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The Deposits Channel of Monetary Policy A Critical Review

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Abstract

Drechsler, Savov, and Schnabl (2017) claim that increases in the monetary policy rate lead to reductions in bank deposits, which account for the negative effect on bank lending. This paper reviews their theoretical analysis, showing that the relationship between the policy rate and the equilibrium amount of deposits is in fact U-shaped. Then, it constructs an alternative model, based on a simple microfoundation for the households' demand for deposits, where an increase in the policy rate always increases the equilibrium amount of deposits. These results question the theoretical underpinnings of the "deposits channel" of monetary policy transmission.

JEL Codes: E52, G21, L13.

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

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> "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 very interesting empirical analysis of the effect of changes in the 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 negative 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 which can account for their empirical findings.

This paper presents a critical review of DSS's theoretical model, showing that increases in the policy rate have ambiguous effects on the equilibrium amount of deposits. In particular, the relationship is U-shaped, first decreasing (as claimed by DSS) and then increasing. Since their model does not yield simple analytical solutions, I construct an alternative model of imperfect competition in a local banking market, based on a simple microfoundation for the households' demand for deposits, which is consistent with their panel results and contradicts their conclusion. In this model, increases in the policy rate always increase the equilibrium amount of deposits.

Before going into the details of the original and the alternative model, 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. 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 which take care of time-varying differences between banks. Bank-specific characteristics (such as lending opportunities) are controlled by comparing branches of the same bank in counties with different concentrations.

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 at branches located in monopolistic counties. In other words, following a tightening of monetary policy, bank branches located in competitive counties have higher increases in deposit rates.

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 monopolistic counties. In other words, following a tightening of monetary policy, bank branches located in competitive counties have lower increases in deposits.

The problem arises with the particular interpretation by DSS 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). But they could have equally written: "Following an increase in the Federal funds rate, the bank's branches in more concentrated counties (...) experience *smaller inflows* relative to its branches in less concentrated counties."

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). Put it differently, the fact that coefficient γ_D is negative and statistically significant in the panel equation for deposits does not imply that increases in the Federal funds rate lead to reductions in the aggregate amount of deposits.

My claim is then that the deposits channel of monetary policy does not follow from the empirical results in DSS. In fact, it does not follow from their theoretical model either, which is the focus of this paper to which I turn now.

DSS's 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 banks that pay the equilibrium deposit rate, and market assets (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 à la Bertrand by setting deposit rates, or equivalently spreads between the policy rate and the deposit rate. Equilibrium spreads are derived from the symmetric Nash equilibrium of the game played by the banks. Armed with this framework, the question is then what is the effect on equilibrium spreads and deposits of an exogenous change in the policy rate.

The model is fairly complicated, and DSS derive results for the limit case in which the weight of liquidity services in the household's utility function goes to zero. My approach to the analysis of this model is to start with the simple case of a monopoly bank. In this case, I show that *increases in the policy rate increase equilibrium spreads, but have an ambiguous effect on equilibrium deposits*: the relationship has a negative slope (as claimed by DSS) for low rates and a positive slope for high rates (contrary to their claim).

To understand the reason for these results, it is convenient to consider a model without cash in which the household's choice is limited to the allocation of her initial wealth between bonds and deposits at the monopoly bank. In such model the effect of an increase in the policy rate on equilibrium deposits can be decomposed into a *negative substitution effect* due to increase in the spread by the monopoly bank, and a *positive income effect* due to higher return to the household's initial wealth. Moreover, this decomposition helps to understand why an increase in the policy rate may lead to an increase in the equilibrium amount of deposits in the model with cash, because the income effect increases the household's demand for liquid assets (both cash and deposits).

The results for the model without cash also serve to understand why the equilibrium quantity of deposits is initially decreasing in the policy rate. In this model, when the policy rate tends to zero deposits yield the same return as bonds, but in addition they provide valuable liquidity services. So we get a corner solution in which the household invests all her wealth in deposits. Increases in the policy rate eventually lead the household to move away from the corner, decreasing her investment in deposits. But at some point the power of the income effect kicks in, leading to the upward sloping relationship noted above.

Next, I consider the general model with n banks, showing that, as in the monopoly case, the relationship between the policy rate and the equilibrium amount of deposits has a negative slope for low rates and a positive slope for high rates. Moreover, and in line with the positive value of γ_s in the panel regression for spreads, the equilibrium spread s^* satisfies

$$\gamma_s = \frac{\partial^2 s^*}{\partial r \partial \mathrm{HHI}} > 0, \tag{2}$$

where $\mathrm{HHI} = 1/n$ is the Herfindahl index for a market with n identical banks.

It should be noted that, due to the complexity of the model, the previous results essentially rely on numerical solutions. To verify the robustness of the results, I next construct a simple model of Cournot competition in a local banking market for which analytical results can be derived.

The model has a continuum of heterogeneous households that differ in a utility premium associated with liquid assets. As before, households can invest their initial wealth in three assets: cash that pays a zero interest rate, bank deposits that pay the equilibrium deposit rate, and bonds that pay the policy rate set by the central bank. Assuming that cash provides higher liquidity services than deposits, I derive the households' aggregate demand for deposits as a function of the spread between the policy rate and the deposit rate, and then compute the corresponding Cournot equilibrium for a deposit market with n banks.

The analytical results of the alternative model show that, in line with the empirical results in DSS, both (2) and

$$\gamma_D = \frac{\partial^2 D^*}{\partial r \partial \text{HHI}} < 0 \tag{3}$$

hold, where D^* denotes the equilibrium amount of deposits. Moreover, it is also the case that, contrary to DSS's claim, D^* is always increasing in the policy rate r.

This paper is related to the growing literature on the transmission of monetary policy when banks have market power; see, for example, Brunnermeier and Koby (2018), Corbae and Levine (2018), and Wang et al. (2019). It is also related to papers that analyze the pass-through from policy rates to deposits and loan rates; see, for example, Eggertsson et al. (2019) and Ulate (2020). 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) and Repullo (2020), for banks with different balance sheet structures.

The remainder of the paper is structured as follows. Section 2 presents my critical review of DSS's theoretical model, starting with the monopoly case and then analyzing the general oligopoly case. Section 3 presents the alternative Cournot model. Section 4 concludes.

2 A Review of DSS's 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

$$U(W, l) = \left(W^{\frac{\rho-1}{\rho}} + (\lambda l)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \tag{4}$$

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

$0 < \rho < 1$.[1]

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

$$l(M, D) = \left(M^{\frac{\epsilon-1}{\epsilon}} + (\delta D)^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{5}$$

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 $\epsilon > 1$.

Finally, deposits D are a composite good produced by a set of n banks according to

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

where D_i are the deposits of bank $i = 1, 2, ..., n$. Following DSS, it is assumed that the deposits of the different banks are substitutes, so the elasticity of substitution satisfies $\eta > 1$. The function in (6) is slight different from the one in DSS, which is

$$D = \left(\frac{1}{n}\sum_{i=1}^{n} D_i^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}. \tag{7}$$

Notice that in this expression when $D_1 = ... = D_n$ we have $D = D_1 = ... = D_n$, so it is difficult to interpret D_i as the deposits of bank i. In contrast, with the function in (6), when $D_1 = ... = D_n$ we have $D = D_1 + ... + D_n$.

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 market assets (bonds) that pay an interest rate r taken to be equal to the monetary policy rate set by the central bank. Final wealth W is then given by

$$W = M + \sum_{i=1}^{n} D_i(1 + r_i) + (W_0 - M - \sum_{i=1}^{n} D_i)(1 + r). \tag{8}$$

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

$$W = W_0(1 + r) - \sum_{i=1}^{n} D_i s_i - Mr. \tag{9}$$

[1] This specification of the utility function is more appealing than the one in DSS(in which λ is raised to the power of 1), since it implies that when the elasticity of substitution $\rho \to 0$ we get a Leontief utility function $U(W, l) = \min\{W, \lambda l\}$ in which liquidity services are a proportion $1/\lambda$ of final wealth.

This expression is easy to understand. Final wealth W equals the market return of the initial wealth $W_0(1+r)$ minus the opportunity cost of deposits holdings $\sum_{i=1}^{n} D_i s_i$ and the opportunity cost of cash holdings Mr.

To simplify the analysis, in what follows I assume that the parameters of the liquidity services function satisfy $\delta = 1$ and $\epsilon = 2$, so (5) becomes

$$l(M, D) = \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^2. \tag{10}$$

To review the results of DSS's model, it is convenient to start with the analysis of the model with a single monopoly bank ($n = 1$).

2.1 The model with a monopoly bank

To assess the effect of a change in the monetary policy rate r on the amount of deposits D the household wants to hold, one has to determine the equilibrium spread s^* set by the monopolist, which in turn requires deriving the household's demand for deposits as a function of the policy rate r and the spread s.

To derive the demand for deposits faced by the monopoly bank, let

$$X = Mr + Ds \tag{11}$$

denote the opportunity cost of the liquidity held by the household. By (9) this implies that final wealth becomes

$$W = W_0(1+r) - X. \tag{12}$$

The optimal way to allocate X between cash M and deposits D is obtained by solving

$$\max_{M,D} \left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right)^2 \tag{13}$$

subject to (11). The first-order conditions that characterize the solution to this problem are

$$\left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right) M^{-\frac{1}{2}} = \mu r, \tag{14}$$

$$\left(M^{\frac{1}{2}} + D^{\frac{1}{2}}\right) D^{-\frac{1}{2}} = \mu s, \tag{15}$$

where μ denotes the Lagrange multiplier associated with the constraint. Dividing (14) by (15) gives

$$\left(\frac{D}{M}\right)^{\frac{1}{2}} = \frac{r}{s}. \tag{16}$$

Substituting (16) into (14) and solving for the Lagrange multiplier μ gives

$$\mu = \frac{1}{r} + \frac{1}{s}. \tag{17}$$

Solving for M in (16) substituting the result into (11) and solving for D implies

$$D = \frac{X}{\mu s^2}. \tag{18}$$

And from here it follows that

$$M = \frac{X}{\mu r^2}. \tag{19}$$

Substituting these results into the liquidity services function (10) gives

$$l = \frac{X}{\mu}\left(\frac{1}{r} + \frac{1}{s}\right)^2 = \mu X. \tag{20}$$

Now, substituting (12) and (20) into the household's utility function (4) yields the following maximization problem

$$\max_X \left[(W_0(1+r) - X)^{\frac{\rho-1}{\rho}} + (\lambda\mu X)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}. \tag{21}$$

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

$$(W_0(1+r) - X)^{-\frac{1}{\rho}} = \lambda\mu(\lambda\mu X)^{-\frac{1}{\rho}}, \tag{22}$$

which implies

$$X = \frac{W_0(1+r)}{1 + (\lambda\mu)^{1-\rho}}. \tag{23}$$

Substituting this result into (18) gives the following demand for deposits faced by the monopoly bank

$$D(s; r) = \frac{W_0(1+r)}{\mu s^2[1 + (\lambda\mu)^{1-\rho}]}, \tag{24}$$

It can be checked that $\partial D/\partial s < 0$, so the demand function is decreasing in the spread s, and that $\partial D/\partial r > 0$, so an increase in the policy rate r leads to an outward shift in the demand for deposits. Substituting (23) into (19) it can also be checked that cash holdings M are increasing in s. Thus, an increase in the spread s reduces the advantage of deposits relative to cash in providing liquidity services, leading to a shift from deposits into cash.

Assuming that the monopoly bank earns the policy rate r on its investments, and given that the deposit rate is $r - s$, it follows that its profits are

$$\pi(s;r) = [r - (r - s)]D(s;r) = sD(s;r). \tag{25}$$

To maximize profits, the monopoly bank chooses the equilibrium spread

$$s^*(r) = \arg\max_s [sD(s;r)], \tag{26}$$

which implies the following equilibrium amount of deposits

$$D^*(r) = D(s^*(r);r). \tag{27}$$

DSS claim that an increase in the policy rate r leads to a reduction in the total amount of deposits, that is

$$\frac{dD^*}{dr} = \frac{\partial D^*}{\partial s}\frac{ds^*}{dr} + \frac{\partial D^*}{\partial r} < 0. \tag{28}$$

I have noted that $\partial D^*/\partial s < 0$ and $\partial D^*/\partial r > 0$, so to get the result it must be the case that $ds^*/dr > 0$ and that the second term in the left-hand side of (28) is greater in absolute value than the first.

The example plotted in Figure 1 shows that this may or may not be the case. In this example, I assume $W_0 = 1$ and $\lambda = 4$,[2] and take three values of the elasticity of substitution between final wealth and liquidity services, namely $\rho = 0$, $\rho = 0.1$ and $\rho = 0.2$. Panel A shows the equilibrium spread $s^*(r)$ and Panel B shows the equilibrium amount of deposits $D^*(r)$ for different values of the policy rate r.

[2]Note that $\lambda = 4$ implies that in the Leontief limit ($\rho \to 0$), liquidity services l are equal to 25% of final wealth W.

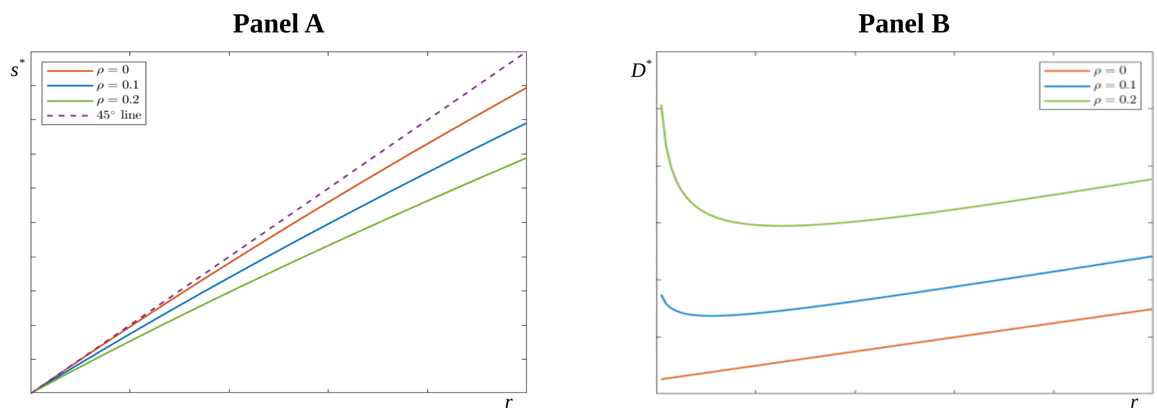

Figure 1. Equilibrium spreads and deposits for the monopoly bank

Panel A shows the relationship between the equilibrium spread and the policy rate and Panel B the relationship between the equilibrium amount of deposits and the policy rate for the model with a monopoly bank and three different values of the elasticity of substitution between final wealth and liquidity services.

The results in Panel A show that the monopoly bank sets a spread $s^*(r)$ that is increasing in the policy rate r, but with a slope smaller than one. By (16) this implies that the ratio D/M will be increasing in r, because of the increase in the opportunity cost of holding cash relative to deposits. Panel A also shows that, for any level of the policy rate r, the spread $s^*(r)$ is decreasing in the elasticity of substitution ρ. This is explained by the fact that a higher value of ρ increases the elasticity of the demand for deposits (24).

The results in Panel B show that, except in the limit case $\rho = 0$, the equilibrium quantity of deposits $D^*(r)$ is first decreasing and then increasing in the policy rate r. Since Panel A shows that $ds^*/dr > 0$, it follows that the second term in the left-hand side of (28) is greater (smaller) in absolute value than the first for low (high) values of r. Panel B also shows that, for any level of the policy rate r, bank deposits $D^*(r)$ are increasing in the elasticity of substitution ρ. This is explained by the fact that, as shown in Panel A, a higher value of ρ leads to a reduction in the spread $s^*(r)$ charged by the monopoly bank thereby increasing the demand for its deposits (24).

The conclusion that follows from Figure 1 is that, contrary to the claim in DSS, an increase in the policy rate need not lead to a reduction in bank deposits. To understand the reason for these results, it is convenient to consider a simpler model without cash.

2.2 The monopoly model without cash

Suppose now that the representative household can invest her initial wealth W_0 in two assets: deposits D of a monopoly bank that pay an interest rate $r - s$, and market assets (bonds) that pay the policy rate r. Final wealth W is then given by

$$W = (W_0 - D)(1 + r) + D(1 + r - s) = W_0(1 + r) - Ds. \tag{29}$$

In the model without cash, the household's utility function (4) simplifies to

$$U(W, D) = \left(W^{\frac{\rho-1}{\rho}} + (\lambda D)^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}. \tag{30}$$

Substituting (29) into the household's utility function (30) yields the following maximization problem

$$\max_D \left[(W_0(1 + r) - Ds)^{\frac{\rho-1}{\rho}} + (\lambda D)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}. \tag{31}$$

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

$$s(W_0(1 + r) - Ds)^{-\frac{1}{\rho}} = \lambda(\lambda D)^{-\frac{1}{\rho}}, \tag{32}$$

which solving for D gives the following demand for deposits faced by the monopoly bank

$$D(s; r) = \frac{W_0(1 + r)}{s[1 + (\lambda/s)^{1-\rho}]}. \tag{33}$$

As before, assuming that the monopoly bank earns the policy rate r on its investments, its profits are given by $\pi(s)$ in (25), so it chooses the equilibrium spread

$$s^*(r) = \arg\max_s [sD(s; r)], \tag{34}$$

where $D(s; r)$ is given by (33).

Since $sD(s;r)$ is increasing in s, it follows that in the model without cash the monopoly bank will set the maximum spread $s^*(r) = r$, so the equilibrium deposit rate will always be $r - s^*(r) = 0$.[3] Substituting this result into (33) then gives

$$D^*(r) = D(s^*(r); r) = \frac{W_0(1+r)}{r[1+(\lambda/r)^{1-\rho})]}. \tag{35}$$

The effect of an increase in the policy rate r on equilibrium deposits D^* can be decomposed into a *negative substitution effect* due to increase in the spread $s^*(r)$ and a *positive income effect* due to higher return to the initial wealth W_0. Figure 2 illustrates the two effects for the following parameter values: $W_0 = 1$, $\lambda = 4$, and $\rho = 0.1$. The horizontal axis represents deposits D while the vertical axis represents final wealth W. The initial equilibrium for a policy rate $r = 0.2$ is denoted by point A. An increase in the policy rate to $r = 0.4$ leads the household to choose point C. The move from A to C can be decomposed into a substitution effect from A to B, and an income effect from B to C. The substitution effect decreases household deposits, while the income effect increases them. The final effect is in principle ambiguous, although for sufficiently low values of the elasticity of substitution ρ it will always lead to an increase in deposits.[4]

The decomposition illustrated in Figure 2 helps to understand the reason why an increase in the policy rate may lead to an increase in the equilibrium amount of deposits in the model with cash. In particular, the first term in the left-hand side of (28) captures, for a given spread $s^*(r)$, a substitution from cash into deposits (since the opportunity cost of holding cash goes up), but also an income effect which increases the household's demand for liquid assets (both cash and deposits).

[3] In this setup the zero lower bound on deposit rates could be justified by assuming that there is still cash, but it is a perfect substitute of bank deposits in liquidity provision. Thus, cash would only be used if deposit rates turned negative.

[4] Note that in the Leontief limit ($\rho \to 0$), we have $W = \lambda D$, so the budget constraint $W = W_0(1+r) - Dr$ implies $D = W_0(1+r)/(\lambda + r)$, which for $\lambda > 1$ is increasing in r.

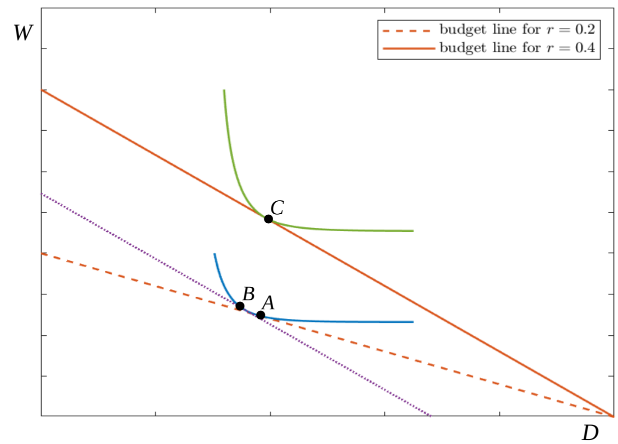

Figure 2. Decomposing the effect of an increase in the policy rate

This figure decomposes the effect of an increase in the policy rate into a substitution effect from A to B, and an income effect from B to C.

The results for the model without cash also serve to understand why in Figure 1 the equilibrium quantity of deposits $D^*(r)$ is decreasing in r for low values of the policy rate. Note that (35) implies that when $r \to 0$ we have $D^*(r) \to \infty$. This means that for sufficiently low r there is a corner solution $D^*(r) = W_0$ in which the household invests all her wealth in deposits.[5] This is easy to explain: when $r \to 0$ bank deposits yield the same return as market investments but in addition they provide liquidity services, so the household only wants to invest in deposits. Increases in the policy rate r eventually lead the household to move away from the corner $D^*(r) = W_0$. Thus, for a range of small values of r the the equilibrium quantity of deposits $D^*(r)$ will be decreasing in r. But at some point the power of the income effect will kick in, leading to an upward sloping relationship between the equilibrium amount of deposits $D^*(r)$ and the policy rate r.

[5]Setting $D^* = W_0$ in (35) and solving for r gives the rate $\underline{r} = \lambda^{(1-\rho)/\rho}$ below which the corner solution obtains.

2.3 The oligopoly model

I next consider DSS's oligopoly model in which n banks indexed by $i = 1, 2, ..., n$ compete in the deposit market by setting spreads s_i. Since the banks' strategic variable is the spread between the policy rate and the deposit rate and the deposits of the different banks are not perfect substitutes, it is a Bertrand model with differentiated products.

As in the case of the monopoly model, to derive the demand for deposits of the n banks let

$$X = Mr + \sum_{i=1}^{n} D_i s_i. \tag{36}$$

denote the opportunity cost of the liquidity held by the household. Substituting (6) into (10), it follows that the optimal way to allocate X between cash M and deposits $D_1, ..., D_n$ is obtained by solving

$$\max_{M, D_1, ..., D_n} \left[M^{\frac{1}{2}} + \left(\frac{1}{n} \sum_{i=1}^{n} (nD_i)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{2(\eta-1)}} \right]^2 \tag{37}$$

subject to (36). Following the same steps as in Section 2.1, it can be shown (see the Appendix for the details) that the solution to this problem is given by

$$M = \frac{X}{\mu r^2}, \tag{38}$$

$$D_i = \frac{1}{n} s_i^{-\eta} \left(\frac{1}{n} \sum_{i=1}^{n} s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}} \frac{X}{\mu}, \tag{39}$$

where

$$\mu = \frac{1}{r} + \left(\frac{1}{n} \sum_{i=1}^{n} s_i^{1-\eta} \right)^{\frac{1}{\eta-1}}. \tag{40}$$

Substituting these results into (6) and rearranging then gives

$$D = \left(\frac{1}{n} \sum_{i=1}^{n} (nD_i)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} = \left(\frac{1}{n} \sum_{i=1}^{n} s_i^{1-\eta} \right)^{\frac{2}{\eta-1}} \frac{X}{\mu}. \tag{41}$$

which using (10), (38), and (40) implies

$$l = \left(M^{\frac{1}{2}} + D^{\frac{1}{2}} \right)^2 = \mu X. \tag{42}$$

Substituting this result into the household's utility function (4) yields the same maximization problem (21) as in the case of the monopoly bank, whose solution is given by (23). Substituting this result into (39) implies the following demand for the deposits of bank i

$$D_i(s_1, ..., s_n; r) = s_i^{-\eta} \left(\frac{1}{n} \sum_{i=1}^{n} s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}} \frac{W_0(1+r)}{n\mu[1+(\lambda\mu)^{1-\rho}]}, \tag{43}$$

where μ is given by (40). The profits of bank i will then be given by

$$\pi_i(s_1, ..., s_n; r) = s_i D_i(s_1, ..., s_n; r) = s_i^{1-\eta} \left(\frac{1}{n} \sum_{i=1}^{n} s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}} \frac{W_0(1+r)}{n\mu[1+(\lambda\mu)^{1-\rho}]}. \tag{44}$$

A *symmetric Nash equilibrium* of the Bertrand game played by the n banks is characterized by a solution to the following equation

$$s^*(r) = \arg\max_{s} \left\{ s^{1-\eta} \left(\frac{1}{n} \left[s^{1-\eta} + (n-1)(s^*)^{1-\eta} \right] \right)^{\frac{2-\eta}{\eta-1}} \frac{W_0(1+r)}{n\mu[1+(\lambda\mu)^{1-\rho}]} \right\}, \tag{45}$$

where

$$\mu = \frac{1}{r} + \left(\frac{1}{n} \left[s^{1-\eta} + (n-1)(s^*)^{1-\eta} \right] \right)^{\frac{1}{\eta-1}}. \tag{46}$$

Finally, substituting the equilibrium spread $s^*(r)$ into (41), and using (23), gives the equilibrium amount of deposits held by the household

$$D^*(r) = \frac{W_0(1+r)}{\mu^*[s^*(r)]^2[1+(\lambda\mu^*)^{1-\rho}]}, \tag{47}$$

where

$$\mu^* = \frac{1}{r} + \frac{1}{s^*(r)}. \tag{48}$$

It should be noted that for $n = 1$ the demand for deposits $D_i(s_i; r)$ of the (single) bank i in (43) coincides with the expression (24) obtained in Section 2.1, so the monopoly model is indeed a special case of the oligopoly model. For this reason, one would expect that increases in the policy rate r have the same ambiguous effects on the total amount of deposits D^*.

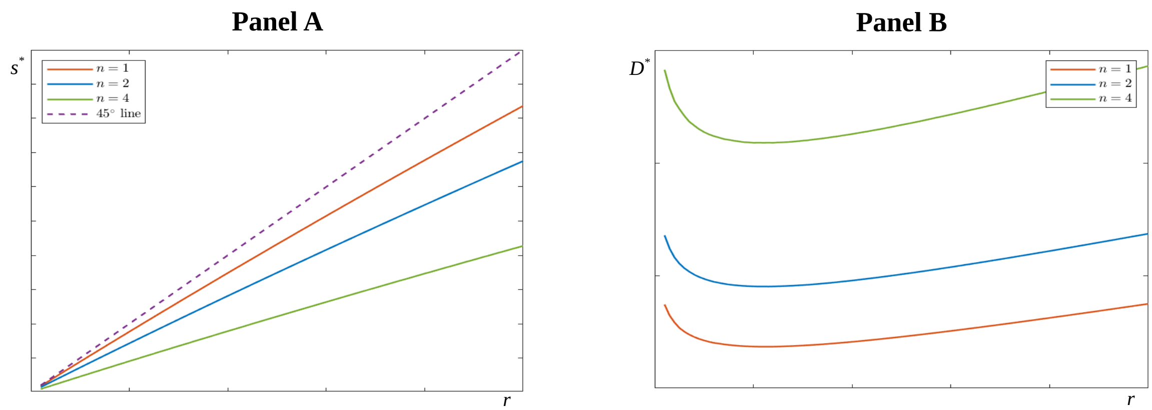

Figure 3. Equilibrium spreads and deposits for different number of banks

Panel A shows the relationship between equilibrium spreads and the policy rate and Panel B the relationship between equilibrium deposits and the policy rate for three different values of the number of banks.

The example plotted in Figure 3 shows that this is the case. In this example, I assume $W_0 = 1$, $\lambda = 4$, $\rho = 0.1$, and $\eta = 1.1$, and take three values of the number of banks n, namely $n = 1$, $n = 2$, and $n = 4$. Panel A shows the equilibrium spread $s^*(r)$ and Panel B shows the equilibrium amount of deposits $D^*(r)$ for different values of the policy rate r. The results in Panel A show that the equilibrium spread $s^*(r)$ is increasing in the policy rate r and decreasing in the number of banks n. Thus, higher competition leads to lower spreads for any value of the policy rate. The results in Panel B show that, as in the monopoly case, the equilibrium amount of deposits $D^*(r)$ is first decreasing and then increasing in the policy rate r. Moreover, the effect of competition on spreads implies that higher competition leads to higher deposits.

The slope of the relationship between equilibrium spread $s^*(r)$ and the policy rate r is what DDS call the *spread beta*. The results in Panel A are consistent with their results showing that the spread beta is decreasing in the number of banks n, or equivalently it is increasing in the Herfindahl index $\text{HHI} = 1/n$ for a market with n identical banks. The results also imply that the pass-through from the policy rate r to the deposit rate $r - s^*(r)$

is increasing in degree of competition in the deposit market.

The conclusion that follows from the analysis of the oligopoly model is that *increases in the policy rate increase equilibrium spreads, but have an ambiguous effect on equilibrium deposits*: the relationship has a negative slope (as claimed by DSS) for low rates and a positive slope for high rates (contrary to their claim).

3 An Alternative Model

This section explores the robustness of the previous results when replacing DSS's Bertrand competition model with differentiated deposits by a standard Cournot model of competition in the deposit market, based on a simple microfoundation for the households' demand for deposits. In this model an increase in the policy rate always leads to a reduction in the equilibrium amount of deposits.

Consider a model with heterogeneous households that differ in a utility premium associated with liquid assets. Specifically, suppose that there is a measure one of atomistic households with unit wealth characterized by a *liquidity premium* x that is uniformly distributed in $[0, 1]$. A household of type x can invest her wealth in three assets, namely cash that pays a zero interest rate, bank deposits that pay an interest rate r_D, and bonds that pay an interest rate r taken to be equal to the monetary policy rate set by the central bank. Investing in cash yields utility

$$U_C(x) = 1 + \gamma x, \tag{49}$$

investing in deposits yields utility

$$U_D(x) = 1 + r_D + x, \tag{50}$$

and investing in bonds yields utility

$$U_B(x) = 1 + r. \tag{51}$$

It is assumed that cash provides higher liquidity services than deposits, so $\gamma > 1$.[6]

[6] This model of the demand for deposits builds on Martinez-Miera and Repullo (2020) by adding the possibility of investing in highly liquid cash.

There are n identical banks that compete à la Cournot in the deposit market and invest the funds raised in assets that pay the policy rate r, so their profits for unit of deposits are given by the spread $s = r - r_D$. To compute the Cournot equilibrium I next derive the households' aggregate demand for deposits $D(s)$ as a function of the spread s.

A household of type x will put all her wealth in cash if $U_C(x) > \max\{U_D(x), U_B(x)\}$, she will put all her wealth in bank deposits if $U_D(x) > \max\{U_C(x), U_B(x)\}$, and she will put all her wealth in bonds if $U_B(x) > \max\{U_C(x), U_D(x)\}$.

For a characterization of the households' investment decisions refer to Figure 4. The horizontal axis represents the liquidity premium x, while the vertical axis represents the households' utilities associated with the three assets. The horizontal red line with intercept $1 + r$ shows the utility of bond investments $U_B(x)$, the green line with intercept $1 + r_D$ and unit slope shows the utility of bank deposits $U_D(x)$, and the blue line with intercept 1 and slope $\gamma > 1$ shows the utility of cash $U_C(x)$. A household is indifferent between deposits and bonds when her liquidity premium x satisfies $U_D(x) = 1 + r_D + x = 1 + r = U_B(x)$, which gives the boundary point

$$\overline{x} = r - r_D = s. \tag{52}$$

A household is indifferent between cash and deposits when her liquidity premium x satisfies $U_C(x) = 1 + \gamma x = 1 + r_D + x = U_D(x)$, which gives the boundary point

$$\widehat{x} = \frac{r_D}{\gamma - 1} = \frac{r - s}{\gamma - 1}. \tag{53}$$

I focus on the case depicted in Figure 4, where there is a positive mass of households that put their wealth in deposits.[7] Moreover, parameter γ is assumed to be sufficiently high so that there is a positive demand for cash. Since each household has a unit amount of wealth and the liquidity premium is uniformly distributed in $[0, 1]$, it follows that the (linear) demand for deposits is given by

$$D(s; r) = \widehat{x} - \overline{x} = \frac{r - \gamma s}{\gamma - 1}. \tag{54}$$

[7] Although the boundary points $\overline{x}$ and $\widehat{x}$ depend on the (endogenous) spread s, the Cournot equilibrium is characterized by a sufficiently small spread such that $\overline{x} < \widehat{x}$.

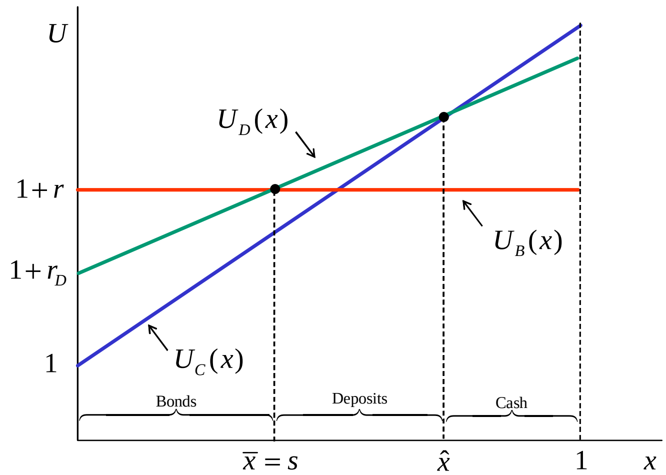

Figure 4. Utility of bonds, deposits, and cash

This figure shows the utility of market investments (red line), bank deposits (green line), and cash (blue line) for the range of values of the households' liquidity premium.

To derive the Cournot equilibrium it is convenient to work with the inverse demand for deposits implied by (54), which is

$$s(D;r) = \frac{r-(\gamma-1)D}{\gamma}. \tag{55}$$

Let d_i denote the deposits chosen by bank $i = 1, ..., n$, so the total amount of deposits is $D = \sum_{i=1}^{n} d_i$. The profits of bank i are given by

$$\pi_i(d_1, ..., d_n; r) = (r - r_D)d_i = s(D; r)d_i. \tag{56}$$

A *symmetric Cournot equilibrium* is characterized by a solution to the equation

$$d^* = \arg\max_d [s(d + (n-1)d^*)d]. \tag{57}$$

Using (55), the first-order condition is

$$s(nd^*) + s'(nd^*)d^* = \frac{r-(\gamma-1)nd^*}{\gamma} - \frac{\gamma-1}{\gamma}d^* = 0, \tag{58}$$

which implies

$$D^*(r) = nd^*(r) = \frac{nr}{(n+1)(\gamma-1)}. \tag{59}$$

The Cournot equilibrium has two interesting properties, namely

$$\frac{dD^*}{dr} = \frac{n}{(n+1)(\gamma-1)} > 0, \tag{60}$$

$$\frac{\partial^2 D^*}{\partial r \partial n} = \frac{1}{(n+1)^2(\gamma-1)} > 0. \tag{61}$$

According to (60), an increase in the policy rate r always increases the equilibrium amount of deposits D^*. According to (61) the positive effect of the policy rate r on equilibrium deposits D^* is stronger when banks have low market power (high n).

To relate this latter result to DSS, it is convenient to rewrite (59) in terms of the Herfindahl index HHI $= 1/n$. Solving for n in this expression, and substituting it into (59) gives

$$D^*(r) = \frac{r}{(1+\text{HHI})(\gamma-1)}. \tag{62}$$

From here it follows that

$$\frac{dD^*}{dr} = \frac{1}{(1+\text{HHI})(\gamma-1)} > 0, \tag{63}$$

$$\frac{\partial^2 D^*}{\partial r \partial \text{HHI}} = -\frac{1}{(1+\text{HHI})^2(\gamma-1)} < 0. \tag{64}$$

This latter result implies that an increase in the policy rate leads to smaller changes in deposits in banks located in monopolistic markets, and corresponds to the result $\gamma_D < 0$ in DDS's deposits panel regression. Moreover, (63) and (64) imply that

$$\frac{dD^*}{dr} = -(1+\text{HHI})\gamma_D. \tag{65}$$

It follows that $\gamma_D < 0$ if and only if deposits are increasing in the policy rate, contrary to DSS's claim.

4 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, increases in the policy rate have ambiguous effects on the equilibrium amount of deposits. I have also constructed an alternative model, based on a simple microfoundation for the households' demand for deposits, which is consistent with their panel results and where increases in the policy rate always increase the equilibrium amount of deposits.

I would like to conclude with a comment on DSS's 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. For this reason, one should aim at building models that encompass both sides of banks' balance sheets.

Appendix

The demand for deposits in DSS's oligopoly model The first-order conditions that characterize the solution to (37) subject to (36) are

$$\left(M^{\frac{1}{2}}+D^{\frac{1}{2}}\right)M^{-\frac{1}{2}} = \mu r, \tag{66}$$

$$\left(M^{\frac{1}{2}}+D^{\frac{1}{2}}\right)D^{-\frac{1}{2}}D^{\frac{1}{\eta}}(nD_i)^{-\frac{1}{\eta}} = \mu s_i, \tag{67}$$

where μ denotes the Lagrange multiplier associated with the constraint. To solve for μ, first note that by (67) we have

$$D_i = D_1\left(\frac{s_1}{s_i}\right)^{\eta}, \tag{68}$$

which by the definition (6) of D implies

$$D=\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}(nD_i)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}} = nD_1 s_1^{\eta}\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{\frac{\eta}{\eta-1}}. \tag{69}$$

From here it follows that

$$D_i s_i^{\eta} = D_1 s_1^{\eta} = \frac{D}{n}\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{-\frac{\eta}{\eta-1}}. \tag{70}$$

Now, dividing (66) by (67) gives

$$\left(\frac{D}{M}\right)^{\frac{1}{2}}\left(\frac{nD_i}{D}\right)^{\frac{1}{\eta}} = \frac{r}{s_i}, \tag{71}$$

which using (70) implies

$$\left(\frac{D}{M}\right)^{\frac{1}{2}} = r\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{\frac{1}{\eta-1}}. \tag{72}$$

Using this result together with (66) gives

$$1+\left(\frac{D}{M}\right)^{\frac{1}{2}} = 1+r\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{\frac{1}{\eta-1}} = \mu r, \tag{73}$$

which implies

$$\mu = \frac{1}{r}+\left(\frac{1}{n}\textstyle\sum_{i=1}^{n}s_i^{1-\eta}\right)^{\frac{1}{\eta-1}}. \tag{74}$$

To solve for D_i use (70) and (72) to get

$$D_i s_i = s_i^{1-\eta} \frac{D}{n} \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{-\frac{\eta}{\eta-1}} = \frac{1}{n} s_i^{1-\eta} M r^2 \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}}, \tag{75}$$

which implies

$$\sum_{i=1}^n D_i s_i = M r^2 \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{\frac{1}{\eta-1}}. \tag{76}$$

Substituting this result into (36) and using (74) gives

$$X = Mr + \sum_{i=1}^n D_i s_i = M r^2 \mu, \tag{77}$$

which implies

$$M = \frac{X}{\mu r^2}. \tag{78}$$

Finally, substituting this result into (75) and solving for D_i gives

$$D_i = \frac{1}{n} s_i^{-\eta} \left(\frac{1}{n} \sum_{i=1}^n s_i^{1-\eta} \right)^{\frac{2-\eta}{\eta-1}} \frac{X}{\mu}, \tag{79}$$

as required.

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