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ABSTRACT

In well-developed financial markets, retail deposits and wholesale funding comove negatively in response to monetary policy changes. This negative comovement weakens the transmission of monetary policy. By contrast, our study finds that in emerging markets such as China, where deposit rate ceilings are regulated, (i) retail deposits and wholesale funding comove positively as the policy rate changes, and (ii) wholesale funding strengthens the transmission of monetary policy to bank lending. We develop a theoretical model that highlights the significant influence of deposit regulation on monetary policy transmission in the context of the world's largest emerging market economy.

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How banks adjust their external funding in response to monetary policy is central to effective policy transmission and broader economic implications. Conventional theories predict that wholesale funding weakens monetary policy transmission as an alternative funding source to retail deposits. When the monetary authority reduces its interest rate (the policy rate), banks often substitute retail deposits for wholesale funding, and the opposite occurs when the interest rate is raised. This substitution effect leads to a negative comovement between retail deposits and wholesale funding in response to changes in the policy rate. Such dynamics are supported by the classical bank lending channel literature (e.g., Stein (1998); Bianchi and Bigio (2022)), which discusses how the Federal Reserve influences banks' ability to create deposits, as well as by the more recent deposits channel literature (e.g., Drechsler et al. (2017); Wang et al. (2022)), focusing on the impact of federal fund rate changes on banks' deposit market power.

This study challenges that view in regulated banking systems such as China's, where deposit rate ceilings constrain banks' ability to attract deposits. Past studies focus on liberalized financial markets. China—the largest emerging-market economy—presents a different case.[1] China continues to impose deposit rate ceilings as part of its banking regulation (Brunnermeier et al., 2022). In such an economy, both the relationship between policy rate changes and banks' funding composition, and the role of wholesale funding in monetary policy transmission, may qualitatively differ from those in economies without such regulatory restrictions. In particular, wholesale funding in the Chinese banking system has emerged as an important source of external funding. In 2017, for instance, wholesale funding constituted nearly 30% of total liabilities on average for all publicly listed banks (Chen et al., 2022).[2]

We explore how wholesale funding affects monetary policy transmission by explicitly incorporating deposit rate ceilings into a standard banking model. To motivate our theoretical model, we first provide evidence using bank-level data from China, a country that has long been subject to deposit rate ceilings. We then develop a theoretical model that rationalizes our empirical evidence. Both our empirical and theoretical results reveal that in economies with deposit rate ceilings, wholesale funding comoves positively with retail deposits in response to changes in the policy rate, thus enhancing the transmission of monetary policy

[1] Other emerging markets (e.g., Brazil, Vietnam, and India) also have direct or indirect deposit interest rate regulations.

[2] In the Chinese banking system, wholesale funding includes borrowings from banks and other financial institutions, borrowings from the central bank, bonds payable, financial assets sold for repurchase, and dues to banks and other financial institutions.

to bank lending. This finding contrasts with the conventional result for economies without such ceilings.

Our empirical evidence motivates the development of our theoretical model, which constitutes the main contribution of the paper. A key innovation of our model is that it allows the capital constraint faced by a bank to vary endogenously with changes in the policy rate. By contrast, existing models such as (Drechsler et al., 2017) assume that the capital constraint remains fixed regardless of policy rate movements. Under this assumption, a decline in the policy rate leads banks to substitute wholesale funding for retail deposits, resulting in a negative comovement between these two sources of external funding. This outcome persists even in economies with binding deposit rate ceilings. Similarly, with capital constraints that endogenously respond to changes in the policy rate, retail deposits still move in the opposite direction of wholesale funding, as the substitution effect dominates (Xiao, 2020). These findings suggest that making capital constraints endogenous is a necessary, but not sufficient, condition for achieving positive comovement between retail deposits and wholesale funding.

When a regulatory ceiling is imposed on deposit rates, however, our model shows that retail deposits and wholesale funding can comove positively in response to policy rate changes. As the policy rate declines, the banks equity increases, thereby relaxing the capital constraint. This relaxation enables banks to expand their use of wholesale funding, especially since deposit rate ceilings limit their ability to attract additional retail deposits. As a result, both wholesale funding and retail deposits increase, reinforcing the transmission of monetary policy to bank lending. Conversely, when the policy rate rises, capital constraints tighten and the deposit rate ceiling continues to bind, causing both funding sources to decline simultaneously.

Recent studies have examined how bank market power in deposit markets affects the transmission of the monetary policy rate through retail deposits and wholesale funding (see, for example, Drechsler et al. (2017); Drechscher et al. (2021); Xiao (2020); Wang et al. (2022)). Existing literature consistently finds that wholesale funding weakens monetary policy transmission because it moves in the opposite direction of retail deposits. This finding suggests that liquidity regulations, such as the Basel III Liquidity Coverage Ratio (LCR), which restrict banks' reliance on wholesale funding, could enhance monetary policy transmission (Choi and Choi, 2021). Our study, however, departs from previous work by showing that in China—where deposit rate ceilings are imposed—wholesale funding complements retail deposits in the transmission of the policy rate to the loan market. As a result, the Basel III liquidity regulation may hinder monetary policy transmission in China, a pivotal player in the global economy and the second-largest economy in the world.

Our model emphasizes that banks capital constraint—largely ignored in the literature on the deposits channel of monetary policy—is crucial for generating a positive comovement between wholesale funding and retail deposits. To the best of our knowledge, our study is the first to explore how deposit rate regulations shape the impact of the policy rate on bank lending in the Chinese context, thereby contributing to the emerging literature on the effects of monetary policy on Chinas banking system.[3]

Motivating evidence

In this section, we present two important findings as empirical evidence motivating our theoretical work. First, for banks with binding deposit rate ceilings, there is a positive correlation between wholesale funding and retail deposits in response to changes in the interest rate. In contrast, for banks not constrained by deposit rate ceilings, the opposite is true. Second, while wholesale funding weakens the transmission of monetary policy to bank lending for banks not constrained by deposit rate ceilings, it strengthens the transmission for banks with binding deposit rate ceilings.

Our findings are based on a sample of all listed banks on the Shanghai and Shenzhen Stock Exchanges, using quarterly data obtained from the China Stock Market and Accounting Research Database (CSMAR). For detailed descriptions and summary statistics of the variables used in this section, see *Supplementary Appendices 1 and 2, Table S1.* We manually collected deposit interest rates from each bank's daily report, and the macroeconomic data are collected from the National Bureau of Statistics of China and the People's Bank of China (PBC). Our bank-quarter dataset covers the period from the first quarter of 2013 (2013Q1) to the fourth quarter of 2019 (2019Q4).

Banks' funding composition: positive comovements between deposits and wholesale funding. We now estimate the impact of changes in the interest rate on the composition of retail deposits and wholesale funding for banks constrained by deposit rate ceilings. Using the difference-in-differences (DID) approach, we find that in response to changes in monetary policy rates, retail deposits comove positively with wholesale funding in banks subject

[3]See Chen et al. (2018); Cong et al. (2019); Chen et al. (2020); Li et al. (2020); Chen et al. (2023), among others.

to binding deposit rate ceilings (hereafter, BBs—binding banks), while this correlation is negative in banks not constrained by these ceilings (hereafter, NBBs—non-binding banks).

Our sample includes two groups of banks: BBs and NBBs. We define the "deposit ceiling spread" as the difference between the deposit rate and its regulatory ceiling. For BBs, this spread is zero, indicating that their deposit rates are bound by the regulatory ceiling. For NBBs, by contrast, this spread is negative, reflecting that their deposit rates are not constrained by the regulatory ceiling. To mitigate the influence of other macroeconomic factors on the deposit ceiling spread, we consider an individual bank's spread one quarter after the China Banking Regulatory Commission's first-time relaxation of the deposit ceiling regulation on June 8, 2012, which predates our sample period. This regulatory change marked the PBC's first increase in the deposit rate ceiling from the benchmark deposit rate to 1.1 times that rate. Therefore, if a bank is subject to or bound by the binding deposit rate ceiling imposed by the regulation, the bank's deposit ceiling spread will be zero following the relaxation of deposit rate ceiling regulation. Conversely, if such regulation does not affect a particular bank, this bank's deposit ceiling spread will be negative.

Wholesale funding supplies a bank with an alternative source of external finance. Loan demand and the availability of banks' internal funds may affect how banks rely on retail deposits and wholesale funding as external sources of funding. To control for these factors, we include in our regression three alternative measures of liquidity: the ratio of net increase of cash (and cash equivalents) to total assets (LIQ), earnings per share (EPS), and the ratio of proceeds from issuing shares to total assets (STK). With these variables controlled for, we run an unbalanced bank-quarter panel regression as follows:

$$\begin{aligned}\Delta y_{b,t} = \alpha R_{t-1} + \beta R_{t-1} \times I(BB) + \gamma X_{b,t-1} \\ + \alpha_b + \tau_y + \tau_q + \epsilon_{b,t},\end{aligned}$$

where $\Delta y_{b,t}$ is the year-over-year change in retail deposits or wholesale funding in bank b in quarter t, scaled by total liabilities; R_{t-1} is the policy interest rate lagged by one quarter, measured as the 7-day reverse repo rate for all financial institutions (R007); I(BB) is a dummy variable equal to 1 if the bank is a BB and zero otherwise; $X_{b,t-1}$ represents a set of bank-level variables, including the control variables and their interaction with the lagged policy interest rate; τ_y is the year fixed effect to control for macroeconomic shocks other than changes in the policy rate; and τ_q represents quarter-of-year fixed effects to account for seasonality. The coefficient α captures the response of deposits or wholesale funding to changes in the policy rate for NBBs. The coefficient β measures the marginal impact of a change in the policy rate on deposits or wholesale funding for BBs, so that the overall impact is measured by $\alpha + \beta$.

Table 1 presents the responses of retail deposits and wholesale funding to changes in the policy rate. In column (1), the estimated coefficient α, representing the response of NBBs' deposits or wholesale funding to policy rate changes, is negative and statistically significant. This estimate implies that for NBBs, a one-percentage-point decrease in the policy rate corresponds to a 1.7 percentage-point increase in retail deposits (as a share of total liabilities). The estimated coefficient β, which measures the marginal impact of policy rate changes on BBs, is significantly positive, indicating that the response of retail deposits in BBs is weaker than that in NBBs. Accordingly, the increase in retail deposits in response to a one-percentage-point decrease in the policy rate is only 0.72 percentage point for BBs, as indicated by the estimated value of $\alpha + \beta$. Thus, BBs experience a less pass-through from changes in the policy rate into retail deposits than NBBs, but nonetheless their deposits rise. This result remains robust when we include time-varying bank-specific controls, as shown in column (2).

Column (3) presents the estimated results for wholesale funding. The estimated coefficient α is positive and statistically significant. The estimate indicates that a one-percentage-point decrease in the policy rate leads to a 0.58 percentage-point decrease in wholesale funding, consistent with existing literature. Intuitively, a policy rate cut reduces the cost of deposit funding, encouraging banks to substitute retail deposits for wholesale funding.[4] By contrast, the estimated coefficient β is negative and statistically significant, indicating that wholesale funding in BBs increases by 1.83 percentage points relative to NBBs in response to a one-percentage-point decrease in the policy rate. The overall impact of a policy rate cut on BBs' wholesale funding, captured by $\alpha + \beta$, is negative and highly significant statistically. Again, our findings are robust to the inclusion of time-varying bank-specific controls (column (4)).

These results reveal significant comovement between retail deposits and wholesale funding when the policy rate changes. Comparing the sign of α between columns (1) and (3), as well as between columns (2) and (4), confirms that in the absence of deposit rate ceilings, as in most developed economies, there is a negative comovement between retail deposits and wholesale funding in response to policy rate changes. This result is consistent with empirical

[4]Conversely, when the monetary authority increases its interest rate and deposits become more expensive, NBBs turn to wholesale funding.

Table 1. Effects of the policy rate on retail deposits and wholesale funding

	Deposits		Wholesale funding	
	(1)	(2)	(3)	(4)
R_{t-1}: α	-1.709***	-1.795***	0.579*	0.845**
	(0.328)	(0.368)	(0.329)	(0.336)
$R_{t-1} \times I(BB)$: β	0.993**	0.924**	-2.410***	-2.027***
	(0.401)	(0.398)	(0.338)	(0.446)
$R_{t-1} \times LIQ_{t-1}$		-0.00740		-0.0114
		(0.0691)		(0.106)
$R_{t-1} \times EPS_{t-1}$		0.407		-0.523
		(0.282)		(0.317)
$R_{t-1} \times STK_{t-1}$		-1.129		-1.029
		(1.553)		(1.187)
$\alpha + \beta$	-0.72**	-0.87**	-1.83***	-1.18**
Bank FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Seasonal FE	YES	YES	YES	YES
N	540	540	543	543
R^2	0.0284	0.0673	0.0850	0.1025

Note: This table presents regression results with the year-over-year change in deposits and wholesale funding for each bank, scaled by total liabilities, as the dependent variable. Wholesale funding includes borrowings from banks and other financial institutions, borrowings from the central bank, bonds payable, and financial assets sold for repurchase. The independent variables include the policy interest rate (R_{t-1}) measured by R007, and its interaction with an indicator of whether the bank is subject to the deposit rate ceiling or not ($I(BB)$). Bank-level control variables include the ratio of net change of liquid assets to total assets (LIQ_{t-1}), earnings per share (EPS_{t-1}), and the ratio of proceeds from issuing shares to total liabilities (STK_{t-1}), along with their interaction terms with R_{t-1}. The regressions control for bank-specific, year fixed, and seasonal fixed effects. Robust standard errors, clustered by bank, are reported in parentheses. Statistical significance is denoted by *** at the 1% level, ** at 5%, and * at 10%.

evidence from the United States. When banks face binding deposit rate ceilings, by contrast, wholesale funding and retail deposits comove positively in response to policy rate changes, as indicated by the same sign of $\alpha + \beta$ in columns (1) and (3), and in columns (2) and (4).

The role of wholesale funding in the monetary transmission mechanism. In this section, we provide empirical evidence on the impact of wholesale funding on the transmission of changes in the policy rate to bank loans for BBs by estimating the following regression, using a subsample that contains only BBs:

$$\begin{aligned}\Delta L_{b,t} = &\alpha W_{b,t-1} + \beta R_{t-1} \times W_{b,t-1} + \gamma R_{t-1} + \kappa X_{b,t-1} \\ &+ \alpha_b + \tau_y + \tau_q + \epsilon_{b,t}\end{aligned},$$

where $\Delta L_{b,t}$ represents the year-over-year changes in bank loans for bank b in quarter t, and $W_{b,t-1}$ denotes the wholesale funding in the previous quarter, both scaled by total liabilities. A vector of control variables, $X_{b,t-1}$, includes the ratio of net profit to total assets (ROA) to control for the effects of loan demand, and the ratio of total liabilities to equity (LEV) to control for the effects of bank leverage. The term α_b denotes bank fixed effects, τ_y year fixed effects, and τ_q quarter (seasonal) fixed effects. Our primary focus is on the coefficient β, which captures the role of wholesale funding in transmitting the monetary policy rate to bank lending.

Table 2 reports the estimation results. The estimated coefficient α is positive and statistically significant, suggesting that banks with higher exposure to wholesale funding experience a larger increase in bank lending. The estimated value of β is negative and statistically significant, indicating that for every one-percentage-point increase in wholesale funding, there is a corresponding 0.06 percentage point increase in the elasticity of bank lending to the policy rate. Our findings are robust to the inclusion of macroeconomic factors such as quarterly year-over-year GDP growth and inflation rates, as well as their interactions with bank-specific variables, as additional control variables. Moreover, our results hold under a different specification that includes bank, year, and seasonal fixed effects to control for unobserved time-varying bank characteristics.

In summary, our results for BBs are twofold. First, we observe that for BBs, wholesale funding comoves positively with retail deposits when the policy rate changes. Second, the higher a bank's exposure to wholesale funding, the more sensitive its lending is to changes in the policy rate. These findings not only shed light on the complex dynamics of bank funding and lending but also provide empirical motivation to develop a theoretical model that explicitly considers the impact of financially repressive regulations such as deposit rate ceilings.

TABLE 2. Effects of wholesale funding exposure on monetary transmission to bank lending

	(1)	(2)	(3)	(4)
W_{t-1}: α	0.252***	0.249***	0.282***	0.258***
	(0.0742)	(0.0741)	(0.0802)	(0.0782)
$R_{t-1} \times W_{t-1}$: β	-0.0588**	-0.0590**	-0.0741***	-0.0663**
	(0.0223)	(0.0217)	(0.0217)	(0.0242)
R_{t-1}: γ	0.278	0.567	-0.304	-1.169
	(0.209)	(0.982)	(1.205)	(1.372)
$R_{t-1} \times ROA_{t-1}$		-0.0955	-0.294	-0.190
		(0.215)	(0.278)	(0.222)
$R_{t-1} \times LEV_{t-1}$		-0.0144	0.0607	0.111
		(0.0551)	(0.0740)	(0.0862)
Bank FE	YES	YES	YES	YES
Year FE	YES	YES	NO	YES
Seasonal FE	YES	YES	NO	YES
Macro Controls	NO	NO	YES	YES
N	543	543	543	543
R^2	0.0719	0.0787	0.1353	0.1078

Note: This table presents regression results in which the dependent variable is the bank-quarter observation of the year-over-year change in outstanding bank loans, scaled by total assets. The independent variables include the standardized ratio of wholesale funding to total liabilities (W_{t-1}) and its interaction with the policy rate (R_{t-1}), measured as R007. The bank-level control variables include net profit scaled by total assets (ROA_{t-1}), the ratio of total liabilities to equity (LEV_{t-1}), and their interactions with R_{t-1}. Macro control variables include the year-over-year GDP growth rate (GDP_t) and the year-over-year CPI inflation rate (INF_t), along with their interactions with bank-specific variables. Robust standard errors, clustered by bank, are reported in parentheses. Statistical significance is indicated by *** at the 1% level, ** at 5%, and * at 10%.

A banking model with deposit market regulation

In this section, we develop a simple model to illustrate how regulatory ceilings on deposit interest rates affect the transmission of monetary policy to banks' funding composition. Our model assumes that banks are subject to imperfect competition in the deposit market, which is a key aspect of the deposit channel for monetary policy transmission. In addition, banks are subject to a capital constraint, and monetary policy influences the tightness of this constraint. In our model, deposit market regulation is characterized by a ceiling on deposit rates, effectively placing a lower bound on the spread between the policy rate and the deposit rate. We demonstrate that under these conditions, wholesale funding can enhance the transmission of monetary policy, a novel finding that has not been previously explored.

Environment. The economy has two types of agents: a set of N monopolistically competitive banks and the representative household. Banks have the option to borrow through deposits (d) or wholesale funding (w). Deposits are subject to monopolistic competition, whereas wholesale funding is not. On the other hand, the marginal cost of raising funds via wholesale funding increases in the amount borrowed, capturing the fact that unlike deposits, wholesale funding is uninsured. Banks can use these funds for two purposes: bank loans (l) and liquid assets in the form of cash (a). The representative household demands deposits and does not lend directly.

The household. The household is endowed with an initial wealth of W_0 and can invest in retail deposits as well as less liquid assets, which we refer to as bonds. At the beginning of the period, the household chooses B, bonds, and D, deposits. Deposits provide liquidity services that are reflected in utility, while bonds do not. We assume that the utility of liquidity services takes the log form that results in a downward-sloping curve of demand for deposits. Without loss of generality, the gross return on bonds is equal to the gross policy rate R_b set by the central bank. By choosing $\{C, D, B\}$, the household maximizes the sum of consumption and liquidity value

$$C + \beta_m \log D$$

subject to

$$C \leq W_0 R_b - DS = BR_b + DR_d,$$

where C represents consumption, β_m is the share parameter between consumption and liquidity services, and R_d denotes the gross return of deposits. Note that $W_0 = B + D$. The household's cost of holding deposits instead of bonds is captured by the deposit spread $S = R_b - R_d$. A first-order condition for this optimization problem leads to the following key equation that relates the household's demand for bank deposits to the deposit spread:

$$D = \frac{\beta_m}{S}. \tag{1}$$

Under deposit market regulation, there exists a ceiling for deposit rates such that

$$R_d \leq (1-\lambda)R_b, \tag{2}$$

which implies a lower bound for the deposit spread: $S \geq \lambda R_b$, where $0 < \lambda < 1$. Without deposit rate ceilings, the household's demand for deposits increases in response to a reduction in the deposit spread. When the deposit rate ceiling is binding, however, the amount of deposits that banks can supply becomes constrained. By combining Equation (1) and (2), we derive the following constraint for the demand of deposit, which individual banks take as given:

$$D \leq \frac{\beta_m}{\lambda R_b} = \bar{D}. \tag{3}$$

The aggregate deposits are a composite good produced by a set of N banks:

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

where η is the elasticity of substitution across banks, which is $1 < \eta < \infty$. Each bank has mass $\frac{1}{N}$ and produces deposits at rate D_i. As in Drechsler et al. (2017), we normalize the mass of each bank to $\frac{1}{N}$ so that the total size of banking sector is 1 regardless of N, and a larger N means higher deposit competition.

The representative household chooses deposits across banks to minimize the opportunity cost of holding deposits:

$$\min_{D_i} \sum_{i=1}^{N} \frac{1}{N} D_i S_i, \tag{5}$$

subject to equation (4).

In the symmetric equilibrium, we have $S_i = S$. We can show that in a symmetric equilibrium the elasticity of demand for bank is deposits is given by

$$-\frac{\partial log D_i}{\partial log S_i} = \frac{N-1}{N}\eta \tag{6}$$

We define $M = -1 - \frac{1}{\frac{\partial log D_i}{\partial log S_i}} = \frac{N}{(N-1)\eta} - 1$ as the market power of the bank i[5].

[5]From *Supplementary Appendix 3, equation (S2)*, M should be positive, hence $1 < \eta < \frac{N}{N-1}$. When $N \to \infty$, $M \to 0$; when $N \geq 2$, $M < 1$. Therefore, M is between 0 and 1.

Banks. Banks consume all of their profit at the end of the period. The profit of bank i at the end of the period is denoted as Π^i, and it represents the sum of the gross return on bank loans, net of the cost of retail deposits and wholesale funding. We follow Wang et al. (2022) and assume that lending involves a maturity transformation between assets and liabilities. Specifically, loans mature in two periods for simplicity (i.e., a portion α of loans mature in the first period, and the remaining $1-\alpha$ mature in the second period). Both retail deposits and wholesale funding are short-term and mature for one period.

Therefore, the bank's profit at the end of the period is:

$$\Pi^i = (1-\alpha)L_{i,-1}r^l_{-1} + \alpha(R_b + l_0)L_i - (R_b + \psi W_i)W_i - (R_b - S_i)D_i, \tag{7}$$

where $L_{i,-1}$ represents existing loans from the last period, r^l_{-1} is the pre-fixed loan interest rate associated with $L_{i,-1}$, $L_i = D_i + W_i$ is the total loans of the current period, and l_0 and $\psi > 0$ are parameters that control the bank's lending opportunities and wholesale funding costs.

The bank's ability to raise funds is subject to the capital requirement:

$$\theta(W_i + D_i) \leq \Pi, \tag{8}$$

where $0 < \theta \leq 1$. Thus, the bank's net profit must exceed a certain fraction of its total funding. Note that the maturity mismatch (i.e., the difference in time-to-maturity between assets and liabilities) makes the tightness of the capital constraint respond endogenously to the policy rate. Because deposit and wholesale funding are short-term, both the deposit rate and interest rate for wholesale funding adjust instantaneously with the policy rate. Loans are long-term, so only a fraction of loans mature, while the remaining $1-\alpha$ of loans carry the same pre-fixed interest rate. Hence, a decrease in the policy rate increases bank capital and relaxes the bank capital constraint.[6]

Effects of monetary policy on banks' funding composition. In this section, we analyze the effects of monetary policy on banks' funding composition. Specifically, we compare the responses of deposits and wholesale funding under two scenarios: with and without deposit rate ceilings. We begin with the following assumption.

Assumption 1.

$$\alpha < \frac{\theta}{l_0}. \tag{9}$$

[6]The capital constraint, represented by equation (8), reflects regulatory requirements on banks' equity or capital. This constraint, discussed in Wang et al. (2022), is a commonly used feature in the literature.

Constraint (9) ensures that an increase in either deposit or wholesale funding tightens the capital constraint.

Proposition 1. Under Assumption 1, in response to changes in the monetary policy rate:

(1) When there are no deposit rate ceilings, equilibrium wholesale funding and retail deposits move in opposite directions, i.e.,

$$\frac{\partial W}{\partial R_b} > 0, \frac{\partial D}{\partial R_b} < 0;$$

if the aggregate supply of deposit $\hat{D}$ from banks is upward sloping in deposit rate spread S.

(2) When deposit rate ceilings are binding, equilibrium wholesale funding and retail deposits move in the same direction, i.e.,

$$\frac{\partial W}{\partial R_b} < 0, \frac{\partial D}{\partial R_b} < 0;$$

iff

$$(1-\alpha)W > (\theta - \alpha l_0)\frac{\bar{D}}{R_b} \tag{10}$$

The proof of Proposition 1 is in *Supplementary Appendix 3*. The intuition for this proposition is illustrated by Figure 1, which plots a bank's capital constraint curve and its indifference curve between retail deposits and wholesale funding. The red convex contour shows the bank's indifference before a change in R_b, and the blue one shows it after R_b decreases. The marginal rate of substitution between deposit and wholesale funding, as reflected in the slope of the convex indifference curve, is

$$\frac{dW_i}{dD_i} = -\frac{\Pi^i_D}{\Pi^i_W} = -\frac{\alpha l_0 - (1-\alpha)R_b - MS_i}{\alpha l_0 - (1-\alpha)R_b - 2\psi W_i}, \tag{11}$$

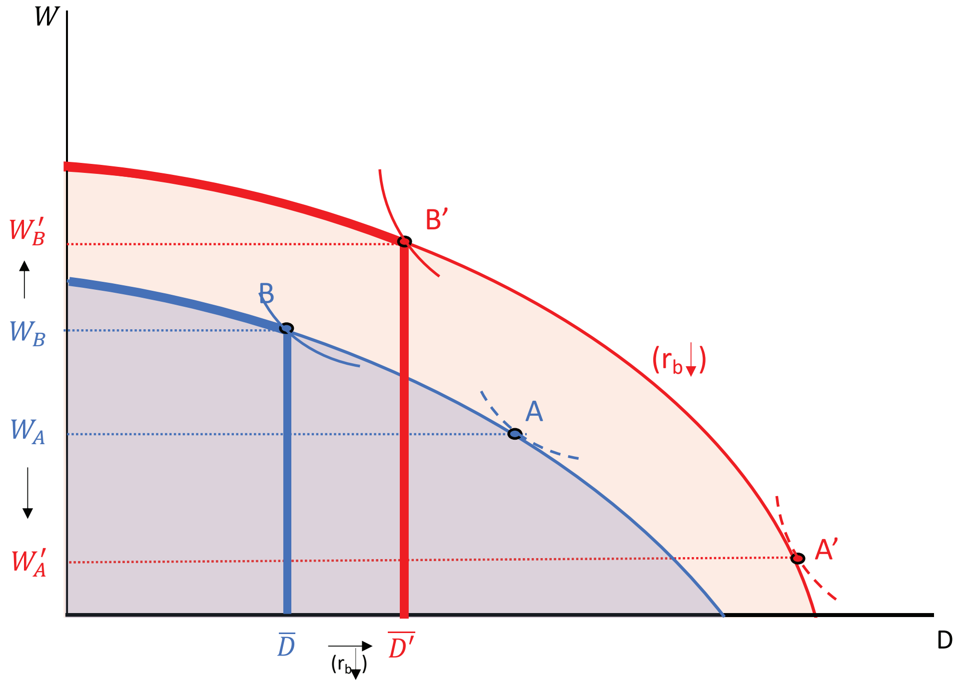
where $\Pi^i_X = \partial \Pi^i / \partial X$. The concave contour is the capital constraint with the slope

$$\frac{dW_i}{dD_i} = -\frac{\theta - (\alpha l_0 - (1-\alpha)R_b - MS_i)}{\theta - (\alpha l_0 - (1-\alpha)R_b - 2\psi W_i)}. \tag{12}$$

Point A in Figure 1, where the concave curve is tangent to the dotted curve, represents the optimal funding composition without deposit rate ceilings. In this case, wholesale funding is determined by *Supplementary Appendix 4, equation (S14)*. When there is a deposit rate ceiling, the deposit supply by the bank is constrained in equilibrium, which moves the optimal funding mix to point B, with a higher W compared to the case without deposit rate ceiling.

A loosening of monetary policy has two opposing effects on wholesale funding. On the one hand, a decrease in the policy rate increases the marginal returns to deposits relative

FIGURE 1. Impacts of changes in the monetary policy rate on banks' funding composition



Note: The vertical axis represents wholesale funding denoted by "W", and the horizontal axis represents deposits denoted by "D".

to wholesale funding, shown by a steeper indifference curve in Figure 1.[7] This effect, called "substitution effect", together with a binding capital constraint, encourages banks to substitute deposits for wholesale funding in the case without deposit rate ceilings. On the other hand, a decrease in the policy rate relaxes the capital constraint by increasing the bank's equity. This leads to a larger feasible set of $\{D, W\}$ and enables banks to expand their sources of funds through an increase in the supply of wholesale funding. This effect is called the "wealth effect".

These two effects underly the overall impacts of policy rates on wholesale funding without deposit rate ceilings. Figure 1 shows that with a lower policy rate, the new optimal point is A', which suggests that the substitution effect plays a dominant role. Intuitively, since wholesale funding increases the marginal cost while deposit does not, it is optimal to substitute deposits for wholesale funding even if the capital constraint is relaxed.

[7]For a given pair of optimal choice (D, W), when the policy rate R_b decreases by one unit, the numerator of (11) increases by $1 - \alpha + \frac{\partial S}{\partial R_b} M$, while the denominator increases only by $1 - \alpha$. Hence, the tangent of the indifference curve is steeper.

The presence of deposit rate ceilings, however, removes the substitution effect on wholesale funding, as the increase of deposit is constrained by the deposit rate ceiling on the policy rate. Accordingly, the overall impact of a decrease in policy rates on wholesale funding depends on two opposing effects on the tightness of the capital constraint. One is the wealth effect as captured by $(1-\alpha)W$, which increases wholesale funding by relaxing the capital constraint. The other effect, via an increase in the deposit rate ceiling and thus deposits, tends to tighten the capital constraint and thus reduce wholesale funding. Condition (10) ensures that the wealth effect outweighs the opposing effect. As illustrated by Figure 1, the new optimal point becomes B' with a higher W, despite the fact that a decrease in R_b increases deposits D by relaxing the deposit ceiling constraint. In other words, wholesale funding and deposits comove positively in response to changes in the policy rate.

In summary, Proposition 1 provides theoretical results regarding the responses of banks' funding composition to changes in the policy rate and, in particular, the role of deposit rate ceilings in such responses. In the next section, we examine the role of wholesale funding in the monetary transmission to bank lending.

Role of wholesale funding in the monetary transmission. In this section, we discuss the transmission of monetary policy to the real economy and provide theoretical results on the significance of wholesale funding in this process. By comparing economies with and without wholesale funding, we establish the following proposition.

Proposition 2. Denote $|_{w>0}$ as the case with wholesale funding and $|_{w=0}$ as the case without wholesale funding. Then, under Assumption 1,

(1) without deposit rate ceilings and with $\frac{\partial S}{\partial R_b} < \frac{(1-\alpha)S}{2[\theta+(1-\alpha)R_b-\alpha l_0]}$, the equilibrium loan L satisfies:
$$\frac{\partial L}{\partial R_b}\Big|_{w>0} > \frac{\partial L}{\partial R_b}\Big|_{w=0};$$
(2) when deposit rate ceilings are binding, the equilibrium loan L satisfies:
$$\frac{\partial L}{\partial R_b}\Big|_{w>0} < \frac{\partial L}{\partial R_b}\Big|_{w=0} < 0.$$

The proof of Proposition 2 is in *Supplementary Appendix 4*. According to this proposition, when deposit rate ceilings are binding, a policy rate reduction relaxes banks' capital constraints. This relaxation allows them to increase their loan supply by raising funds through wholesale markets. As a result, the equilibrium loan increases more in response to a policy rate reduction when banks have access to wholesale funding than in the absence of wholesale funding. Access to wholesale funding provides banks with an alternative source of funding for their lending activities.

Conclusion

Our study challenges the conventional view that wholesale funding weakens monetary policy transmission. In the context of China, where deposit rate ceilings constrain banks ability to attract retail funding, we show that wholesale funding instead complements retail deposits, thereby enhancing the transmission of policy rate changes to bank lending.

We develop a theoretical model to explain this dynamic outcome. When deposit rate ceilings bind, a policy rate cut relaxes banks capital constraints, generating a wealth effect that allows banks to expand both wholesale funding and retail deposits, leading to a positive comovement. By contrast, when such regulations are absent, the standard substitution effect dominates, and the traditional inverse relationship re-emerges. Using bank-level data from China, we provide empirical support for this mechanism.

These findings have significant implications for the design of liquidity regulations. While Basel III's Liquidity Coverage Ratio aims to reduce systemic risk by discouraging reliance on wholesale funding, our results suggest that such regulations may inadvertently weaken monetary policy transmission in economies with regulated deposit rates. As policymakers confront the dual challenge of financial stability and macroeconomic responsiveness, our work highlights the need for regulatory frameworks tailored to institutional contexts. Future research should explore how these trade-offs play out in emerging markets with similar regulatory constraints.

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