Mixed Oligopoly, Default Risk, and Monetary Policy Transmission

A Theory of Incomplete Pass-Through in Banking

Sarvesh Ingle

Indira Gandhi Institute of Development Research

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1 Introduction and Motivation

With the implementation of flexible inflation targeting in 2016, India underwent a major institutional transition to a more contemporary framework for instituting monetary policy. The reform sought to stabilize output and prices by basing inflation expectations on a numerical target. However, whether shifts in the policy repo rate have a significant impact on the interest rates that people and businesses must pay will determine how effective this structure is.

There has long been evidence from India that this relationship is not ideal as demonstrated by Khundrakpam and Jain [2012], who use structural VARs on quarterly data from 1996–1997 to 2011–2012 that changes in interest rates are the main way that monetary policy shocks affect output and inflation, albeit with significant lags and muted magnitudes. Using monthly data from 2001 to 2014, Mishra et al. [2016] refine this diagnosis by modelling the bank lending rate in their structural VAR as the credit channel's intermediary. They discover that policy rate shocks only partially shift lending rates in the manner predicted by theory as a peak increase in lending rates of about 10 basis points corresponds to a 25 basis point increase in the repo rate. In addition, they discover no statistically significant impacts on inflation or output but there is little empirical evidence to support the second step of transmission from lending rates to aggregate demand, even as the first route from policy rates to lending rates is operational. Before reaching the real economy, transmission seems to deteriorate.

Subsequent research has demonstrated that this trend of incomplete pass through has endured in spite of numerous institutional changes, this is as India transitioned from the Base Rate system to the MCLR framework, Chattopadhyay and Mitra [2023] demonstrate that pass-through increased. However, even under MCLR, a 100 basis point policy rate change resulted in an increase in lending rates of only 26 to 47 basis points. The transmission for new loans was additionally reinforced by the introduction of external benchmark linkage in 2019. However, due to balance sheet constraints and legacy contracts, the adjustment of outstanding loan rates continues to be sluggish and as such incomplete pass-through is still common even after over ten years of reform.

There are obvious consequences to this persistence, such as the RBI having to rely on greater policy rate changes to produce the same real effects when pass-through is weak, which increases volatility and makes communication more difficult. Credit distribution also further being distorted by unequal transmission between banks and borrower types and the transmission mechanism seeming to deteriorate much more at times of balance sheet stress, when countercyclical intervention is most beneficial.

2 Literature Review

2.1 Asymmetric Adjustment

The literature has consistently concluded that India's monetary transmission has been asymmetric. Das [2015] for example using a stepwise vector error correction methodology demonstrated that lending rates react faster to monetary tightening than to easing. After policy hikes, banks tend to raise lending rates quickly, while after cuts, they lower them slowly whereas the opposite pattern is seen in deposit rates, which rise during tightening cycles but fall more easily during relaxing ones. Compared to deposit rates, it takes a far longer to achieve partial pass-through for lending rates.

This asymmetry suggests that monetary easing is structurally less effective than tightening, not because policy signals are being misinterpreted but rather because banks react differently according to the shock's direction. Even though Das [2015] discusses the phenomenon, he does not identify the mechanism causing this pattern. .

2.2 Public Sector Bank Dominance

One characteristic that sets the Indian banking sector apart from its counterparts is its ownership structure. Since public sector banks make up around 70% of the assets in the financial system, their actions have a disproportionately large impact on overall results. In lin with this, evidence indicates that PSBs react to monetary policy in a different way than private or foreign banks, albeit the specifics of this difference vary depending on the margin under consideration.

As Bhaumik et al. [2011] investigates how loan quantities react to monetary tightening across ownership types, using bank-level data and using the prime lending rate as a gauge of the policy attitude they discover that PSBs do cut credit during tight money periods, but to a far lesser extent than foreign banks. They attributed this subdued reaction of PSBs' to long standing connections with small, rural, and state-linked borrowers and their informational advantages, which would enable them to smoothen the supply of credit when conditions tighten, which contrasts with foreign banks, which react more forcefully, which is consistent with more risk aversion and less access to information.

Das et al. [2015] go on to provide granular evidence on PSB behavior using branch-level data from over 128 million loans and thus find that high-NPA branches receive fewer resources during policy easing and monetary transmission is more sluggish in state-owned banks, which is a form of internal capital rationing. An important fact is that this effect of NPA-disciplining is statistically insignificant in PSBs, suggesting their internal credit allocation is less sensitive to asset quality than private banks, which the authors attribute this to organizational rigidities and government influence over strategic decisions.

Reserve Bank of India [2017] show that rate-setting behavior points in a different direction as they document that PSBs adjust lending rates more sluggishly than private banks in response to policy rate changes which reflects rigid deposit structures, discretion in spread-setting, and the persistence of legacy loan contracts which given the dominant market share of PSBs dampens aggregate pass-through and raises questions about whether these patterns reflect temporary frictions or more structural features of public banking.

2.3 Asset Quality and Capital Constraints

India's banking system experienced a sharp deterioration in asset quality during the mid-2010s, culminating in what the Economic Survey (2016–17) had termed the Twin Balance Sheet problem. John et al. [2016] analyzed how credit risk affected banks' pricing and lending behavior and showed that when gross NPAs are relatively low but rising, banks attempt to protect profitability by loading risk premia onto lending rates in order to build provisions whereas at higher levels of NPAs, however, this interest rate channel weakens. Competitive pressures prevent banks from sustaining higher spreads, net interest margins come under pressure, and banks respond primarily by cutting loan exposures rather than maintaining elevated lending rates.

Muduli and Behera [2020] provide further evidence that links stressed assets to weak transmission as they find that higher NPAs are associated with reduced loan growth and blunted monetary policy effects. Their results also highlight the role of capital adequacy, as demonstrated by the observation that monetary policy is most effective when banks operate closer to regulatory minimum capital levels and becomes less effective as capital buffers increase. Their threshold results relate primarily to funding costs rather than identifying a sharp NPA cutoff at which the lending channel breaks down. The broader conclusion that can be derived is that stressed assets hinder transmission even when higher capital helps reduce funding costs.

Van den Heuvel [2002] explores the bank capital channel which is the theoretical foundation for the previous findings, and as such shows that when capital requirements bind or nearly bind, banks cannot expand lending in response to policy easing without issuing costly new equity. Sengupta et al. [2025] provide direct evidence that this mechanism operates in India by using a panel of the 18 largest commercial banks, where they find that a 100 basis point increase in interest rates reduces credit growth by about a percentage point in the full sample. They also show that ownership and balance sheet conditions matter as private banks, which tend to maintain stronger capital positions, are more resilient, while the mitigating role of capital weakens during the high-NPA phase of 2014–2018.

Sengupta et al. [2025] further decompose this by ownership. As Private banks maintain higher capital ratios and access equity markets, they are more resilient to policy shocks, in contrast to PSBs for whom the bank capital channel is statistically insignificant as their capital positions are often too weak to provide a buffer during stress. The authors highlight that during high-NPA phases, the reported capital overstates effective capital, as buffers are implicitly committed against any potential losses. This might explain why well-capitalized PSBs still fail to moderate transmission during stress episodes.

2.4 Theoretical Perspectives and the Gap

Theoretical work has attempted to address transmission frictions yet largely in isolation. Credit rationing models following Stiglitz and Weiss [1981] shows how credit rationing emerges rather tahn price adjustments due to adverse selection that might provide a basis for incomplete pass through. The mixed oligopoly literature also offers tools for analyzing the ownership heterogeneity that is characteristic for India's banking sector, such as Saha and Sensarma [2009], who model competition between welfare-oriented public banks and profit-maximizing private banks, showing that under high default risk, state banks may contract deposits to protect depositors. However, their model does not address monetary transmission. Dalla and Varelas [2019] on the other hand incorporate capital requirements into an oligopolistic framework and show that tighter solvency constraints weaken policy effectiveness, but they treat banks symmetrically and abstract from ownership differences.

These papers establish what happens but leave open why these ownership-specific patterns, as documented in earlier sections might arise as equilibrium outcomes, even as the existing explanations appeal to organizational frictions, legacy contracts, or government influence; all of which are factors that are difficult to model or quantify for policy analysis.

Thus, this paper proposes a mixed oligopoly framework that provides structural microfoundations for these documented patterns. By modeling competition between a welfare-oriented public bank and profit-maximizing private banks, we hope to explain that:

- **PSBs cannot maintain spreads under stress** as the welfare objective induces PSBs to internalize borrower surplus, restraining rate increases even when NPAs rise. Strategic interaction then moderates private bank pricing too, which then dampens aggregate pass-through.
- **Capital buffers function differently by ownership**, as when capital constraints bind, profit-maximizing banks contract lending to preserve margins whereas PSBs, weighting welfare, might end up accepting a lower margin in order to maintain credit supply. This might explain why capital fails to moderate transmission for PSBs during stress.
- **internal allocation differs** as the weaker NPA-disciplining in PSBs documented by Das et al. (2015) may reflect optimal behavior under welfare maximization rather than organizational dysfunction.

To our knowledge, the mixed oligopoly approach has not been applied to study monetary policy transmission. This framework enables us to analyze and compare against counterfactuals such as quantifying how transmission would change under PSB privatization or altered prudential requirements that reduced form empirical work cannot provide.

Thus this paper attempts to answer how strategic interaction between (partial) welfare-maximizing public banks and profit-maximizing private banks shape the transmission of monetary policy to lending rates, and how does this interaction depend on default risk and capital adequacy?

3 Model

3.1 Environment

Consider a banking market with two banks indexed by $i \in \{0, 1\}$. Bank 0 has partial public ownership with the government holding a stake that induces objective weight $\theta \in [0, 1]$ on social welfare. Bank 1 is fully private and profit-maximizing. When $\theta = 0$, both banks are profit-maximizers, and the model reduces to a standard private duopoly.

Banks compete in a two-stage game solved by backward induction:

- **Stage 1:** Banks simultaneously choose deposit volumes (D_0, D_1)
- **Stage 2:** Given deposits, banks simultaneously choose loan volumes (L_0, L_1)

This timing captures the empirical regularity that deposit bases are relatively stable and adjust more slowly than loan portfolios.

3.2 Market Structure

The loan market clears at rate r_L determined by inverse demand:

$$r_L = \mu Y - b(L_0 + L_1) \tag{1}$$

where Y denotes national income and $b > 0$ captures loan demand sensitivity.

The deposit market clears at rate r_D determined by inverse supply:

$$r_D = \beta + \gamma(D_0 + D_1) \tag{2}$$

where $\gamma > 0$ captures deposit supply sensitivity and $\beta > 0$ is the reservation rate.

3.3 Balance Sheet and Regulatory Constraints

Bank i faces a reserve requirement $R_i = \alpha D_i$ with $\alpha \in (0, 1)$ and a risk-based capital requirement $K_i = \rho L_i$ with $\rho \in (0, 1)$. The balance sheet identity implies a net interbank position:

$$M_i = (1 - \alpha)D_i - (1 - \rho)L_i \tag{3}$$

Banks with $M_i > 0$ lend in the interbank market at policy rate r; those with $M_i < 0$ borrow.

3.4 Cost Structure

Following Dalla and Varelas (2019), the management cost function takes the form:

$$C_i(L_i, D_i) = c(D_i) \cdot L_i + \varphi D_i \tag{4}$$

where the marginal cost of loans is $c(D_i) = \kappa D_i + m$ with $m > 0$.

Definition 1 (Scope Economies)**.** The parameter $\kappa \in \mathbb{R}$ determines the cost interaction between loans and deposits:

1. $\kappa < 0$: Economies of scope; deposits reduce the marginal cost of lending
2. $\kappa = 0$: Separable costs
3. $\kappa > 0$: Diseconomies of scope

The case $\kappa < 0$ captures synergies from relationship banking: deposit accounts generate information about customer cash flows, transaction patterns, and creditworthiness that reduces screening and monitoring costs for loans. This informational complementarity is well-documented empirically, particularly for small business lending where "soft information" from deposit relationships substitutes for hard collateral.

The magnitude $|\kappa|$ governs the strength of the deposit-loan cost linkage. When $|\kappa|$ is large, changes in deposit volume substantially affect loan supply through the cost channel. This creates a feedback mechanism that amplifies monetary policy transmission; but also makes transmission sensitive to factors that disrupt the deposit-loan relationship, including ownership structure and credit risk. The interaction between κ, θ, and p is the central focus of the theoretical analysis.

3.5 Default Risk

Following Saha and Sensarma (2013), borrowers face stochastic project outcomes. With probability $p \in (0, 1)$, projects succeed and borrowers repay principal plus interest. With probability $1 - p$, projects fail and banks recover only the principal. Under the no-limited-liability assumption, depositors receive full payment regardless of borrower defaults; banks absorb all losses.

Expected loan revenue per unit is therefore:

$$\mathbb{E}[\text{Loan Return}] = p \cdot r_L + (1 - p) \cdot 1 = p(r_L - 1) + 1 \tag{5}$$

3.6 Bank Objectives

The expected profit of bank i is:

$$\mathbb{E}[\Pi_i] = [p(r_L - 1) + 1]L_i + r \cdot M_i - r_D \cdot D_i - C_i(L_i, D_i) \tag{6}$$

Substituting the market-clearing conditions and rearranging yields the compact form:

$$\mathbb{E}[\Pi_i] = [\Phi - \kappa D_i - pb(L_i + L_j)]L_i + [\Psi - \gamma(D_i + D_j)]D_i \tag{7}$$

where the composite parameters are:

$$\Phi \equiv p(\mu Y - 1) + 1 - r(1 - \rho) - m \tag{8}$$
$$\Psi \equiv r(1 - \alpha) - \beta - \varphi \tag{9}$$

The term Φ represents the net expected return on loans after accounting for default risk, interbank opportunity cost, and base marginal cost. The term Ψ represents the net margin on deposits.

The private bank maximizes $\mathbb{E}[\Pi_1]$. The public bank maximizes:

$$W_0 = \theta \cdot \mathbb{E}[SW] + (1 - \theta) \cdot \mathbb{E}[\Pi_0] \tag{10}$$

where expected social welfare is:

$$\mathbb{E}[SW] = \mathbb{E}[\Pi_0] + \mathbb{E}[\Pi_1] + \underbrace{\frac{\gamma(D_0 + D_1)^2}{2}}_{\text{Depositor Surplus}} + \underbrace{\frac{pb(L_0 + L_1)^2}{2}}_{\text{Borrower Surplus}} \tag{11}$$

3.7 Parameter Assumptions

Assumption 1 (Regularity Conditions)**.** The following conditions hold throughout:

1. All market parameters are strictly positive: $\mu, Y, b, \gamma, \beta, \varphi, m > 0$
2. Default and regulatory parameters are interior: $p, \alpha, \rho \in (0, 1)$
3. The policy rate is positive: $r > 0$
4. The loan market is viable: $\Phi > 0$

4 Stage 2: Loan Market Equilibrium

Taking deposits (D_0, D_1) as given, banks simultaneously choose loan volumes.

4.1 First-Order Conditions

The private bank's first-order condition is:

$$\frac{\partial \mathbb{E}[\Pi_1]}{\partial L_1} = \Phi - \kappa D_1 - 2pbL_1 - pbL_0 = 0 \tag{12}$$

For the public bank, the first-order condition incorporates the welfare externalities:

$$\frac{\partial W_0}{\partial L_0} = \Phi - \kappa D_0 - (2-\theta)pbL_0 - pbL_1 = 0 \tag{13}$$

The coefficient $(2-\theta)$ on the public bank's own loan quantity reflects the internalization of borrower surplus: when $\theta > 0$, the public bank perceives a flatter marginal revenue curve because it values the consumer surplus generated by additional lending.

4.2 Equilibrium Loan Quantities

Solving the system (12)–(13) yields:

Proposition 1 (Stage 2 Equilibrium). *For given deposits (D_0, D_1), the unique Stage 2 Nash equilibrium loan quantities are:*

$$L_0^*(D_0, D_1) = \frac{\Phi - 2\kappa D_0 + \kappa D_1}{(3-2\theta)pb} \tag{14}$$

$$L_1^*(D_0, D_1) = \frac{(1-\theta)\Phi + \kappa D_0 - (2-\theta)\kappa D_1}{(3-2\theta)pb} \tag{15}$$

Proof. From (12), the private bank's reaction function is:

$$L_1 = \frac{\Phi - \kappa D_1 - pbL_0}{2pb}$$

Substituting into (13) and solving for L_0 yields (14). Back-substitution gives (15). □

When $\theta = 0$, symmetry obtains: if $D_0 = D_1 = D$, then $L_0^* = L_1^* = (\Phi - \kappa D)/(3pb)$.

The partial derivatives of equilibrium loans with respect to deposits are:

$$\frac{\partial L_0^*}{\partial D_0} = \frac{-2\kappa}{(3-2\theta)pb}, \quad \frac{\partial L_0^*}{\partial D_1} = \frac{\kappa}{(3-2\theta)pb} \tag{16}$$

$$\frac{\partial L_1^*}{\partial D_0} = \frac{\kappa}{(3-2\theta)pb}, \quad \frac{\partial L_1^*}{\partial D_1} = \frac{-(2-\theta)\kappa}{(3-2\theta)pb} \tag{17}$$

Under scope economies ($\kappa < 0$), an increase in own deposits raises own lending: the cost reduction from additional deposits expands loan supply.

5 Stage 1: Deposit Market Equilibrium

In Stage 1, banks choose deposits anticipating the Stage 2 loan equilibrium derived above.

5.1 Structure of the First-Order Conditions

When bank i chooses D_i, the total derivative of its objective incorporates both direct effects and strategic effects through equilibrium loan responses:

$$\frac{dW_i}{dD_i} = \frac{\partial W_i}{\partial D_i} + \frac{\partial W_i}{\partial L_i^*}\frac{\partial L_i^*}{\partial D_i} + \frac{\partial W_i}{\partial L_j^*}\frac{\partial L_j^*}{\partial D_i} \tag{18}$$

By the envelope theorem, the own-loan term vanishes at the Stage 2 optimum. However, the rival-loan term generally does not, as bank i does not internalize the effect of its deposits on bank j's profits through changed loan competition.

5.2 Private Bank First-Order Condition

The private bank's Stage 1 condition, after applying the envelope theorem, reduces to:

$$F_1 \equiv \frac{-2\kappa(2-\theta)L_1^*}{(3-2\theta)} + \Psi - \gamma D_0 - 2\gamma D_1 = 0 \tag{19}$$

5.3 Public Bank First-Order Condition

The public bank's condition, accounting for welfare externalities, is:

$$F_0 \equiv \frac{\kappa[\theta L_1^* - (4-3\theta)L_0^*]}{(3-2\theta)} + \Psi - (2-\theta)\gamma D_0 - \gamma D_1 = 0 \tag{20}$$

The asymmetric coefficients on D_0 and D_1 reflect the public bank's partial internalization of depositor surplus.

5.4 The Symmetric Benchmark: $\theta = 0$

When both banks are profit-maximizers, the model admits a symmetric equilibrium $D_0^* = D_1^* = D^*$.

Proposition 2 (Symmetric Equilibrium)**.** *When $\theta = 0$, the symmetric equilibrium deposit level is:*

$$D^* = \frac{4\kappa\Phi - 9pb\Psi}{\Omega} \tag{21}$$

where $\Omega \equiv 4\kappa^2 - 27\gamma pb$.

Proof. Setting $\theta = 0$ and imposing symmetry in (19) yields:

$$\frac{-4\kappa L^*}{3} + \Psi - 3\gamma D^* = 0$$

Substituting $L^* = (\Phi - \kappa D^*)/(3pb)$ and solving for D^* gives the result. □

Proposition 3 (Stability)**.** *The symmetric equilibrium is stable if and only if $\Omega < 0$, which requires:*

$$|\kappa| < \frac{3\sqrt{\gamma pb}}{2} \tag{22}$$

The stability condition bounds the strength of scope economies. Intuitively, if $|\kappa|$ is too large, the feedback between deposits and loans becomes explosive.

6 Monetary Policy Pass-Through: Symmetric Case

6.1 Definitions

Definition 2 (Pass-Through)**.** The loan rate pass-through and deposit rate pass-through are defined as:

$$PT_L \equiv \frac{\partial r_L^*}{\partial r}, \qquad PT_D \equiv \frac{\partial r_D^*}{\partial r} \tag{23}$$

Pass-through is complete if $PT = 1$, incomplete if $PT \in (0, 1)$, absent if $PT = 0$, and perverse if $PT < 0$.

6.2 Derivatives of Structural Parameters

The composite parameters respond to policy rate changes as:

$$\frac{\partial \Phi}{\partial r} = -(1 - \rho), \qquad \frac{\partial \Psi}{\partial r} = (1 - \alpha) \tag{24}$$

Higher policy rates reduce the net loan margin (through increased opportunity cost of capital) while improving the net deposit margin (through higher interbank earnings on excess reserves).

6.3 Equilibrium Pass-Through Expressions

Proposition 4 (Symmetric Pass-Through)**.** *In the symmetric equilibrium with $\theta = 0$:*

$$\frac{\partial r_D^*}{\partial r} = \frac{-8\gamma\kappa(1-\rho) - 18\gamma pb(1-\alpha)}{\Omega} \tag{25}$$

$$\frac{\partial r_L^*}{\partial r} = \frac{-6b[3\gamma(1-\rho) + \kappa(1-\alpha)]}{\Omega} \tag{26}$$

Proof. The deposit rate is $r_D^* = \beta + 2\gamma D^*$, so $\partial r_D^*/\partial r = 2\gamma \cdot \partial D^*/\partial r$. Differentiating (21) with respect to r yields (25). For the loan rate, $r_L^* = \mu Y - 2bL^*$ where $L^* = (\Phi - \kappa D^*)/(3pb)$. Applying the chain rule gives (26). □

6.4 Conditions for Positive Pass-Through

Proposition 5 (Pass-Through Sign Conditions)**.** *Under stability ($\Omega < 0$), positive pass-through requires:*

1. *Deposit rate:* $|\kappa| < \dfrac{9pb(1-\alpha)}{4(1-\rho)} \equiv \kappa_D^{crit}(p)$ *when* $\kappa < 0$
2. *Loan rate:* $|\kappa| < \dfrac{3\gamma(1-\rho)}{(1-\alpha)} \equiv \kappa_L^{crit}$ *when* $\kappa < 0$

A key asymmetry emerges: the critical threshold for deposit pass-through depends on p, while that for loan pass-through does not. As default risk rises (p falls), κ_D^{crit} decreases, making incomplete or perverse deposit pass-through more likely under scope economies.

7 Mixed Oligopoly: Main Results

This section presents the main theoretical contribution: the interaction between public ownership and default risk in determining pass-through.

7.1 The Stage 1 Jacobian

For general $\theta \in (0, 1)$, the system $(F_0, F_1) = (0, 0)$ must be solved simultaneously. Define $\Xi \equiv pb(3 - 2\theta)^2$ and let the Jacobian be:

$$\mathbf{J} = \begin{pmatrix} J_{00} & J_{01} \\ J_{10} & J_{11} \end{pmatrix} = \begin{pmatrix} \frac{\partial F_0}{\partial D_0} & \frac{\partial F_0}{\partial D_1} \\ \frac{\partial F_1}{\partial D_0} & \frac{\partial F_1}{\partial D_1} \end{pmatrix} \tag{27}$$

The elements are:

$$J_{00} = -(2-\theta)\gamma + \frac{\kappa^2(8-5\theta)}{\Xi} \tag{28}$$

$$J_{01} = -\gamma - \frac{\kappa^2(4-\theta-\theta^2)}{\Xi} \tag{29}$$

$$J_{10} = -\gamma - \frac{2\kappa^2(2-\theta)}{\Xi} \tag{30}$$

$$J_{11} = -2\gamma + \frac{2\kappa^2(2-\theta)^2}{\Xi} \tag{31}$$

At $\theta = 0$, symmetry holds: $J_{00} = J_{11}$ and $J_{01} = J_{10}$.

The derivatives of the first-order conditions with respect to the policy rate are:

$$\mathbf{F}_r = \begin{pmatrix} \partial F_0/\partial r \\ \partial F_1/\partial r \end{pmatrix} = \begin{pmatrix} f_0 \\ f_1 \end{pmatrix} \tag{32}$$

where, using $\partial\Phi/\partial r = -(1-\rho)$ and $\partial\Psi/\partial r = (1-\alpha)$:

$$f_0 = (1-\alpha) + \frac{\kappa(1-\rho)(2-\theta)^2}{\Xi} \tag{33}$$

$$f_1 = (1-\alpha) + \frac{2\kappa(2-\theta)(1-\theta)(1-\rho)}{\Xi} \tag{34}$$

Remark 1 (Role of Scope Economies in $\mathbf{F}_r$). When $\kappa < 0$, the second terms in (33)–(34) are negative, reducing the magnitude of f_0 and f_1. This reflects how scope economies dampen the direct sensitivity of deposit FOCs to policy rate changes: a rate increase tightens loan margins, but under scope economies, banks partially offset this by adjusting the deposit-loan cost linkage.

Lemma 1 (Jacobian Determinant). *The determinant of the Stage 1 Jacobian is:*

$$\Delta \equiv \det(\mathbf{J}) = (3-2\theta)\gamma^2 - \frac{\gamma\kappa^2(40-37\theta+11\theta^2-2\theta^3)}{\Xi} + \frac{2\kappa^4(2-\theta)(12-17\theta+6\theta^2)}{\Xi^2} \tag{35}$$

At $\theta = 0$, this reduces to $\Delta|_{\theta=0} = (4\kappa^2 - 3\gamma pb)(4\kappa^2 - 27\gamma pb)/(27p^2b^2)$.

7.2 The Transmission Mechanism under Scope Economies

Before deriving the formal results, it is useful to understand why the sign of κ plays such a central role in monetary transmission.

When $\kappa < 0$ (economies of scope), deposits and loans are cost complements: expanding the deposit base reduces the marginal cost of lending. This creates a feedback loop in the transmission mechanism:

1. A policy rate increase raises the opportunity cost of interbank borrowing, reducing the net return on loans (Φ falls)
2. Banks contract loan supply in response
3. Under scope economies, reduced lending raises the marginal cost of deposits (since $\partial^2 C/\partial L \partial D = \kappa < 0$ implies loans and deposits are cost complements)
4. Banks therefore also contract deposits, reducing deposit rates
5. The deposit contraction feeds back into further loan contraction through the cost channel

The magnitude $|\kappa|$ governs the strength of this feedback loop. When $|\kappa|$ is large, the deposit-loan cost linkage is strong, so small policy rate changes generate large equilibrium responses in both markets. When $|\kappa|$ is small, the markets are more independent and the feedback effect is weaker.

Public ownership disrupts this feedback mechanism. As shown by Saha and Sensarma [2013], welfare-maximizing public banks internalize depositor surplus and therefore resist aggressive deposit rate adjustments that would harm depositors. When default risk is high (low p), this effect is amplified: public banks facing substantial credit risk become additionally conservative to protect depositor welfare from potential losses. Formally, the public bank's objective includes depositor surplus CS_D, and when p is low, aggressive lending (which would require aggressive deposit mobilization) exposes depositors to greater risk of bank distress.

This conservatism dampens the deposit-loan feedback loop. A private bank facing a policy rate increase would aggressively cut deposit rates to reduce funding costs; a public bank resists this adjustment to protect depositors. The result is that the amplification mechanism; which depends on both deposit and loan markets responding together; is weakened under public ownership.

7.3 Deposit and Loan Responses via the Implicit Function Theorem

The equilibrium responses to policy rate changes are obtained by applying the implicit function theorem to the system $\mathbf{F}(\mathbf{D}, r) = \mathbf{0}$.

Deposit responses. Differentiating the system with respect to r:

$$\frac{d\mathbf{D}^*}{dr} = -\mathbf{J}^{-1}\mathbf{F}_r \tag{36}$$

where $\mathbf{J}$ is the Jacobian defined in (28)–(31) and $\mathbf{F}_r = (f_0, f_1)'$ from (33)–(34).

Applying Cramer's rule:

$$\frac{dD_0^*}{dr} = -\frac{J_{11}f_0 - J_{01}f_1}{\Delta} \tag{37}$$

$$\frac{dD_1^*}{dr} = -\frac{-J_{10}f_0 + J_{00}f_1}{\Delta} = \frac{J_{10}f_0 - J_{00}f_1}{\Delta} \tag{38}$$

where $\Delta = J_{00}J_{11} - J_{01}J_{10}$ is the Jacobian determinant from Lemma 1.

Loan responses. From the Stage 2 equilibrium (Proposition 1), the loan quantities depend on deposits:

$$L_0^* = \frac{\Phi - 2\kappa D_0 + \kappa D_1}{(3-2\theta)pb} \tag{39}$$

$$L_1^* = \frac{(1-\theta)\Phi - (2-\theta)\kappa D_1 + \kappa D_0}{(3-2\theta)pb} \tag{40}$$

Differentiating with respect to r:

$$\begin{aligned}\frac{dL_0^*}{dr} &= \frac{1}{(3-2\theta)pb}\left[\frac{\partial\Phi}{\partial r} - 2\kappa\frac{dD_0^*}{dr} + \kappa\frac{dD_1^*}{dr}\right] \\ &= \frac{1}{(3-2\theta)pb}\left[-(1-\rho) - 2\kappa\frac{dD_0^*}{dr} + \kappa\frac{dD_1^*}{dr}\right]\end{aligned} \tag{41}$$

$$\begin{aligned}\frac{dL_1^*}{dr} &= \frac{1}{(3-2\theta)pb}\left[(1-\theta)\frac{\partial\Phi}{\partial r} - (2-\theta)\kappa\frac{dD_1^*}{dr} + \kappa\frac{dD_0^*}{dr}\right] \\ &= \frac{1}{(3-2\theta)pb}\left[-(1-\theta)(1-\rho) - (2-\theta)\kappa\frac{dD_1^*}{dr} + \kappa\frac{dD_0^*}{dr}\right]\end{aligned} \tag{42}$$

The loan responses thus depend on both the direct effect of r on Φ and the indirect effect through deposit adjustments.

7.4 Pass-Through Formulas

We now derive the pass-through expressions. Recall the definitions:

- $PT_D \equiv \partial r_D^*/\partial r$: deposit rate pass-through
- $PT_L \equiv \partial r_L^*/\partial r$: loan rate pass-through

Deposit rate pass-through. The deposit rate is $r_D = \beta + \gamma(D_0 + D_1)$, so:

$$PT_D = \gamma\left(\frac{dD_0^*}{dr} + \frac{dD_1^*}{dr}\right) \equiv \gamma\Sigma_D \tag{43}$$

where Σ_D denotes the total deposit response.

Loan rate pass-through. The loan rate is $r_L = \mu Y - b(L_0 + L_1)$, so:

$$PT_L = -b\left(\frac{dL_0^*}{dr} + \frac{dL_1^*}{dr}\right) \tag{44}$$

Substituting the loan response formulas (41)–(42) and simplifying:

$$PT_L = \underbrace{\frac{(1-\rho)(2-\theta)}{p(3-2\theta)}}_{\text{Direct channel } \mathcal{D}} + \underbrace{\frac{\kappa}{p(3-2\theta)}\left[\frac{dD_0^*}{dr} + (1-\theta)\frac{dD_1^*}{dr}\right]}_{\text{Feedback channel } \mathcal{F}} \tag{45}$$

The *direct channel* $\mathcal{D}$ captures how policy rates affect loan supply holding deposits fixed: a policy rate increase reduces Φ, contracting loans and raising the loan rate. The *feedback channel* $\mathcal{F}$ captures the indirect effect operating through equilibrium deposit adjustments: deposit changes alter bank costs, which feed back into loan supply.

Remark 2 (Decomposition). The term in brackets in the feedback channel, $dD_0^*/dr + (1-\theta)dD_1^*/dr$, is *not* the total deposit response Σ_D. The weight $(1-\theta)$ on the private bank's deposit response reflects the asymmetric Stage 2 structure: public ownership ($\theta > 0$) reduces the private bank's equilibrium loan quantity, which dampens how private bank deposits feed into aggregate loan supply.

7.5 Main Results

We now state the main propositions. Throughout, $PT_D = \partial r_D^*/\partial r$ denotes deposit rate pass-through and $PT_L = \partial r_L^*/\partial r$ denotes loan rate pass-through.

Proposition 6 (Default Risk Effect)**.** *In the symmetric benchmark ($\theta = 0$), under economies of scope ($\kappa < 0$) and the condition $3\gamma(1-\rho) > |\kappa|(1-\alpha)$ (which ensures positive loan rate pass-through):*

$$\left.\frac{\partial PT_D}{\partial p}\right|_{\theta=0} > 0, \qquad \left.\frac{\partial PT_L}{\partial p}\right|_{\theta=0} < 0 \tag{46}$$

Higher repayment probability strengthens deposit rate pass-through but weakens loan rate pass-through.

Proof. We derive each sign explicitly.

Deposit rate pass-through. From equation (25):

$$PT_D = \frac{N_D}{\Omega}, \quad \text{where } N_D = -8\gamma\kappa(1-\rho) - 18\gamma pb(1-\alpha), \quad \Omega = 4\kappa^2 - 27\gamma pb$$

Applying the quotient rule:

$$\frac{\partial PT_D}{\partial p} = \frac{(\partial N_D/\partial p)\Omega - N_D(\partial \Omega/\partial p)}{\Omega^2} \tag{47}$$

Computing the derivatives:

$$\frac{\partial N_D}{\partial p} = -18\gamma b(1-\alpha) < 0 \tag{48}$$

$$\frac{\partial \Omega}{\partial p} = -27\gamma b < 0 \tag{49}$$

Under stability ($\Omega < 0$) and $\kappa < 0$, we have $N_D = 8\gamma|\kappa|(1-\rho) - 18\gamma pb(1-\alpha)$. For positive deposit pass-through ($PT_D > 0$), we need $N_D/\Omega > 0$. Since $\Omega < 0$, this requires $N_D < 0$.

Substituting into (47):

$$\frac{\partial PT_D}{\partial p} = \frac{(-)(-) - (-)(-)}{(-)^2} = \frac{(+) - (+)}{(+)}$$

After simplification (detailed in Appendix):

$$\left.\frac{\partial PT_D}{\partial p}\right|_{\theta=0} = \frac{-72b\gamma\kappa[(1-\alpha)\kappa + 3\gamma(1-\rho)]}{\Omega^2} \tag{50}$$

For $\kappa < 0$ and $3\gamma(1-\rho) > |\kappa|(1-\alpha)$, the term in brackets is positive, so the numerator is positive (since $-72b\gamma\kappa > 0$ when $\kappa < 0$). With $\Omega^2 > 0$, we have $\partial PT_D/\partial p > 0$.

Loan rate pass-through. From equation (26):

$$PT_L = \frac{N_L}{\Omega}, \quad \text{where } N_L = -6b[3\gamma(1-\rho) + \kappa(1-\alpha)]$$

Applying the quotient rule:

$$\frac{\partial PT_L}{\partial p} = \frac{(\partial N_L/\partial p)\Omega - N_L(\partial \Omega/\partial p)}{\Omega^2} \tag{51}$$

Since N_L does not depend on p:

$$\frac{\partial N_L}{\partial p} = 0$$

Therefore:

$$\frac{\partial PT_L}{\partial p} = \frac{-N_L \cdot (-27\gamma b)}{\Omega^2} = \frac{27\gamma b \cdot N_L}{\Omega^2} \tag{52}$$

Under the stated condition, $3\gamma(1-\rho) > |\kappa|(1-\alpha)$ implies $3\gamma(1-\rho) + \kappa(1-\alpha) > 0$ (since $\kappa < 0$). Thus $N_L < 0$, and:

$$\left.\frac{\partial PT_L}{\partial p}\right|_{\theta=0} = \frac{27\gamma b \cdot N_L}{\Omega^2} < 0$$

□

Remark 3 (Naming Convention). The condition $3\gamma(1-\rho) > |\kappa|(1-\alpha)$ ensures that the direct channel dominates the feedback channel in determining the sign of loan rate pass-through. When this condition fails, scope economies are so strong that the feedback effect reverses the sign of pass-through. We impose this as a maintained assumption because perverse (negative) pass-through is empirically implausible for loan rates.

The counterintuitive result for loan pass-through that higher repayment probability *weakens* transmission reflects the structure of the model. Higher p enters only through Ω (not N_L), and since $\partial\Omega/\partial p < 0$, higher p makes Ω more negative, reducing the magnitude $|PT_L| = |N_L|/|\Omega|$.

This can potentially be explained as follows: When loans are safe (high pp p), expected returns are high, so banks compete aggressively for deposits to fund profitable lending. This intensified deposit competition acts as a shock absorber; banks absorb part of the policy rate change in their margins rather than fully passing it to borrowers.

When loans are risky (low pp p), lending is less attractive, deposit competition is muted, and banks have thinner margins. They cannot afford to absorb cost increases, so they pass through more of the policy rate change to loan rates.

Proposition 7 (Public Ownership Effect)**.** *Define the function $G : (p_{\min}, 1) \to \mathbb{R}$ by*

$$G(p) \equiv \left.\frac{\partial PT_L}{\partial \theta}\right|_{\theta=0}, \tag{53}$$

which measures how a marginal increase in public ownership affects loan rate pass-through, evaluated at the symmetric benchmark. The lower bound

$$p_{\min} \equiv \frac{4\kappa^2}{27\gamma b}$$

is imposed by the stability condition $\Omega = 4\kappa^2 - 27\gamma p b < 0$.

Under economies of scope ($\kappa < 0$), positive pass-through, and stability, there exists a *unique threshold* $p^{**} \in (p_{\min}, 1)$ *such that:*

$$G(p) \begin{cases} < 0 & \textit{if } p < p^{**}, \\ = 0 & \textit{if } p = p^{**}, \\ > 0 & \textit{if } p > p^{**}. \end{cases} \tag{54}$$

Public ownership dampens loan rate pass-through when default risk is high and enhances it when default risk is low.

Proof. The proof proceeds in four steps.

Step 1: Explicit structure of $G(p)$*.* From the decomposition $PT_L = \mathcal{D} + \mathcal{F}$,

$$\mathcal{D}(\theta, p) = \frac{(1-\rho)(2-\theta)}{p(3-2\theta)}, \tag{55}$$

$$\mathcal{F}(\theta, p) = \frac{\kappa}{p(3-2\theta)} \left[\frac{dD_0^*}{dr} + (1-\theta)\frac{dD_1^*}{dr} \right]. \tag{56}$$

Differentiating with respect to θ and evaluating at $\theta = 0$ yields:

$$G(p) = \underbrace{\frac{1-\rho}{9p}}_{\text{Direct channel}} + \underbrace{\frac{\kappa[-4\kappa(1-\rho) - 9pb(1-\alpha)]}{9p\Omega}}_{\text{Feedback I}} + \underbrace{\frac{\kappa(\Lambda_0 + \Lambda_1)}{3p}}_{\text{Feedback II}}, \tag{57}$$

where $\Omega = 4\kappa^2 - 27\gamma pb$ and $\Lambda_i \equiv \partial(dD_i^*/dr)/\partial\theta|_{\theta=0}$.

Step 2: Lower bound ($p \to p_{\min}^+$)*.* As $p \to p_{\min}$, we have $\Omega \to 0^-$. The direct term remains bounded, while the feedback terms scale as $O(1/\Omega)$. For $\kappa < 0$, the leading feedback contribution is negative and diverges to $-\infty$. Hence,

$$\lim_{p \to p_{\min}^+} G(p) < 0.$$

Step 3: Upper bound ($p \to 1$)*.* As $p \to 1$, $\Omega \to 4\kappa^2 - 27\gamma b < 0$ is finite. All feedback terms remain bounded, while the direct channel satisfies:

$$\lim_{p \to 1} \frac{1-\rho}{9p} = \frac{1-\rho}{9} > 0.$$

Thus,

$$\lim_{p \to 1} G(p) > 0.$$

Step 4: Existence and uniqueness. All components of $G(p)$ are continuous on $(p_{\min}, 1)$. By Steps 2 and 3, $G(p)$ changes sign on this interval. The Intermediate Value Theorem guarantees existence of p^{**}.

Moreover, direct differentiation of $G(p)$ shows that $\partial G/\partial p > 0$ on $(p_{\min}, 1)$, so $G(p)$ is strictly increasing. Hence the zero is unique. □

8 Conclusion

This paper develops a theoretical framework for understanding incomplete monetary policy pass-through in banking systems characterized by mixed ownership and elevated credit risk. The analysis integrates the mixed oligopoly approach of Saha and Sensarma [2013] with explicit default risk modeling to examine how public bank behavior interacts with credit conditions to shape interest rate transmission.

Two main findings emerge. First, default risk has asymmetric effects on pass-through: higher repayment probability strengthens deposit rate transmission but weakens loan rate transmission (Proposition 6). The loan rate result reflects that safer lending environments intensify deposit competition, allowing banks to absorb policy rate changes in their margins rather than passing them fully to borrowers. When loans are risky, banks operate on thinner margins and must pass through more of the policy rate change.

Second, public ownership has regime-dependent effects on loan rate pass-through. There exists a critical threshold p^{**} such that public ownership dampens pass-through when default risk is high ($p < p^{**}$) but enhances it when default risk is low ($p > p^{**}$). This threshold arises from the tension between two channels: a direct channel through which public banks internalize borrower surplus (enhancing transmission), and a feedback channel through which public bank conservatism disrupts the deposit-loan cost linkage (dampening transmission). When default risk is elevated, public banks become additionally conservative to protect depositor welfare, and the feedback disruption dominates.

These results have implications for India, where public sector banks control approximately 60% of assets while facing elevated non-performing assets. The model predicts that pass-through should be weakest precisely when NPAs are highest, consistent with the incomplete transmission observed during 2015–2020. As NPAs are resolved and balance sheets strengthen, pass-through should improve as the banking system moves above the critical threshold p^{**}.

Several extensions warrant future investigation. Incorporating capital requirements following Dalla and Varelas [2019] would allow analysis of how Basel III interacts with ownership structure and credit risk. Endogenizing default probability would create feedback between bank behavior and credit conditions. Finally, empirical estimation using Indian bank-level data would permit testing the predicted threshold effect and quantifying the magnitudes identified here.

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A Derivation of Stage 2 Equilibrium

The Stage 2 first-order conditions form the linear system:

$$\begin{pmatrix} (2-\theta)pb & pb \\ pb & 2pb \end{pmatrix} \begin{pmatrix} L_0 \\ L_1 \end{pmatrix} = \begin{pmatrix} \Phi - \kappa D_0 \\ \Phi - \kappa D_1 \end{pmatrix} \tag{58}$$

The determinant is $(2-\theta) \cdot 2 \cdot p^2b^2 - p^2b^2 = (3-2\theta)p^2b^2$. Applying Cramer's rule:

$$L_0^* = \frac{2pb(\Phi - \kappa D_0) - pb(\Phi - \kappa D_1)}{(3-2\theta)p^2b^2} = \frac{\Phi - 2\kappa D_0 + \kappa D_1}{(3-2\theta)pb} \tag{59}$$

The expression for L_1^* follows by symmetric argument, accounting for the asymmetric coefficient $(2-\theta)$ in the public bank's FOC.

B Derivation of Symmetric Pass-Through (Proposition 4)

This appendix provides the complete derivation of the pass-through expressions in equations (25)–(26).

B.1 Preliminary: Equilibrium Deposit Response

From equation (21), the symmetric equilibrium deposit level is:

$$D^* = \frac{4\kappa\Phi - 9pb\Psi}{\Omega} \tag{60}$$

where $\Omega = 4\kappa^2 - 27\gamma pb$.

Recall from (8)–(9):

$$\Phi = p(\mu Y - 1) + 1 - r(1-\rho) - m \tag{61}$$

$$\Psi = r(1-\alpha) - \beta - \varphi \tag{62}$$

The derivatives with respect to r are:

$$\frac{\partial \Phi}{\partial r} = -(1-\rho), \qquad \frac{\partial \Psi}{\partial r} = (1-\alpha) \tag{63}$$

B.2 Deposit Response to Policy Rate

Differentiating (60) with respect to r:

$$\begin{aligned}\frac{\partial D^*}{\partial r} &= \frac{1}{\Omega}\left[4\kappa\frac{\partial \Phi}{\partial r} - 9pb\frac{\partial \Psi}{\partial r}\right] \\ &= \frac{1}{\Omega}\left[4\kappa \cdot (-(1-\rho)) - 9pb \cdot (1-\alpha)\right] \\ &= \frac{-4\kappa(1-\rho) - 9pb(1-\alpha)}{\Omega}\end{aligned} \tag{64}$$

B.3 Deposit Rate Pass-Through

The deposit rate in symmetric equilibrium is:

$$r_D^* = \beta + \gamma(D_0^* + D_1^*) = \beta + 2\gamma D^* \tag{65}$$

Differentiating:

$$\begin{aligned}\frac{\partial r_D^*}{\partial r} &= 2\gamma \cdot \frac{\partial D^*}{\partial r} \\ &= 2\gamma \cdot \frac{-4\kappa(1-\rho) - 9pb(1-\alpha)}{\Omega} \\ &= \frac{-8\gamma\kappa(1-\rho) - 18\gamma pb(1-\alpha)}{\Omega}\end{aligned} \tag{66}$$

This confirms equation (25).

B.4 Loan Rate Pass-Through

The loan rate in symmetric equilibrium is:

$$r_L^* = \mu Y - b(L_0^* + L_1^*) = \mu Y - 2bL^* \tag{67}$$

From the Stage 2 solution at $\theta = 0$:

$$L^* = \frac{\Phi - \kappa D^*}{3pb} \tag{68}$$

Differentiating:

$$\begin{aligned}
\frac{\partial L^*}{\partial r} &= \frac{1}{3pb}\left[\frac{\partial \Phi}{\partial r} - \kappa \frac{\partial D^*}{\partial r}\right] \\
&= \frac{1}{3pb}\left[-(1-\rho) - \kappa \cdot \frac{-4\kappa(1-\rho) - 9pb(1-\alpha)}{\Omega}\right] \\
&= \frac{1}{3pb}\left[\frac{-(1-\rho)\Omega + 4\kappa^2(1-\rho) + 9pb\kappa(1-\alpha)}{\Omega}\right] \qquad (69)
\end{aligned}$$

Substituting $\Omega = 4\kappa^2 - 27\gamma pb$ into the numerator:

$$\begin{aligned}
&-(1-\rho)\Omega + 4\kappa^2(1-\rho) + 9pb\kappa(1-\alpha) \\
&= -(1-\rho)(4\kappa^2 - 27\gamma pb) + 4\kappa^2(1-\rho) + 9pb\kappa(1-\alpha) \\
&= -4\kappa^2(1-\rho) + 27\gamma pb(1-\rho) + 4\kappa^2(1-\rho) + 9pb\kappa(1-\alpha) \\
&= 27\gamma pb(1-\rho) + 9pb\kappa(1-\alpha) \\
&= 9pb\left[3\gamma(1-\rho) + \kappa(1-\alpha)\right] \qquad (70)
\end{aligned}$$

Substituting back into (69):

$$\frac{\partial L^*}{\partial r} = \frac{9pb[3\gamma(1-\rho) + \kappa(1-\alpha)]}{3pb \cdot \Omega} = \frac{3[3\gamma(1-\rho) + \kappa(1-\alpha)]}{\Omega} \qquad (71)$$

The loan rate pass-through is:

$$\begin{aligned}
\frac{\partial r_L^*}{\partial r} &= -2b \cdot \frac{\partial L^*}{\partial r} \\
&= -2b \cdot \frac{3[3\gamma(1-\rho) + \kappa(1-\alpha)]}{\Omega} \\
&= \frac{-6b[3\gamma(1-\rho) + \kappa(1-\alpha)]}{\Omega} \qquad (72)
\end{aligned}$$

This confirms equation (26).

B.5 Verification of Signs

Under the stability condition $\Omega = 4\kappa^2 - 27\gamma pb < 0$:

Deposit rate pass-through: From (66), the numerator is $-8\gamma\kappa(1-\rho) - 18\gamma pb(1-\alpha)$. When $\kappa < 0$:

- First term: $-8\gamma\kappa(1-\rho) = 8\gamma|\kappa|(1-\rho) > 0$
- Second term: $-18\gamma pb(1-\alpha) < 0$

The sign depends on the relative magnitudes. The condition $|\kappa| < \kappa_D^{crit}(p)$ ensures positive pass-through.

Loan rate pass-through: From (72), the numerator is $-6b[3\gamma(1-\rho)+\kappa(1-\alpha)]$. When $\kappa < 0$:

- $3\gamma(1-\rho) > 0$
- $\kappa(1-\alpha) < 0$

The bracket is positive when $3\gamma(1-\rho) > |\kappa|(1-\alpha)$, i.e., $|\kappa| < \kappa_L^{crit}$. Under this condition, the numerator is negative, and with $\Omega < 0$, pass-through is positive.

C Derivation of Pass-Through Sign Conditions (Proposition 5)

This appendix derives the critical values $\kappa_D^{crit}(p)$ and κ_L^{crit} that determine when pass-through is positive.

C.1 General Principle

For a ratio $\frac{N}{\Omega}$ to be positive when $\Omega < 0$ (stability), we require $N < 0$.

C.2 Deposit Rate Pass-Through Sign

From Proposition 4:

$$\frac{\partial r_D^*}{\partial r} = \frac{-8\gamma\kappa(1-\rho) - 18\gamma p b(1-\alpha)}{\Omega} \tag{73}$$

Let $N_D \equiv -8\gamma\kappa(1-\rho) - 18\gamma p b(1-\alpha)$ denote the numerator.

Case: $\kappa < 0$ (scope economies). Write $\kappa = -|\kappa|$:

$$\begin{aligned} N_D &= -8\gamma(-|\kappa|)(1-\rho) - 18\gamma p b(1-\alpha) \\ &= 8\gamma|\kappa|(1-\rho) - 18\gamma p b(1-\alpha) \end{aligned} \tag{74}$$

For positive pass-through, we need $N_D < 0$:

$$\begin{aligned} 8\gamma|\kappa|(1-\rho) - 18\gamma pb(1-\alpha) < 0 \\ 8\gamma|\kappa|(1-\rho) &< 18\gamma pb(1-\alpha) \\ |\kappa| &< \frac{18\gamma pb(1-\alpha)}{8\gamma(1-\rho)} \\ |\kappa| &< \frac{18pb(1-\alpha)}{8(1-\rho)} \\ |\kappa| &< \frac{9pb(1-\alpha)}{4(1-\rho)} \end{aligned} \tag{75}$$

Therefore:

$$\boxed{\kappa_D^{crit}(p) \equiv \frac{9pb(1-\alpha)}{4(1-\rho)}} \tag{76}$$

Deposit rate pass-through is positive if and only if $|\kappa| < \kappa_D^{crit}(p)$ when $\kappa < 0$.

Case: $\kappa > 0$ (scope diseconomies).

$$\begin{aligned} N_D &= -8\gamma\kappa(1-\rho) - 18\gamma pb(1-\alpha) \\ &= -\gamma[8\kappa(1-\rho) + 18pb(1-\alpha)] < 0 \end{aligned} \tag{77}$$

Both terms in brackets are positive, so $N_D < 0$ always. Deposit rate pass-through is always positive when $\kappa > 0$.

Case: $\kappa = 0$ (no scope effects).

$$N_D = -18\gamma pb(1-\alpha) < 0 \tag{78}$$

Pass-through is always positive.

C.3 Loan Rate Pass-Through Sign

From Proposition 4:

$$\frac{\partial r_L^*}{\partial r} = \frac{-6b[3\gamma(1-\rho) + \kappa(1-\alpha)]}{\Omega} \tag{79}$$

Let $N_L \equiv -6b[3\gamma(1-\rho) + \kappa(1-\alpha)]$ denote the numerator.

Since $-6b < 0$, the sign of N_L is opposite to the sign of the bracket $[3\gamma(1-\rho)+\kappa(1-\alpha)]$.

Case: $\kappa < 0$ (scope economies). Write $\kappa = -|\kappa|$:

$$3\gamma(1-\rho) + \kappa(1-\alpha) = 3\gamma(1-\rho) - |\kappa|(1-\alpha) \tag{80}$$

For positive pass-through, we need $N_L < 0$, which requires the bracket to be positive:

$$\begin{aligned} 3\gamma(1-\rho) - |\kappa|(1-\alpha) > 0 \\ 3\gamma(1-\rho) > |\kappa|(1-\alpha) \\ |\kappa| < \frac{3\gamma(1-\rho)}{(1-\alpha)} \end{aligned} \tag{81}$$

Therefore:

$$\boxed{\kappa_L^{crit} \equiv \frac{3\gamma(1-\rho)}{(1-\alpha)}} \tag{82}$$

Loan rate pass-through is positive if and only if $|\kappa| < \kappa_L^{crit}$ when $\kappa < 0$.

Case: $\kappa > 0$ (scope diseconomies).

$$3\gamma(1-\rho) + \kappa(1-\alpha) > 0 \tag{83}$$

Both terms are positive, so the bracket is positive, $N_L < 0$, and pass-through is always positive.

Case: $\kappa = 0$ (no scope effects).

$$N_L = -6b \cdot 3\gamma(1-\rho) = -18b\gamma(1-\rho) < 0 \tag{84}$$

Pass-through is always positive.

C.4 Key Asymmetry: Dependence on p

Comparing the two critical values:

$$\kappa_D^{crit}(p) = \frac{9pb(1-\alpha)}{4(1-\rho)} \quad \text{— depends on } p \tag{85}$$

$$\kappa_L^{crit} = \frac{3\gamma(1-\rho)}{(1-\alpha)} \quad \text{— independent of } p \tag{86}$$

This asymmetry has important implications:

1. As default risk increases (p falls), $\kappa_D^{crit}(p)$ *decreases*
2. This means the condition $|\kappa| < \kappa_D^{crit}(p)$ becomes harder to satisfy
3. High default risk makes incomplete or perverse deposit pass-through more likely under scope economies

4. Loan rate pass-through conditions are unaffected by default risk at this level of analysis

C.5 Numerical Example

Suppose $\gamma = 0.1$, $b = 1$, $\alpha = 0.1$, $\rho = 0.1$, and consider $|\kappa| = 0.5$.

Loan rate threshold:

$$\kappa_L^{crit} = \frac{3(0.1)(0.9)}{0.9} = \frac{0.27}{0.9} = 0.3 \tag{87}$$

Since $|\kappa| = 0.5 > 0.3 = \kappa_L^{crit}$, loan rate pass-through is *negative* (perverse).

Deposit rate threshold at $p = 0.9$:

$$\kappa_D^{crit}(0.9) = \frac{9(0.9)(1)(0.9)}{4(0.9)} = \frac{7.29}{3.6} = 2.025 \tag{88}$$

Since $|\kappa| = 0.5 < 2.025$, deposit rate pass-through is positive.

Deposit rate threshold at $p = 0.5$:

$$\kappa_D^{crit}(0.5) = \frac{9(0.5)(1)(0.9)}{4(0.9)} = \frac{4.05}{3.6} = 1.125 \tag{89}$$

Still $|\kappa| = 0.5 < 1.125$, so pass-through remains positive, but the margin has narrowed.

This example illustrates how elevated default risk (lower p) tightens the conditions for positive pass-through.

D Derivation of the Jacobian Determinant

Computing $J_{00}J_{11}$:

$$\begin{aligned} J_{00}J_{11} &= \left[-(2-\theta)\gamma + \frac{\kappa^2(8-5\theta)}{\Xi}\right]\left[-2\gamma + \frac{2\kappa^2(2-\theta)^2}{\Xi}\right] \\ &= 2(2-\theta)\gamma^2 - \frac{2\gamma\kappa^2[(2-\theta)^3 + (8-5\theta)]}{\Xi} + \frac{2\kappa^4(8-5\theta)(2-\theta)^2}{\Xi^2} \end{aligned} \tag{90}$$

Computing $J_{01}J_{10}$:

$$J_{01}J_{10} = \left[-\gamma - \frac{\kappa^2(4-\theta-\theta^2)}{\Xi}\right]\left[-\gamma - \frac{2\kappa^2(2-\theta)}{\Xi}\right]$$
$$= \gamma^2 + \frac{\gamma\kappa^2[2(2-\theta)+(4-\theta-\theta^2)]}{\Xi} + \frac{2\kappa^4(4-\theta-\theta^2)(2-\theta)}{\Xi^2} \tag{91}$$

The difference $\Delta = J_{00}J_{11} - J_{01}J_{10}$ yields expression (35) after algebraic simplification.

Verification at $\theta = 0$: Setting $\theta = 0$ gives $\Xi = 9pb$ and:

$$\Delta|_{\theta=0} = 3\gamma^2 - \frac{40\gamma\kappa^2}{9pb} + \frac{48\kappa^4}{81p^2b^2}$$
$$= \frac{243\gamma^2p^2b^2 - 360\gamma\kappa^2pb + 48\kappa^4}{81p^2b^2}$$
$$= \frac{(4\kappa^2 - 3\gamma pb)(4\kappa^2 - 27\gamma pb)}{27p^2b^2} \tag{92}$$

E Derivation of $\mathbf{F}_r$

The vector $\mathbf{F}_r = (\partial F_0/\partial r, \partial F_1/\partial r)'$ captures how the Stage 1 first-order conditions respond to policy rate changes.

Preliminary derivatives: From (8)–(9):

$$\frac{\partial\Phi}{\partial r} = -(1-\rho), \qquad \frac{\partial\Psi}{\partial r} = (1-\alpha) \tag{93}$$

The equilibrium loan derivatives with respect to r are:

$$\frac{\partial L_0^*}{\partial r} = \frac{\partial\Phi/\partial r}{(3-2\theta)pb} = \frac{-(1-\rho)}{(3-2\theta)pb} \tag{94}$$
$$\frac{\partial L_1^*}{\partial r} = \frac{(1-\theta)\partial\Phi/\partial r}{(3-2\theta)pb} = \frac{-(1-\theta)(1-\rho)}{(3-2\theta)pb} \tag{95}$$

Public bank FOC derivative: From (20):

$$
\begin{aligned}
f_0 = \frac{\partial F_0}{\partial r} &= \frac{\kappa}{(3-2\theta)}\left[\theta\frac{\partial L_1^*}{\partial r} - (4-3\theta)\frac{\partial L_0^*}{\partial r}\right] + \frac{\partial \Psi}{\partial r} \\
&= \frac{\kappa}{(3-2\theta)}\left[\frac{-\theta(1-\theta)(1-\rho)}{(3-2\theta)pb} + \frac{(4-3\theta)(1-\rho)}{(3-2\theta)pb}\right] + (1-\alpha) \\
&= \frac{\kappa(1-\rho)[(4-3\theta)-\theta(1-\theta)]}{(3-2\theta)^2 pb} + (1-\alpha) \\
&= \frac{\kappa(1-\rho)(4-4\theta+\theta^2)}{(3-2\theta)^2 pb} + (1-\alpha) \\
&= (1-\alpha) + \frac{\kappa(1-\rho)(2-\theta)^2}{\Xi} \qquad (96)
\end{aligned}
$$

Private bank FOC derivative: From (19):

$$
\begin{aligned}
f_1 = \frac{\partial F_1}{\partial r} &= \frac{-2\kappa(2-\theta)}{(3-2\theta)}\frac{\partial L_1^*}{\partial r} + \frac{\partial \Psi}{\partial r} \\
&= \frac{-2\kappa(2-\theta)}{(3-2\theta)} \cdot \frac{-(1-\theta)(1-\rho)}{(3-2\theta)pb} + (1-\alpha) \\
&= (1-\alpha) + \frac{2\kappa(2-\theta)(1-\theta)(1-\rho)}{\Xi} \qquad (97)
\end{aligned}
$$

Verification at $\theta = 0$: Setting $\theta = 0$:

$$
f_0|_{\theta=0} = (1-\alpha) + \frac{4\kappa(1-\rho)}{9pb} \qquad (98)
$$

$$
f_1|_{\theta=0} = (1-\alpha) + \frac{4\kappa(1-\rho)}{9pb} \qquad (99)
$$

Symmetry holds: $f_0 = f_1$ when $\theta = 0$, as expected.

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