The Deposits Channel of Monetary Policy A Critical Review

Rafael Repullo
CEMFI and CEPR

March 2025

Abstract

Drechsler, Savov, and Schnabl (2017) claim that increases in the monetary policy rate lead to reductions in bank deposits, which account for the subsequent contraction in lending. This paper reviews their theoretical analysis, based on a model of imperfect competition in a local banking market, showing that the relationship between the policy rate and the equilibrium amount of deposits is either flat or increasing in the relevant range. Moreover, this is consistent with their panel regression results showing that an increase in the policy rate leads to smaller changes in deposits at branches with high market power. These results question the theoretical underpinnings of the "deposits channel" of monetary policy transmission.

JEL Classification: E52, G21, L13

Keywords: Monetary policy transmission, banks' market power, deposits channel.

I would like to thank the comments of Anmol Bhandari (the Editor) and three anonymous referees, as well as those of Viral Acharya, David Martinez-Miera, Pablo Ruiz-Verdú, Mauricio Ulate, and seminar audiences at the European Central Bank, the Federal Reserve Board, and the congresses of the European and the Spanish Economic Associations. I am also grateful to Vedant Agarwal, Paolo De Rosa, Martin Farias, Manuel Ruiz, Junyan Yu, and Jianing Yuan, for their research assistance. Financial support from the Spanish Ministry of Science and Innovation, Grant No. PID2022-142998NB-I00 is acknowledged. E-mail: repullo@cemfi.es.

> "When the Fed funds rate rises, banks widen the interest spreads they charge on deposits, and deposits flow out of the banking system. Since banks rely heavily on deposits for their funding, these outflows induce a contraction in lending."
>
> Drechsler, Savov, and Schnabl (2017)

1 Introduction

The paper by Drechsler, Savov, and Schnabl (2017), henceforth DSS, presents a novel empirical analysis of the effect of changes in the monetary policy rate on the amount of bank deposits in local markets characterized by different degrees of market power. In particular, they show in a panel regression that increases in the Federal funds rate lead to smaller changes in deposits at bank branches located in concentrated counties relative to those in less concentrated counties. This result is then used to propose a novel explanation of the effect of monetary policy on bank lending, called the "deposits channel" of monetary policy. In their words: "Deposits are the main source of funding for banks. Their stability makes them particularly well suited for funding risky and illiquid assets. As a result, when banks contract deposit supply they also contract lending." The paper also constructs a theoretical model of imperfect competition in a local banking market to account for their empirical findings.

This paper presents a critical review of DSS theoretical model, showing that *the relationship between the policy rate and the equilibrium amount of deposits is either flat or increasing in the relevant range*. The model features a representative household with an initial wealth that can be invested in three types of assets: cash that pays a zero interest rate, deposits of a set of n banks that pay the equilibrium deposit rates, and bonds that pay the policy rate set by the central bank. The demand for bank deposits is derived from a utility function that depends on final wealth and liquidity services provided by cash and deposits. Banks offer differentiated deposits and compete by setting deposit rates, earning the policy rate on their investments. Equilibrium deposit rates are derived from the symmetric Nash equilibrium of the game played by the banks. The key question is: What is the effect on equilibrium deposits of an exogenous change in the policy rate?

The contrast with the results in DSS is explained by the introduction of two reasonable assumptions not considered by them. The first assumption is a borrowing constraint stating that the household cannot borrow at the policy rate to overinvest in cash and/or deposits. The second assumption is that banks cannot pay negative deposit rates. These assumptions are binding for low values of the policy rate: if cash and deposits yield valuable liquidity services and pay a similar return as bonds, the household would want to short a very large amount of bonds to invest the proceeds in the liquid assets. If this is not possible, the household would have to invest all her wealth in cash and deposits. For sufficiently low values of the policy rate, the banks would set a zero deposit rate, in which case the equilibrium amount of cash and deposits would not change with the policy rate. Beyond this threshold, deposit rates would start to go up, and the household would increase her holdings of deposits and reduce her holdings of cash. Hence, the flat and then increasing relationship between the policy rate and the equilibrium amount of deposits.

Before explaining the effect of market power on this relationship, I would like to briefly comment on DSS's empirical results. Their paper starts presenting some suggestive time series evidence showing a negative correlation between changes in the Federal funds rate and changes in various types of bank deposits. But since business cycle developments may be driving all these variables, they propose an identification strategy that relies on panel data on deposit rates and deposit holdings at bank branches in different counties. Exploiting the variation in market power at the county level, they compare the effect of changes in the Federal funds rate in branches of the same bank located in different counties.

The key panel regressions have as dependent variables (i) the quarterly change in the spread s_{it} between the Federal funds rate r_t and the deposit rate of a bank's branch i, and (ii) the annual log change in the deposits D_{it} of branch i. The main explanatory variable is an interaction term between the change in the Federal funds rate r_t and the Herfindahl index HHI_i computed with the deposit market shares of the banks operating in the county where branch i is located. Thus, they estimate the following equation

$$\Delta y_{it} = \alpha_i + \gamma(\Delta r_t \times \text{HHI}_i) + \text{ Controls } + \varepsilon_{it}, \tag{1}$$

where Δy_{it} is either Δs_{it} or $\Delta \ln D_{it}$, and the controls include bank-time fixed effects. Bank-specific characteristics (such as lending opportunities) are controlled by comparing branches of the same bank in different counties.

The results for the *spreads equation* show that γ_s is positive and statistically significant, which means that an increase in the Federal funds rate leads to larger changes in spreads (and smaller changes in deposit rates) at branches located in high concentration counties. The results for the *deposits equation* show that γ_D is negative and statistically significant, which means that an increase in the Federal funds rate leads to smaller changes in deposits at branches located in high concentration counties.[1]

The problem arises with DSS interpretation of these empirical results. They write: "Following an increase in the Federal funds rate, the bank's branches in more concentrated counties (...) experience *larger outflows* relative to its branches in less concentrated counties" (my italics). More importantly, from here they jump to the conclusion that these results imply that "when the Federal funds rate rises, banks widen the interest spreads they charge on deposits, and *deposits flow out of the banking system*" (my italics). But the fact that coefficient γ_D is negative and statistically significant does not imply that increases in the Federal funds rate lead to reductions in the aggregate amount of deposits. The panel regressions only imply a relative effect when comparing counties with high and low market power, not an absolute effect of the policy rate on bank deposits.

To rationalize these empirical results, I use the theoretical model to analyze the effect of a change in the number n of banks on the relationship between the policy rate and equilibrium spreads and deposits. In line with their empirical results, I show that increasing the number of banks (i) reduces the slope of the relationship between the policy rate and equilibrium spreads, and (ii) increases the slope of the relationship between the policy rate and equilibrium deposits. Thus, the predictions of the model are consistent with the empirical

[1] These empirical results have been criticized by Begenau and Stafford (2023) because of the widespread use of uniform deposit pricing policies among large commercial banks. See Drechsler et al. (2024) for a response to this criticism. See also d'Avernas et al. (2023) for a model with large and small banks, where the former provide superior liquidity services but face higher costs and are more likely to rely on simple decision rules regarding lending and pricing.

results in DSS's regressions: spreads are more sensitive and deposits are less sensitive to changes in the policy rate when banks' market power is high than when it is low. More importantly, my results show that, in the relevant range of policy rates, increases in the policy rate do not lead to a reduction in bank deposits, questioning that theoretical underpinnings of the "deposits channel" of monetary policy transmission.

This paper is related to the growing literature on the transmission of monetary policy when banks have market power; see, for example, Corbae and Levine (2018), Wang et al. (2022), and Abadi et al. (2023). It is also related to papers that analyze the pass-through from policy rates to deposits and loan rates; see, for example, Ulate (2021) and Eggertsson et al. (2023). In terms of results, it is closer to the papers that emphasize the heterogeneous effects of monetary policy, such as Kashyap and Stein (2000), for large and small banks, Jiménez et al. (2012), for banks with different levels of capital, Martinez-Miera and Repullo (2020), for banks with different degrees of market power, and Heider et al. (2019), for banks with different balance sheet structures.

The remainder of the paper is structured as follows. Section 2 presents DSS theoretical model. Section 3 analyzes the equilibrium of the model in the special case of a monopoly bank. Section 4 analyzes the equilibrium in the general oligopoly case. Section 5 concludes. The proofs of all the results are in the Appendix.

2 DSS Model

Consider a representative household with *initial wealth* W_0 and preferences described by a CES utility function over *final wealth* W and *liquidity services* L such that

$$U(W,L) = \left(W^{\frac{\rho-1}{\rho}} + \lambda L^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}, \tag{2}$$

where $\lambda > 0$ captures the utility of liquidity services relative to final wealth. Following DSS, it is assumed that final wealth and liquidity services are complements, so the elasticity of substitution satisfies $0 < \rho < 1$.

Liquidity services L are derived from a CES function over *cash* M and *deposits* D such that

$$L(M,D)=\left(M^{\frac{\epsilon-1}{\epsilon}}+\delta D^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{3}$$

where $\delta > 0$ captures the liquidity of deposits relative to cash. Following DSS, it is assumed that cash and deposits are substitutes, so the elasticity of substitution satisfies $\epsilon > 1$.

Deposits D are a composite good produced by a set of n banks according to a CES function of the deposits D_i of the $i = 1, ..., n$ banks with

$$D=\left(\frac{1}{n}\sum_{i=1}^{n} D_i^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}, \tag{4}$$

where D_i are the deposits of bank i. Following DSS, it is assumed that the deposits of the different banks are substitutes, so the elasticity of substitution satisfies $\eta > 1$.

The representative household can invest her initial wealth W_0 in three types of assets: *cash* M that pays a zero interest rate, *deposits* D_i of bank $i = 1, 2, ...n$ that pay an interest rate r_i, and *bonds* that pay an interest rate $r \geq 0$ which is interpreted as the monetary policy rate set by the central bank. Final wealth W is then given by

$$W = M + \sum_{i=1}^{n} D_i(1 + r_i) + (W_0 - M - \sum_{i=1}^{n} D_i)(1 + r).$$

Letting $s_i = r - r_i$ be the *deposit spread* charged by bank i, final wealth simplifies to

$$W = W_0(1 + r) - \sum_{i=1}^{n} D_i s_i - Mr. \tag{5}$$

According to this expression, final wealth W equals the market return of the initial wealth $W_0(1 + r)$ minus the opportunity cost of deposit holdings $\sum_{i=1}^{n} D_i s_i$ and the opportunity cost of cash holdings Mr.

One feature of DSS specification of the composite deposits (4) is that $D_1 = ... = D_n$ implies $D = D_1 = ... = D_n$, so D_i cannot really be interpreted as the deposits of bank i. This is important since the opportunity cost of a given amount of composite deposits D, assuming that all banks charge the same spread s, is nDs. Thus, an increase in the number of banks would increase the cost of deposit holdings without any increase in the household's utility, leading to a downward bias in the demand for deposits. Given that the key DSS regression is about the effect of changes in the policy rate on equilibrium deposits for different degrees of banks' market power, this feature has consequences for understanding their empirical results.

For this reason, in the analysis of the oligopoly model in Section 4, I will assume an alternative specification of the composite deposits, namely

$$D = \left(\frac{1}{n} \sum_{i=1}^{n} (nD_i)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{6}$$

where $\eta > 1$. Under this specification, $D_1 = ... = D_n$ implies $D = D_1 + ... + D_n$, so D_i can be interpreted as the deposits of bank i. In this case, an increase in the number of banks increases both the cost and the utility of deposit holdings. However, it is important to note that both specifications, (4) and (6), are identical in the case of a monopoly bank analyzed in Section 3.

Given the policy rate r and the deposit spreads $s_1, ..., s_n$ set by the n banks, the representative household maximizes her utility function (2) subject to the constraint (5). The solution to this problem yields a demand for deposits $D_i(s_1, ..., s_n; r)$ of bank $i = 1, ..., n$. Assuming that banks earn the policy rate r on their investments, the profits of bank $i = 1, ..., n$ are

$$\pi_i(s_1, ..., s_n; r) = (r - r_i) D_i(s_1, ..., s_n; r) = s_i D_i(s_1, ..., s_n; r). \tag{7}$$

These payoff functions are used to compute the symmetric *Nash equilibrium spread* $s^*(r)$ set by the banks as a function of the policy rate r. Finally, substituting the equilibrium spreads into the household demand for deposits, and using (6), gives the *equilibrium amount of deposits* $D^*(r)$. DSS claim that $D^*(r)$ is decreasing in the policy rate r.

In what follows I will examine the validity of the this claim under two reasonable assumptions not considered by DSS. The first assumption is that the household's choice of cash and deposits is restricted to satisfy the borrowing constraint

$$M + \sum_{i=1}^{n} D_i \leq W_0. \tag{8}$$

Thus, the household cannot borrow at the policy rate r to overinvest in cash and deposits. The second assumption is that banks cannot pay negative deposit rates, so $r_i \geq 0$ for

$i = 1, ..., n$. Thus, deposit spreads have to satisfy $s_i = r - r_i \leq r$ for $i = 1, ..., n$.[2]

Finally, to simplify the analysis, in what follows I assume that the parameters of the liquidity services function take the values $\delta = 1$ and $\epsilon = 2$, so (3) becomes

$$L(M, D) = \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^2. \tag{9}$$

To review the results of DSS, it is convenient to start with the simpler case of a monopoly bank ($n = 1$).

3 The Monopoly Model

To assess the effect of a change in the monetary policy rate r on the equilibrium amount of deposits of the monopoly bank, one has to determine the equilibrium spread set by the bank, which in turn requires deriving the household's demand for cash M and deposits D as a function of the policy rate r and the deposit spread s.

I first derive these functions for the case in which there is no borrowing constraint (8). Then, I show that this constraint will be violated for small values of the policy rate r, and derive the demands for cash and deposits under this constraint. Finally, I characterize the monopoly bank's optimal choice of spread s^* and the corresponding equilibrium amount of deposits D^* as a function of r.

Proposition 1 *In the absence of the borrowing constraint $M + D \leq W_0$, the household's unconstrained demands for cash and deposits are*

$$\widehat{M}(s; r) = \frac{W_0(1 + r)}{\mu r^2(1 + \lambda^{-\rho}\mu^{1-\rho})} \text{ and } \widehat{D}(s; r) = \frac{W_0(1 + r)}{\mu s^2(1 + \lambda^{-\rho}\mu^{1-\rho})}, \tag{10}$$

where

$$\mu = \frac{1}{r} + \frac{1}{s}. \tag{11}$$

It can be checked that $\partial\widehat{D}/ds < 0$, so the demand for deposits is decreasing in the spread s, and that $\partial\widehat{D}/dr > 0$, so an increase in the policy rate r leads to an outward shift in the demand for deposits.

[2] Note that since cash and deposits enter the utility function and are imperfect substitutes, the demand for deposits of bank i would not drop to zero when $r_i < 0$. Thus, $r_i \geq 0$ is an assumption.

It is important to note that if the deposit rate cannot be negative, the demand for deposits $\widehat{D}(s;r)$ becomes unbounded for low values of the policy rate r. To show this, note that $0 \leq s \leq r$ implies $\lim_{r\to 0} s = 0$ and $\lim_{r\to 0}(s/r) \leq 1$, so for $0 < \rho < 1$ the denominator of $\widehat{D}(s;r)$ in (10) satisfies

$$\lim_{r\to 0}[\mu s^2(1+\lambda^{-\rho}\mu^{1-\rho})] = \lim_{r\to 0}\left[s\left(\frac{s}{r}+1\right)+\lambda^{-\rho}s^{\rho}\left(\frac{s}{r}+1\right)^{2-\rho}\right] = 0.$$

Hence, for low values of r the constraint $M + D \leq W_0$ is always violated. This is easy to explain: if cash and deposits yield valuable liquidity services and (in the limit) pay the same return as bonds, the household would want to short an infinite amount of bonds to invest the proceeds in the liquid assets.[3]

To ascertain under what conditions the borrowing constraint $M + D \leq W_0$ is binding, I first state the following result.

Proposition 2 *The household's unconstrained demands for cash and deposits* (10) *are such that* $\widehat{M}(s;r) + \widehat{D}(s;r)$ *is decreasing in the spread* s.

This result implies that

$$\widehat{M}(s;r) + \widehat{D}(s;r) > \widehat{M}(r;r) + \widehat{D}(r;r)$$

for $s < r$. Hence, a sufficient condition for the constraint $M + D \leq W_0$ to be binding is that

$$\widehat{M}(r;r) + \widehat{D}(r;r) \geq W_0,$$

which leads to the following result.

Proposition 3 *The borrowing constraint* $M + D \leq W_0$ *is binding if*

$$\rho \geq \frac{\ln 2}{\ln \lambda - \ln r + \ln 2}. \tag{12}$$

Figure 1 plots the sufficient condition (12) for the two parameters of the utility function (2), namely λ that captures the utility of liquidity services relative to final wealth (in the

[3] This point was noted by Sá and Jorge (2019), but they did not formally analyze the model with a nonnegative restriction on bond holdings.

horizontal axis) and ρ that captures the elasticity of substitution between final wealth and liquidity services (in the vertical axis), and two values of the policy rate, namely $r = 5\%$ and $r = 10\%$.

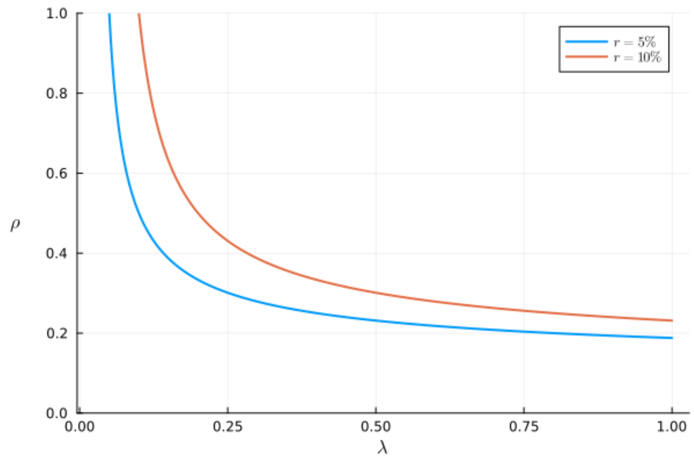

Figure 1. Sufficient condition for a binding borrowing constraint

This figure plots the sufficient condition (12) for a binding borrowing constraint, with parameter λ in the horizontal axis and parameter ρ in the vertical axis. In the region above the red (blue) line the constraint is binding for a policy rate of 10% (5%).

The conclusion is that for low values of the policy rate r, high values of the parameter λ that captures the utility of liquidity services relative to final wealth, and high values of the parameter ρ that captures the elasticity of substitution between final wealth and liquidity services the borrowing constraint $M + D \leq W_0$ will be violated.

To complete the analysis of the monopoly model I next analyze the case where the household's choice of cash and deposits is restricted to satisfy the constraint $M + D \leq W_0$.

I start by considering a situation in which the household can only invest in cash and deposits, so $M + D = W_0$. In this case her final wealth is $W = M + D(1 + r_1) = W_0 + Dr_1$, where $r_1 = r - s$ denotes the deposit rate set by the monopoly bank 1. Hence, the problem of the household becomes

$$\max_{D} \left[(W_0 + Dr_1)^{\frac{\rho-1}{\rho}} + \lambda \left((W_0 - D)^{\frac{1}{2}} + D^{\frac{1}{2}} \right)^{\frac{2(\rho-1)}{\rho}} \right]^{\frac{\rho}{\rho-1}}. \tag{13}$$

I can now prove the following result.

Proposition 4 *When the household can only invest in cash and deposits, her constrained demands for cash and deposits are*

$$\overline{M}(s;r) = W_0 - \overline{D}(s;r) \text{ and } \overline{D}(s;r) = \overline{D}(r_1),$$

where $\overline{D}(r_1)$ *is a solution to the first-order condition*

$$(W_0 + Dr_1)^{-\frac{1}{\rho}} r_1 = \lambda \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^{-\frac{2}{\rho}} \left[\left(\frac{D}{M}\right)^{\frac{1}{2}} - \left(\frac{M}{D}\right)^{\frac{1}{2}}\right], \tag{14}$$

with $r_1 = r - s$ *and* $M = W_0 - D$.

The first-order condition (14) implies that when $r_1 = 0$, that is when the deposit rate paid by the monopoly bank equals zero, the solution is $\overline{D} = \overline{M} = W_0/2$, so the household's initial wealth is equally divided between cash and deposits.[4] Similarly, for $r_1 > 0$, (14) implies $\overline{D} > W_0/2 > \overline{M}$, so the household holds more deposits than cash.

I can now turn to the characterization of the monopoly bank's optimal choice of spread s^* for any given level of the policy rate r, which requires specifying the household's demand for deposits $D(s;r)$. Since the unconstrained demand derived in Proposition 1 satisfies $\lim_{s\to 0} \widehat{D}(s;r) = \infty$, the constraint $M + D \leq W_0$ will be binding for low values of the spread, in which case $D(s;r) = \overline{D}(s;r)$, where $\overline{D}(s;r)$ is the constrained demand derived in Proposition 4; otherwise, we have $D(s;r) = \widehat{D}(s;r)$. From here it follows that the household's demand for deposits for $0 \leq s \leq r$ is given by

$$D(s;r) = \min\left\{\overline{D}(s;r), \widehat{D}(s;r)\right\}. \tag{15}$$

Substituting (15) into the bank's profit function (7) for $n = 1$ gives the profit maximizing spread

$$s^*(r) = \arg\max_{0\leq s\leq r} [sD(s;r)],$$

[4]It can be checked that when the parameter δ of the liquidity services function (3) that captures the liquidity of deposits relative to cash is greater (smaller) than 1, the household holds more (less) deposits than cash when the deposit rate $r_1 = 0$.

which implies the following equilibrium amount of deposits

$$D^*(r) = D(s^*(r); r).$$

Figure 2 plots the function $D(s; r)$ for two cases with $W_0 = 1$ (a normalization), $\rho = 0.5$, and $r = 10\%$. Panel A takes $\lambda = 0.2$, in which case $D(s; r) = \overline{D}(s; r)$. The profit maximizing spread is located at the corner where the deposit rate set by the monopoly bank is at the zero lower bound, with $s^* = r = 10\%$ and an equilibrium amount of deposits $D^* = 0.5$. As noted above, with an equilibrium deposit rate $r_1^* = r - s^* = 0$ the household's initial wealth is equally divided between cash and deposits. Panel B takes $\lambda = 0.1$, in which case the profit maximizing spread is located at the kink where $\overline{D}(s; r) = \widehat{D}(s; r)$, with $s^* = 5\%$ and an equilibrium amount of deposits $D^* = 0.8$. Since the constraint $M + D \leq W_0$ is binding, the equilibrium amount of cash holdings is $M^* = 1 - D^* = 0.2$.

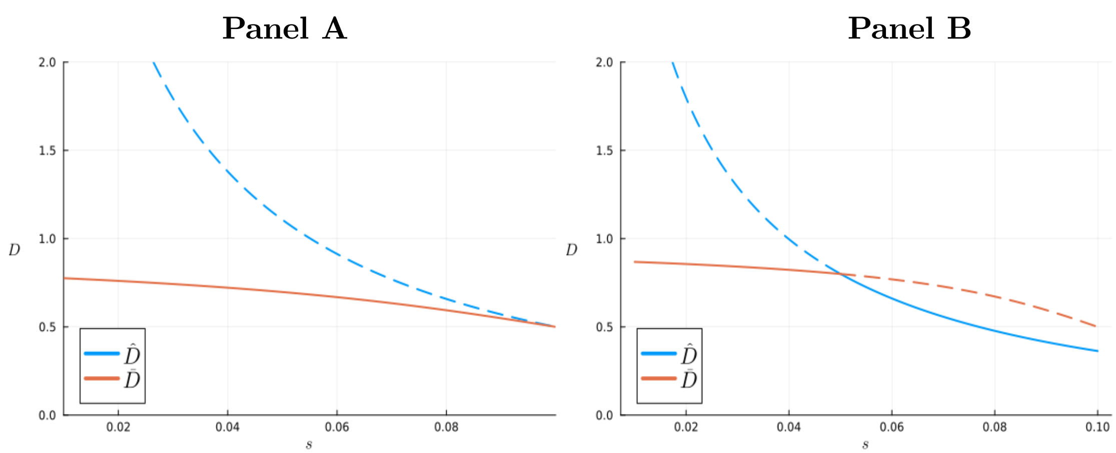

Figure 2. Profit maximizing spreads of the monopoly bank

This figure characterizes the profit maximizing spreads of the monopoly bank. The blue (red) curves correspond to the unconstrained (constrained) demand for deposits. The borrowing constraint is binding to the left of the intersection between the two curves. In Panel A the bank sets a spread at the corner with $s^* = r$. In Panel B the bank sets a spread at the kink with $s^* < r$.

Figure 3 plots the equilibrium amount of deposits of the monopoly bank $D^*(r)$ for values of the policy rate that range from $r = 0$ to $r = 40\%$, and different combinations of parameters λ and ρ, which capture, respectively, the utility of liquidity services relative to final wealth and the elasticity of substitution between final wealth and liquidity services. In order to cover a wide range of these parameters I take $\lambda = 0.1$, 0.2, and 0.5, and $\rho = 0.2$, 0.5, and 0.8. The pattern that emerges from this figure is clear. For high values of the elasticity of substitution ρ equilibrium deposits D^* are initially flat, corresponding to the deposit rate being at the zero lower bound, and then increasing in the policy rate r. For low values of the the elasticity of substitution ρ the same pattern obtains for very low values of the policy rate, but beyond a critical rate there is a reversal in the sign of the relationship, corresponding to the point where the borrowing constraint $M + D \leq W_0$ ceases to be binding. At the same time, increases in the utility of liquidity services relative to final wealth λ move to the right the points at which the zero lower bound on deposit rates and the borrowing constraint cease to be binding.

It should be noted that when the borrowing constraint $M + D \leq W_0$ is not binding, an increase in the policy rate r has a non-monotonic effect on the equilibrium amount deposits D^*, which are first decreasing and then increasing in r. This is explained by a combination of substitution and income effects going in opposite directions. To see this, consider the household's budget constraint (5) rewritten as

$$Mr + Ds + W = W_0(1 + r).$$

An increase in the policy rate r increases the "price" of cash r and the "price" of deposits s (since s is generally increasing in r), so there is a *substitution effect* that reduces the demand for cash and deposits. At the same time, the increase in r produces an *income effect* that increases the demand for cash and deposits, so the final effect is in general ambiguous. The numerical results show that the substitution effect dominates for intermediate values of the policy rate while the income effect dominates for high values of the policy rate.

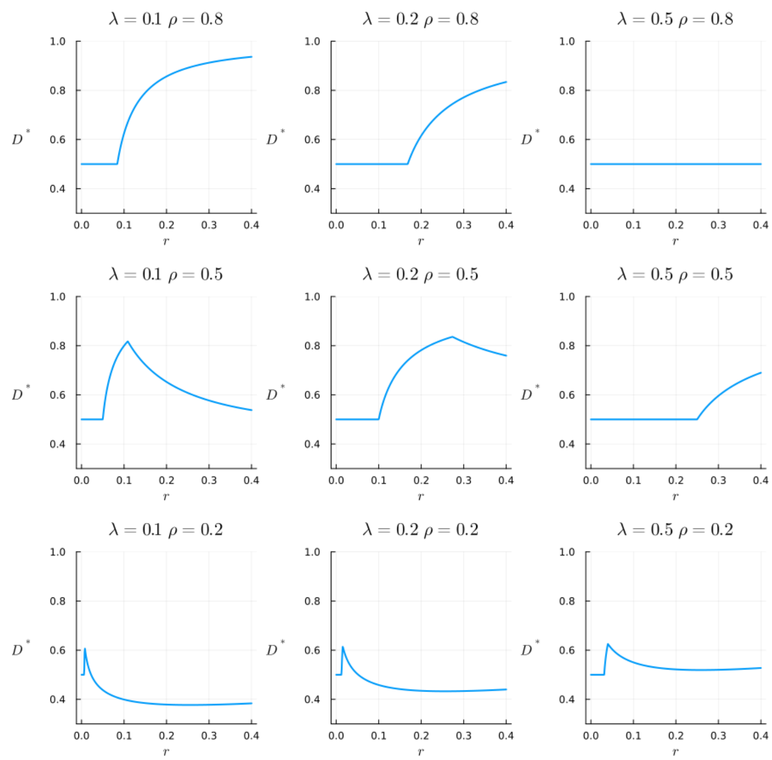

Figure 3. Equilibrium deposits of the monopoly bank

This figure plots the equilibrium amount of deposits of the monopoly bank for values of the policy rate that range from 0% to 40% and different combinations of parameters λ and ρ.

It is worth noting that when $\rho \to 0$ the borrowing constraint $M + D \leq W_0$ will not be binding and equilibrium amount of deposits D^* will be increasing in the policy rate r, so the income effect dominates the substitution effect. To see this, consider the limit case $\rho = 0$ and suppose that the borrowing constraint $M + D \leq W_0$ is not binding, so

$$D(s;r) = \widehat{D}(s;r) = \frac{W_0(1+r)}{\mu s^2(1+\mu)}.$$

Then, one can show that $s^*(r) = r/\sqrt{1+r}$ and

$$D^*(r) = \frac{1+r}{2+\sqrt{1+r}+1/\sqrt{1+r}},$$

which is an increasing function of r. Since $M^*(r) + D^*(r) \leq W_0$ for a large range of values of r,[5] the borrowing constraint $M + D \leq W_0$ will in fact not be binding in this range. Hence, by continuity, for small values of the elasticity of substitution ρ the equilibrium amount of deposits D^* will also be increasing in the policy rate r.

Summing up, I have shown that for low values of the policy rate the household will always invest her entire initial wealth in cash and deposits of the monopoly bank, in which case the equilibrium amount of deposits will be first flat and then increasing in the policy rate. Moreover, the range of values of the policy rate for which this result obtains is decreasing in the parameter λ that captures the utility of liquidity services relative to final wealth, and increasing in the parameter ρ that captures the elasticity of substitution between final wealth and liquidity services. Finally, when the borrowing constraint is not binding, the equilibrium amount of deposits will be increasing in the policy rate as long as the elasticity of substitution ρ is sufficiently low.

4 The Oligopoly Model

I next consider the oligopoly model in which $n > 1$ banks indexed by $i = 1, 2, ..., n$ compete in the deposit market by setting spreads s_i between the policy rate r and their deposit rate r_i. As in the case of the monopoly model, I start with the case in which there is no borrowing constraint.

Proposition 5 *In the absence of the borrowing constraint* (8), *the household's unconstrained demands for cash and deposits of any bank i are*

$$\widehat{M}(s_1, ..., s_n; r) = \frac{W_0(1+r)}{\mu r^2 (1 + \lambda^{-\rho} \mu^{1-\rho})} \tag{16}$$

and

$$\widehat{D}_i(s_1, ..., s_n; r) = s_i^{-\eta} \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}} \frac{W_0(1+r)}{n\mu(1 + \lambda^{-\rho} \mu^{1-\rho})}, \tag{17}$$

where

$$\mu = \frac{1}{r} + \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{\frac{1}{\eta-1}}. \tag{18}$$

[5] By the proof of Proposition 1, $M^* = D^* r^2 / s^2$. Substituting $s^* = r/\sqrt{1+r}$ into this expression implies $M^* = D^*/(1+r)$. Solving $M^* + D^* = D^*(2+r)/(1+r) \leq W_0$ then gives $r \leq 238\%$.

Proposition 5 implies that in a symmetric Nash equilibrium where all the banks set the same spread s we have

$$\widehat{M}(s,...,s;r)=\widehat{M}(s;r) \text{ and } \textstyle\sum_{i=1}^{n}\widehat{D}_i(s,...,s;r)=\widehat{D}(s;r),$$

where $\widehat{M}(s;r)$ and $\widehat{D}(s;r)$ are defined in Proposition 1, and μ in (18) is the same as μ in (11). From here it follows that, when focussing on symmetric equilibria, Propositions 2 and 3 also apply to the oligopoly model. Thus, for low values of the policy rate r the household's choice of cash and deposits has to be restricted to satisfy the borrowing constraint (8).

As in the case of monopoly, I next consider a situation in which the household can only invest in cash and deposits, in which case her final wealth is

$$W=M+\textstyle\sum_{i=1}^{n}D_i(1+r_i)=W_0+\sum_{i=1}^{n}D_ir_i.$$

Hence, the problem of the household becomes

$$\max_{D_1,\dots,D_n}\left[\left(W_0+\textstyle\sum_{i=1}^{n}D_ir_i\right)^{\frac{\rho-1}{\rho}}+\lambda\left(\left(W_0-\sum_{i=1}^{n}D_i\right)^{\frac{1}{2}}+D^{\frac{1}{2}}\right)^{\frac{2(\rho-1)}{\rho}}\right]^{\frac{\rho}{\rho-1}},\tag{19}$$

where D is given by (6).

Proposition 6 *When the household can only invest in cash and deposits, her constrained demands for cash and deposits of any bank i when it pays a deposit rate r_i and the other $n-1$ banks pay a deposit rate r_{-i} are*

$$\overline{M}(s_i,s_{-i};r)=W_0-\overline{D}_i(s_i,s_{-i};r)-(n-1)\overline{D}_{-i}(s_i,s_{-i};r),$$

where $\overline{D}_i(s_i,s_{-i};r)=\overline{D}_i(r_i,r_{-i})$ and $\overline{D}_{-i}(s_i,s_{-i};r)=\overline{D}_{-i}(r_i,r_{-i})$ are a solution to the first-order conditions

$$\begin{aligned}(W_0+D_ir_i+(n-1)D_{-i}r_{-i})^{-\frac{1}{\rho}}r_i &= \lambda(M^{\frac{1}{2}}+D^{\frac{1}{2}})^{\frac{\rho-2}{\rho}}\left(M^{-\frac{1}{2}}-D^{\frac{2-\eta}{2\eta}}(nD_i)^{-\frac{1}{\eta}}\right), \quad (20)\\ (W_0+D_ir_i+(n-1)D_{-i}r_{-i})^{-\frac{1}{\rho}}r_{-i} &= \lambda(M^{\frac{1}{2}}+D^{\frac{1}{2}})^{\frac{\rho-2}{\rho}}\left(M^{-\frac{1}{2}}-D^{\frac{2-\eta}{2\eta}}(nD_{-i})^{-\frac{1}{\eta}}\right), \quad (21)\end{aligned}$$

with

$$D=\left(\frac{1}{n}(nD_i)^{\frac{\eta-1}{\eta}}+\frac{n-1}{n}(nD_{-i})^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

$r_i = r - s_i$, $r_{-i} = r - s_{-i}$, *and* $M = W_0 - D_i - (n-1)D_{-i}$,

Note that dividing (20) by (21) gives

$$\frac{r_i}{r_{-i}} = \frac{M^{-\frac{1}{2}} - D^{\frac{2-\eta}{2\eta}}(nD_i)^{-\frac{1}{\eta}}}{M^{-\frac{1}{2}} - D^{\frac{2-\eta}{2\eta}}(nD_{-i})^{-\frac{1}{\eta}}}.$$

Hence, $r_i > r_{-i}$ implies $(nD_i)^{-\frac{1}{\eta}} < (nD_{-i})^{-\frac{1}{\eta}}$, which in turn implies $D_i > D_{-i}$. Thus, if bank i pays a higher deposit rate than the other $n-1$ banks, it will get a higher amount of deposits.

Also, note that when all banks pay a zero deposit rate, (20) implies

$$M^{-\frac{1}{2}} = D^{\frac{2-\eta}{2\eta}}(nD_i)^{-\frac{1}{\eta}} = (nD_i)^{\frac{2-\eta}{2\eta}}(nD_i)^{-\frac{1}{\eta}} = (nD_i)^{-\frac{1}{2}},$$

which implies $\overline{M} = W_0/2$ and $n\overline{D}_i = W_0/2$, so the household's initial wealth is equally divided between cash and deposits of the n banks.

I can now turn to the characterization of the symmetric *Nash equilibrium spread* $s^*(r)$ set by the banks as a function of the policy rate r. As in the case of the monopoly bank, the demand for deposits of any bank i has two possible regimes, namely one in which the borrowing constraint (8) is not binding, where the demand is given in Proposition 5, and one in which the constraint is binding, where the demand is characterized in Proposition 6.

The Nash equilibrium spread is such that the best response of any bank i to the spread $s^*(r)$ set by the other $n-1$ banks is $s^*(r)$. To compute the best response function, write the profits (7) of bank i as

$$\pi_i(s_i, s_{-i}; r) = s_i D_i(s_i, s_{-i}; r),$$

where

$$D_i(s_i, s_{-i}; r) = \min\left\{\widehat{D}_i(s_i, s_{-i}; r), \overline{D}_i(s_i, s_{-i}; r)\right\},$$

$\widehat{D}_i(s_i, s_{-i}; r)$ is the unconstrained demand (17) for the case where bank i sets a spread s_i and the other $n-1$ banks set a spread s_{-i}, and $\overline{D}_i(s_i, s_{-i}; r)$ is the constrained demand characterized in Proposition 6. Then, the Nash equilibrium spread satisfies

$$s^*(r) = \arg\max_{s_i} \pi_i(s_i, s^*(r); r),$$

and the equilibrium amount of deposits is

$$D^*(r) = nD_i(s^*(r), s^*(r); r).$$

I am now ready to present the main results of the paper. I focus the discussion on the range of values of the Federal funds rate in Panel A of Figure 1 in DSS, which goes from $r = 0$ to $r = 10\%$. I also focus the discussion on two particular values of the number of banks, namely $n = 2$ and $n = 5$, which correspond to the values of the mean Herfindahl index (HHI) corresponding to high HHI (0.49) and low HHI (0.20) counties in Panel A of Table 1 in DSS.[6] To allow for significant spreads, I assume that the elasticity of substitution between the deposits of the banks is $\eta = 1.5$. Finally, I assume two particular values for the parameters that capture the utility of liquidity services relative to final wealth and the elasticity of substitution between final wealth and liquidity services, namely $\lambda = 0.1$ and $\rho = 0.5$. According to the results in Figure 3 above, with these parameter values a monopoly bank would start paying a positive deposit rate when the policy rate equals 5%.

Panel A of Figure 4 shows the relationship between the policy rate r (in the horizontal axis) and the equilibrium spread $s^*(r)$ (in the vertical axis), with the red line corresponding to high market power ($n = 2$) and the blue line corresponding to low market power ($n = 5$). The results show that (i) spreads are equal to the policy rate for low values of the policy rate (implying a deposit rate at the zero lower bound), (ii) spreads are increasingly below the policy rate for higher values of the policy rate (implying an increasing deposit rate), in which case (iii) they are higher in markets with high market power (implying lower deposit rates).

Panel B of Figure 4 shows the relationship between the policy rate r (in the horizontal axis) and the equilibrium amount of deposits $D^*(r)$ (in the vertical axis), with the red line corresponding to high market power ($n = 2$) and the blue line corresponding to low market power ($n = 5$). The results show that (i) deposits are flat for low values of the policy rate (where the deposit rate is at the zero lower bound), (ii) deposits are increasing in the policy rate for higher values of the policy rate (where the deposit rate is also increasing), in which

[6] Recall that the Herfindahl index for a market with n identical banks is HHI $= 1/n$.

case (iii) deposits are higher in markets with low market power (where the deposit rate is higher).

Thus, increases in the policy rate generally increase bank deposits, except in the case where the policy rate is close to zero and there is a zero lower bound on deposit rates, in which case they do not have any effect on equilibrium deposits.[7] Moreover, I next show that these results are consistent with the empirical results in DSS panel regressions.

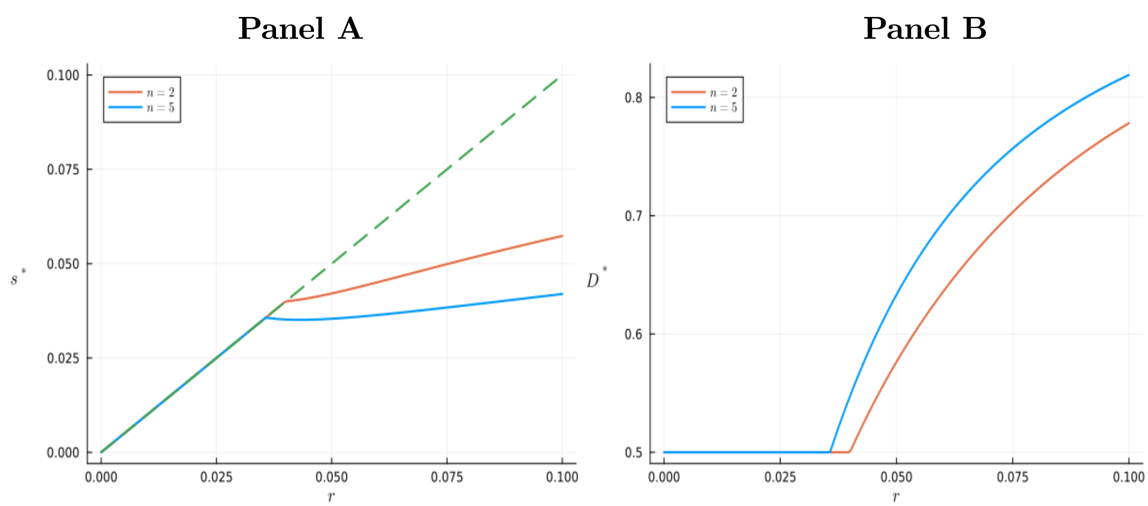

Figure 4. Equilibrium spreads and deposits

This figure plots the equilibrium spreads (in Panel A) and deposits (in Panel B) for high (in red) and low (in blue) market power.

Panel A of Figure 5 shows the relationship between the policy rate r (in the horizontal axis) and the slope $ds^*(r)/dr$ of the equilibrium spread (in the vertical axis), with the red line corresponding to high market power ($n = 2$) and the blue line corresponding to low market power ($n = 5$). The results show that, for values of the policy rate for which the deposit rate is not at the zero lower bound, spreads are more sensitive to changes in the policy rate

[7] In contrast with the recent literature on deposit betas (see, for example, Drechsel et al., 2021 and Drechsel et al., 2023), which assumes a linear relationship between bank deposits and the policy rate, these results suggest that a non-linear relationship with a positive quadratic term should provide a better approximation to the data.

when market power is high. This is consistent with γ_s, the coefficient of the interaction term $\Delta r_t \times \text{HHI}_i$ in DSS spreads equation (1), being positive and statistically significant.

Panel B of Figure 5 shows the relationship between the policy rate r (in the horizontal axis) and the slope $dD^*(r)/dr$ of the equilibrium amount of deposits (in the vertical axis), with the red line corresponding to high market power ($n = 2$) and the blue line corresponding to low market power ($n = 5$). The results show that, for intermediate values of the policy rate, deposits are more sensitive to changes in the policy rate when market power is low. Since the sample used by DSS in the estimation covers the years 1994 to 2013, when the maximum value of the Federal funds rate was 6.5%, this is consistent with γ_D, the coefficient of the interaction term $\Delta r_t \times \text{HHI}_i$ in DSS deposits equation (1), being negative and statistically significant.

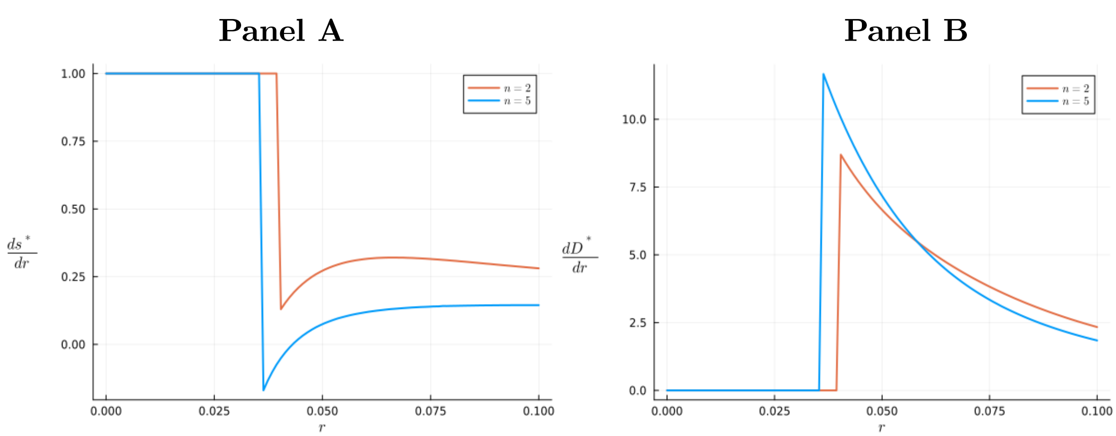

Figure 5. Sensitivity of equilibrium spreads and deposits

This figure plots the sensitivity of equilibrium spreads (in Panel A) and deposits (in Panel B) to changes in the policy rate for high (in red) and low (in blue) market power.

The conclusion that follows from these results is that *DSS theoretical model does not yield predictions that are consistent with a novel "deposits channel" for the transmission of monetary policy*: in the relevant range, increases in the policy rate never lead to a reduction in bank deposits. In addition, *the predictions of the model are consistent with the empirical* *results in DSS regressions*: spreads are more sensitive and deposits are less sensitive to changes in the policy rate when banks' market power is high than when it is low.

5 Conclusion

This paper has reviewed the claim in Drechsler, Savov, and Schnabl (2017) that the transmission of monetary policy should be understood from the liability side of banks' balance sheets. In particular, they argue that there is a "deposits channel" whereby increases in the policy rate widen deposit rate spreads, leading to deposit outflows that reduce banks' lending capacity. I have shown that, contrary to their claim, in their theoretical model of imperfect competition in a local banking market, the relationship between the policy rate and the equilibrium amount of deposits is either flat or increasing in the relevant range.

I would like to conclude with a comment on DSS approach. They look at the effect of monetary policy on bank lending through the lens of deposit taking. In this approach, the characteristics of the loan market take a back seat. It is true that "deposits are a special source of funding for banks, one that it is not perfectly substitutable with wholesale funding." But it is also true that if the focus of the analysis is on bank lending, characteristics such as market power and risk-taking in lending should have a prominent role.

Appendix

Proof of Proposition 1 To derive the household's demand for cash and deposits, let

$$X = Mr + Ds \tag{22}$$

denote the opportunity cost of the liquidity held by the household. The optimal way to allocate X between cash M and deposits D is obtained by solving

$$\max_{M,D} \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^2$$

subject to (22). The first-order conditions that characterize the solution to this problem are

$$\left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right) M^{-\frac{1}{2}} = \mu r, \tag{23}$$

$$\left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right) D^{-\frac{1}{2}} = \mu s, \tag{24}$$

where μ denotes the Lagrange multiplier associated with the constraint. Dividing (23) by (24) gives

$$\left(\frac{D}{M}\right)^{\frac{1}{2}} = \frac{r}{s}. \tag{25}$$

Substituting (25) into (23) and solving for the Lagrange multiplier gives (11). Solving for M in (25) and substituting the result into (22) and solving for D in (25) and substituting the result into (22) then gives

$$M = \frac{X}{\mu r^2} \textit{ and } D = \frac{X}{\mu s^2}. \tag{26}$$

Substituting (26) into the liquidity services function (9) implies

$$L = \frac{X}{\mu}\left(\frac{1}{r} + \frac{1}{s}\right)^2 = \mu X.$$

Hence, the household's maximization problem becomes

$$\max_X \left[(W_0(1+r) - X)^{\frac{\rho-1}{\rho}} + \lambda(\mu X)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}. \tag{27}$$

The first-order condition that characterizes the solution to this problem is

$$(W_0(1+r) - X)^{-\frac{1}{\rho}} = \lambda\mu(\mu X)^{-\frac{1}{\rho}}, \tag{28}$$

which implies

$$X = \frac{W_0(1+r)}{1+\lambda^{-\rho}\mu^{1-\rho}}. \tag{29}$$

Substituting this result into (26) gives (10). $\square$

Proof of Proposition 2 To prove that

$$\widehat{M}(s;r) + \widehat{D}(s;r) = \left(\frac{1}{r^2} + \frac{1}{s^2}\right) \frac{W_0(1+r)}{\mu(1+\lambda^{-\rho}\mu^{1-\rho})}$$

is decreasing in the spread s for $s \leq r$, note first that

$$\left(\frac{1}{r^2} + \frac{1}{s^2}\right)\frac{1}{\mu} = \frac{\left(\frac{1}{r}+\frac{1}{s}\right)^2 - \frac{2}{rs}}{\frac{1}{r}+\frac{1}{s}} = \frac{1}{r} + \frac{1}{s} - \frac{2}{r+s},$$

Hence, one has to prove that

$$\frac{d}{ds}\left(\frac{\frac{1}{r}+\frac{1}{s}-\frac{2}{r+s}}{1+\lambda^{-\rho}\mu^{1-\rho}}\right) = \frac{\left(\frac{2}{(r+s)^2} - \frac{1}{s^2}\right)(1+\lambda^{-\rho}\mu^{1-\rho}) + \frac{\frac{1}{r}+\frac{1}{s}-\frac{2}{r+s}}{\mu s^2}(1-\rho)\lambda^{-\rho}\mu^{1-\rho}}{(1+\lambda^{-\rho}\mu^{1-\rho})^2} < 0.$$

Since

$$\frac{2}{(r+s)^2} - \frac{1}{s^2} = \frac{s^2 - r^2 - 2sr}{(r+s)^2 s^2} < 0,$$

for $0 < s \leq r$, and

$$\frac{\frac{1}{r}+\frac{1}{s}-\frac{2}{r+s}}{\mu s^2} = \frac{\mu - \frac{2}{r+s}}{\mu s^2} = \left(1 - \frac{2rs}{(r+s)^2}\right)\frac{1}{s^2} = \frac{r^2+s^2}{(r+s)^2 s^2} > 0,$$

it follows that

$$\begin{aligned} &\frac{s^2 - r^2 - 2sr}{(r+s)^2 s^2}(1+\lambda^{-\rho}\mu^{1-\rho}) + \frac{r^2+s^2}{(r+s)^2 s^2}(1-\rho)\lambda^{-\rho}\mu^{1-\rho} \\ &< \frac{s^2 - r^2 - 2sr + (1-\rho)(r^2+s^2)}{(r+s)^2 s}\lambda^{-\rho}\mu^{1-\rho} < \frac{2(s-r)}{(r+s)^2 s}\lambda^{-\rho}\mu^{1-\rho} \leq 0, \end{aligned}$$

which implies the result. $\square$

Proof of Proposition 3 By the proof of Proposition 2

$$\widehat{M}(r;r) + \widehat{D}(r;r) = \frac{W_0\left(1+\frac{1}{r}\right)}{1+\lambda^{-\rho}\left(\frac{2}{r}\right)^{1-\rho}},$$

so $\widehat{M}(r;r)+\widehat{D}(r;r)\geq W_0$ simplifies to

$$\frac{1}{r}\geq\lambda^{-\rho}\left(\frac{2}{r}\right)^{1-\rho},$$

which taking logs implies the result. □

Proof of Proposition 4 Differentiating the household's objective function (13) with respect to D gives

$$(W_0+Dr_1)^{-\frac{1}{\rho}}r_1-\lambda\left(M^{\frac{1}{2}}+D^{\frac{1}{2}}\right)^{\frac{\rho-2}{\rho}}\left(D^{-\frac{1}{2}}-M^{-\frac{1}{2}}\right)=0.$$

Multiplying and dividing the second term in this expression by $M^{\frac{1}{2}}+D^{\frac{1}{2}}$ and rearranging the resulting expression implies the result. □

Proof of Proposition 5 To derive the household's demand for cash and deposits of the n banks for a policy rate r and set of spreads $s_1,...,s_n$ let

$$X=Mr+\textstyle\sum_{i=1}^{n}D_is_i. \tag{30}$$

denote the opportunity cost of the liquidity held by the household. Substituting (6) into (9), it follows that the optimal way to allocate X between cash M and deposits $D_1,...,D_n$ is obtained by solving

$$\max_{M,D_1,...,D_n}\left[M^{\frac{1}{2}}+\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}(nD_i)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{2(\eta-1)}}\right]^2$$

subject to (30). The first-order conditions that characterize the solution to this problem are

$$\left(M^{\frac{1}{2}}+D^{\frac{1}{2}}\right)M^{-\frac{1}{2}} = \mu r, \tag{31}$$

$$\left(M^{\frac{1}{2}}+D^{\frac{1}{2}}\right)D^{-\frac{1}{2}}D^{\frac{1}{\eta}}(nD_i)^{-\frac{1}{\eta}} = \mu s_i, \tag{32}$$

where μ denotes the Lagrange multiplier associated with the constraint. To solve for μ, first note that by (32) we have

$$D_i=D_1\left(\frac{s_1}{s_i}\right)^{\eta},$$

which by the definition (6) of D implies

$$D=\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}(nD_i)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}=nD_1s_1^{\eta}\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{\frac{\eta}{\eta-1}}.$$

From here it follows that

$$D_i s_i^\eta = D_1 s_1^\eta = \frac{D}{n}\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{-\frac{\eta}{\eta-1}}. \tag{33}$$

Now, dividing (31) by (32) gives

$$\left(\frac{D}{M}\right)^{\frac{1}{2}}\left(\frac{nD_i}{D}\right)^{\frac{1}{\eta}} = \frac{r}{s_i},$$

which using (33) implies

$$\left(\frac{D}{M}\right)^{\frac{1}{2}} = r\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{1}{\eta-1}}. \tag{34}$$

Using this result together with (31) gives

$$1+\left(\frac{D}{M}\right)^{\frac{1}{2}} = 1 + r\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{1}{\eta-1}} = \mu r,$$

which implies (18). To solve for D_i use (33) and (34) to get

$$D_i s_i = s_i^{1-\eta}\frac{D}{n}\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{-\frac{\eta}{\eta-1}} = \frac{1}{n}s_i^{1-\eta}Mr^2\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{2-\eta}{\eta-1}}, \tag{35}$$

which implies

$$\sum_{i=1}^n D_i s_i = Mr^2\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{1}{\eta-1}}.$$

Substituting this result into (30) and using (18) gives

$$X = Mr + \sum_{i=1}^n D_i s_i = Mr^2\mu,$$

which implies

$$M = \frac{X}{\mu r^2}. \tag{36}$$

Substituting this result into (35) and solving for D_i gives

$$D_i = s_i^{-\eta}\left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{2-\eta}{\eta-1}}\frac{X}{n\mu}. \tag{37}$$

Hence, (6) implies

$$D = \left(\frac{1}{n}\sum_{i=1}^n (nD_i)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}} = \left(\frac{1}{n}\sum_{i=1}^n s_i^{1-\eta}\right)^{\frac{2}{\eta-1}}\frac{X}{\mu}. \tag{38}$$

Substituting (36) and (38) into (9) gives

$$L = \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^2 = \mu X.$$

Substituting this result into the household's utility function (2) yields the same maximization problem (27) as in the case of the monopoly bank, whose solution is given by (29). Finally, substituting this result into (36) and (37) implies (16) and (17), as required. □

Proof of Proposition 6 Differentiating the household's objective function (19) with respect to D_i gives the first-order conditions

$$(W_0 + \textstyle\sum_{i=1}^n D_i r_i)^{-\frac{1}{\rho}} r_i = \lambda (M^{\frac{1}{2}} + D^{\frac{1}{2}})^{\frac{\rho-2}{\rho}} \left(M^{-\frac{1}{2}} - D^{\frac{2-\eta}{2\eta}} (nD_i)^{-\frac{1}{\eta}}\right),$$

for $i = 1, ..., n$, where $M = W_0 - \sum_{i=1}^n D_i$. Particularizing these conditions for the case where bank i pays a deposit rate r_i and the other $n-1$ banks pay a deposit rate r_{-i} implies the result. □

References

Abadi, J., M. Brunnermeier, and Y. Koby (2023), "The Reversal Interest Rate, " *American Economic Review*, 113, 2084-2120.

Begenau, J., and E. Stafford (2023), "Uniform Rate Setting and the Deposit Channel," SSRN Research Paper No. 4136858.

Corbae, D., and R. Levine (2018), "Competition, Stability and Efficiency in Financial Markets," in Federal Reserve Bank of Kansas City, Jackson Hole Symposium: Changing Market Structure and Implications for Monetary Policy, 357-409.

d'Avernas, A., A. Eisfeldt, C. Huang, R. Stanton, and N. Wallace (2023), "The Deposit Business at Large vs. Small Banks," NBER Working Paper No. 31865.

Drechsler, I., A. Savov, and P. Schnabl (2017), "The Deposits Channel of Monetary Policy," *Quarterly Journal of Economics*, 132, 1819-1876.

Drechsler, I., A. Savov, and P. Schnabl (2021), "Banking on Deposits: Maturity Transformation without Interest Rate Risk," *Journal of Finance*, 76, 1091-1143.

Drechsler, I., A. Savov, P. Schnabl, and O. Wang (2023), "Banking on Uninsured Deposits," NBER Working Paper No. 31138.

Drechsler, I., A. Savov, and P. Schnabl (2024), "Response to Begenau and Stafford (2023)."

Eggertsson, G., R. Juelsrud, L. Summers, and E. Wold (2023), "Negative Nominal Interest Rates and the Bank Lending Channel," *Review of Economic Studies*, 91, 2201-2275.

Heider, F., F. Saidi, and G. Schepens (2019), "Life below Zero: Bank Lending under Negative Policy Rates," *Review of Financial Studies*, 32, 3728-3761.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina (2012), "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications," *American Economic Review*, 102, 2301-2326.

Kashyap, A., and J. Stein (2000), "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?," *American Economic Review* , 90, 407-428.

Martinez-Miera, D., and R. Repullo (2020), "Interest Rates, Market Power, and Financial Stability," CEPR Discussion Paper No. 15063.

Sá, A. I., and J. Jorge (2019), "Does the Deposits Channel Work under a Low Interest Rate Environment?," *Economics Letters*, 185, 108736.

Ulate, M. (2021), "Alternative Models of Interest Rate Pass-Through in Normal and Negative Territory," *International Journal of Central Banking*, 17, 3-34.

Wang, Y., T. Whited, Y. Wu, and K. Xiao (2022), "Bank Market Power and Monetary Policy Transmission: Evidence from a Structural Estimation," *Journal of Finance*, 77, 2093-2141.