i_b^b, i_d^d\) 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 \(i_l^l l_0\) and a fraction \(\delta\) of outstanding principal \(l_0\), interest income on bonds \(i_b^b b_0\) and the principal repayment \(b_0\), and pay interest on deposits \(i_d^d d_0\) and repay the principal \(d_0\). Similarly, cash
flows at the beginning of period $t = 2$ are:

$$CF_2 = (1 + i_0^l)(1 - \delta)l_0 + (1 + i_1)b_1 - (1 + i_1^d)d_1$$  \hspace{1cm} (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 $i_1b_1$ 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:

$$b_1 + c_1 = d_1 + CF_1$$  \hspace{1cm} (30)$$

$$c_2 = CF_2$$

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 $(1 + i_1)(e_1 - c_1)$.

$$e_1 = (i_0^l - i_0)l_0 + (i_0 - i_0^d)d_0$$  \hspace{1cm} (31)$$

$$e_2 = (i_0^l - i_1)(1 - \delta)l_0 + (i_1 - i_1^d)d_1 + (1 + i_1)(e_1 - c_1)$$
Interest rate risk. If $i_0^l > i_0$, 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 $i_0^l$. Then, if interest rate increases in the second period such that $i_0^l < i_1$, bank equity in that period would be decreasing in the amount of loans $l_0$. Hence, the spread between $i_0^l$ 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:

$$\max_{c_2, c_1, d_1} \log(c_1) + \beta E_1 \log(c_2)$$

subject to

$$c_2 = (i_0^l - i_1)(1 - \delta)l_0 + (i_1 - i_1^d)d_1 + (1 + i_1)(e_1 - c_1)$$

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

$$c_2 = \beta(1 + i_1)c_1$$

$$i_1 - i_1^d = \frac{1}{1 + \varepsilon^d i_1}$$

where $\varepsilon^d = \frac{\partial d}{\partial i_1} > 0$. The deposit spread is increasing in the policy rate if we assume that the elasticity of deposits $\varepsilon^d$ 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 \(\delta\) 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:

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

subject to \(34\)

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 \(\varepsilon^d\)). 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 $i^d_t$ 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:

$$c_1 = \gamma^d_1 d_1 + \gamma^l l_0 + \gamma^d_0 d_0$$  \hspace{1cm} (37)$$

where:

$$\gamma^d_1 = \frac{1}{1 + \epsilon^d (1 + i_1)(1 + \beta)}$$  \hspace{1cm} \gamma^d_0 = \frac{1}{1 + \epsilon^d (1 + \beta)}$$

$$\gamma^l = \frac{(i^d_0 - i_1)(1 - \delta)}{(1 + i_1)(1 + \beta)} + \frac{(i^d_0 - i_0)}{(1 + \beta)}$$

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

$$E_0 \left[ \frac{\gamma^l}{c_1} \right] = 0$$  \hspace{1cm} (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 $d_0$

$$E_0 \left[ \frac{\gamma^l}{c_1} (\gamma^l MPL + \gamma^d_0) \right] = 0$$  \hspace{1cm} (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. $\Delta d_0 = E_0 \Delta d_1 = 1$
\[
MPL = \frac{-E_0 \left[ \frac{\gamma'}{c_1} \right]}{E_0 \left[ \left( \frac{\gamma'}{c_1} \right)^2 \right]} \gamma_0^d = \frac{\text{Cov}_0 \left( \frac{\gamma'}{c_1}, \frac{1}{c_1} \right)}{\text{Var}_0 \left( \frac{\gamma'}{c_1} \right)} \gamma_0^d > 0 
\]

(40)

Notice that \( E_0 \left[ \gamma' c_1 \right] = E_0 \left[ \frac{\gamma'}{c_1} c_1 \right] = \text{Cov}_0 \left( \frac{\gamma'}{c_1}, \frac{1}{c_1} \right) < 0 \) because an increase in the interest rate \( i_1 \) increases losses from maturity transformation (lower \( \frac{\gamma'}{c_1} \)), 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 \( \gamma_0^d \) and lower variance term in equation (40) but it reduces MPL by lowering the covariance term.

\[
\frac{dMPL}{d(1+e^d)} = \frac{\text{Cov}_0 \left( \frac{\gamma'}{c_1}, -\frac{1}{c_1} \right)}{\text{Var}_0 \left( \frac{\gamma'}{c_1} \right)} \frac{i_0}{1 + \beta} \left[ 1 + \frac{2}{1 + e^d} \frac{\text{Cov}_0 \left( \frac{1}{c_1}, \frac{\gamma'}{c_1} d(1/(1+e^d)) \right)}{\text{Cov}_0 \left( \frac{\gamma'}{c_1}, -\frac{1}{c_1} \right)} \right] 
\]

(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. $\text{Cov}_0\left(\frac{\gamma^l_{c_1}}{c_1}, \frac{1}{c_1}\right)$, 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:

$$\text{Cov}_0\left(\frac{1}{c_1}, \frac{\gamma^l}{c_1} \frac{dc_1}{d(1/(1+\epsilon^d))}\right) < 0$$

(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. $\text{Var}_0 \left( \frac{\gamma}{c_1} \right)$, is lower for banks with more market power because their marginal utility of consumption $\frac{1}{c_1}$ is relatively lower. Hence, we have:

$$\text{Cov}_0 \left( \frac{\gamma^f}{c_1}, \frac{\gamma^f}{c_1^2} \frac{dc_1}{d(1/(1 + e^d))} \right) > 0 \quad (43)$$

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

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

\[
V_0 = \max_{l_0,d_0} \mathbb{E}_0 \Lambda_{0,1} [(1 - \rho) n_1 + \rho V_1]
\]

s.t. \( n_1 = (i_0^l - i_0) l_0 + (i_0^d - i_0) (1 - \delta) l_{-1} + (i_0 - i_0^d) d_0 \)  

\( V_0 \geq \lambda \left[ l_0 + (1 - \delta) l_{-1} \right] \)  

\( V_1 = \max_{d_1} \mathbb{E}_1 \Lambda_{1,2} \left[ (i_0^l - i_1) (1 - \delta) l_0 + (i_1 - i_1^d) d_1 + (1 + i_1) n_1 \right] \)  

\( (44) \)

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

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

\( (45) \)

where:

\[
\Gamma_{-1}^l = \frac{(1-\rho)(i_{-1} - i_0)(1-\delta)}{1+i_0} - \frac{\lambda (1-\delta)}{\lambda - \frac{i_0^d - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left( \frac{i_0^d - i_1}{1+i_1} \right) (1-\delta)}
\]

\[
\Gamma_0^d = \frac{i_0^d - i_0}{1+i_0} - \frac{\rho \mathbb{E}_0 \Lambda_{0,1} \left( \frac{i_0^d - i_1}{1+i_1} \right) (1-\delta)}{\lambda - \frac{i_0^d - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left( \frac{i_0^d - i_1}{1+i_1} \right) (1-\delta)}
\]

\[
\Gamma_1^d = \frac{\rho \Lambda_{0,1} \left( \frac{i_1^1 - i_1}{1+i_1} \right)}{\lambda - \frac{i_0^d - i_0}{1+i_0} - \rho \mathbb{E}_0 \Lambda_{0,1} \left( \frac{i_0^d - i_1}{1+i_1} \right) (1-\delta)}
\]

33
In this case, the marginal propensity to lend is $\frac{\partial l_0}{\partial d_0} = \Gamma d_0$. Since the stochastic discount factor is independent of bank-specific variables, a higher deposit spread, $i_0 - i^d_0$, 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:

$$\frac{(i_0^d - i_0)}{1 + i_0} + \rho(1 - \delta)E_0\Lambda_0 \frac{(i_0^d - i_1)}{1 + i_1} = 0 \quad (46)$$

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:

\[
V_0 = \max_{l_0,d_0} \mathbb{E}_0 \Lambda_{0,1} \text{div}_1 + \mathbb{E}_0 \Lambda_{0,2} \text{div}_2
\]

subject to

\[
e_1 = (i^l_0 - i_0)l_0 + (i^l_{-1} - i_0)(1 - \delta)l_{-1} + (i^d_0 - i^d_0)d_0 - \text{div}_1 - f(\text{div}_1)
\]

\[
\text{div}_2 = (i^l_0 - i_1)(1 - \delta)l_0 + (i_1 - i^d_1)d_1 + (1 + i_1)e_1 - f(\text{div}_2)
\]

\[
V_1 = \max_{\text{div}_1,\text{div}_2,d_1} \text{div}_1 + \mathbb{E}_1 \Lambda_{1,2} \text{div}_2
\]

\[
f(\text{div}_t) = \frac{\kappa}{2} (\text{div}_t - \bar{\text{div}})^2
\]

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

\[
\mathbb{E}_0 \left[ \frac{\Lambda_{0,1}}{1 + \kappa(\text{div}_1 - \bar{\text{div}})} \left( \frac{(i^l_0 - i_1)(1 - \delta)}{1 + i_1} + (i^d_0 - i_0) \right) \right] = 0 \tag{48}
\]

where:

\[
\text{div}_1 + f(\text{div}_1) = \left[ \frac{(i^l_0 - i_1)(1 - \delta) + (i^l_0 - i_0)(1 + i_1)}{2 + i_1} \right] l_0 + \left[ \frac{i_1 - i_1^d}{2 + i_1} \right] d_1
\]

\[
+ \left[ \frac{(1 + i_1)(i_0 - i_0^d)}{2 + i_1} \right] d_0 + \left[ \frac{(1 + i_1)(i_{-1}^l - i_0)(1 - \delta)}{2 + i_1} \right] l_{-1} \tag{49}
\]

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.

8 Bibliography


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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 \( i^d_t \). Interest expenses on deposits divided by total deposits and multiplied by 100.

Policy rate \( i_t \). Fed funds target rate from FRED.

Deposit Spread \( i_t - i^d_t \). The first difference \( \Delta(i_t - i^d_t) \) 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.

\[
\log d_t = X_{t-1}'\beta + \log d^p_t + \log d^T_t \quad (50)
\]

where \(X_{t-1}\) is a vector of lagged bank-level controls, \(\log d^p_t\) 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.

\[
\log d^p_t = \log d^p_{t-1} + \varepsilon^P_t \\
\log d^T_t = \varepsilon^T_t
\]

where \(\varepsilon^P_t\) and \(\varepsilon^T_t\) are serially uncorrelated. Then, the unexplained change in log deposits is:

\[
\Delta \tilde{d}_t = \varepsilon^P_t + \Delta \varepsilon^T_t \quad (51)
\]

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:

\[
\Delta \tilde{l}_t = \chi^d \varepsilon^P_t + \lambda^d \varepsilon^T_t + \xi_t \quad (52)
\]

where \(\chi^d\) measures the impact of permanent deposit shocks on lending and \(\lambda^d\) captures the impact of transitory deposit shocks on bank lending, and \(\xi_t\) represents unexpected changes in lending independent of deposit shocks. We

\footnote{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 $\lambda^d$ multiply by the ratio of loans over deposits. Identification of $\lambda^d$ 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:

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

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

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

$$
\text{Cov}(\Delta d_t, \Delta d_{t+1}) = -\text{Var}(\varepsilon^T_t) \tag{55}
$$

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

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

where $l$ and $d$ denote average loans and average deposits.