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SHADOW BANKING AND REGULATION: A QUANTITATIVE ASSESSMENT

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Shadow Banking and Regulation: A Quantitative Assessment*

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Abstract/Résumé

We develop a framework to quantitatively assess the links between traditional and shadow banks and how these links are modified by regulatory reforms in the traditional banking sector. In the model, banks screen projects and originate loans, and then sell some of these loans (securitize them) to shadow banks, in order to redeploy capital and invest in alternative productive investment opportunities. This capital redeployment towards profitable investment implies a potentially socially beneficial role for shadow banks. However, the availability of securitization might also lead banks to screen projects less intensively and increase risk-taking. We explore the quantitative implication of this tradeoff and how it is affected by regulation of the traditional bank sector.

Nous développons un modèle macroéconomique permettant d'analyser les liens entre le secteur bancaire traditionnel et le secteur parallèle ("shadow banking") et comment ces liens sont affectés par la réglementation bancaire imposée au secteur bancaire traditionnel. Dans le modèle, les banques traditionnelles font la sélection initiale des projets et émettent des prêts, mais peuvent ensuite une partie de ces prêts (en les titrisant) à leur contreparties du secteur parallèle, afin de réallouer leur capital à d'autres opportunités d'investissement productives. Cette réallocation de capital vers des investissements rentables confère aux shadow banks un rôle potentiellement bénéfique sur le plan social. Toutefois, la possibilité de titrisation des prêts peut également inciter les banques à réduire leurs efforts initiaux dans les sélection des projets et à prendre davantage de risques. Nous examinons les implications quantitatives de cette tension et la manière dont celles-ci sont influencées par la réglementation du secteur bancaire traditionnel.

Keywords/Mots-clés: Banks, Shadow banks, Moral hazard, Bank regulation / secteur bancaire traditionnel, secteur bancaire parallèle (shadow banking), réglementation bancaire, aléa moral

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1 Introduction

In the years preceding the $2007-2008$ financial crisis, a lightly regulated "shadow" banking system played an increasingly prominent role in the provision of credit to households and firms. Shadow banks facilitated credit expansion by purchasing securitized assets from originating banks and financing these purchases through repos–short-term debt instruments collateralized by the underlying assets.[1]

The impact of shadow banking on the efficiency and stability of financial systems remains an open and important question. On the one hand, shadow banks offer access to alternative funding sources, thereby helping diversify the economy's credit infrastructure. This funding flexibility complements the comparative advantage of traditional banks in screening and originating loans and may generate meaningful efficiency gains. On the other hand, the availability of securitization can weaken originating banks' incentives to conduct thorough screening, thereby reducing loan quality and increasing the risk of systemic financial disruptions.

In addition, the regulatory environment for traditional banks may play a critical role in shaping their interaction with shadow banking sector. For example, tighter leverage requirements may incentivize traditional banks to intensify screening, mitigating some of the negative effects associated with securitization. Conversely, stricter regulation may prompt a migration of financial activity away from the traditional sector and toward the less-regulated shadow sector.

This paper develops a framework to quantitatively evaluate these tradeoffs and inform policy debates. Specifically, we construct a dynamic general equilibrium model that captures the key tension between the funding advantages of shadow banks and the potential adverse effects on loan origination. In the model, traditional banks possess a technology to screen investment projects and originate loans. Once originated, a fraction of these loans can be securitized and sold to shadow banks, allowing traditional banks to reallocate capital toward other productive opportunities. While such reallocation may be socially beneficial, the presence of securitization also introduces an incentive for banks to economize on screening costs, thereby lowering loan quality and increasing financial fragility.

Our results show that the presence of shadow banks can indeed lower the screening intensity of traditional banks, lowering the success probability of financed projects and increasing overall banking sector risk. Furthermore, we find that greater availability of short-term debt–the primary funding source for shadow banks– raises the price of securitized loans, which further reduces screening effort and amplifies systemic risk.

Understanding both the strengths and vulnerabilities of shadow banks–and identifying appropriate regulatory responses–remains a central concern for policymakers and regulators. A growing literature investigates the structure of the shadow banking sector and its interaction with traditional banks, both theoretically and empirically (Gorton and Metrick, 2010; Plantin, 2015; Goodhart et al., 2012, 2013; Begenau and Landvoigt, 2021). Our paper contributes to this literature by building on the insights of Holmstrom and Tirole (1997), Parlour and Plantin (2008), and Meh and Moran (2010), and by providing a quantitative framework to assess the interplay between traditional and shadow banks and its implications for financial regulation.

The remainder of this paper is organized as follows. Section 2 describes the model's environment and defines the competitive equilibrium. Section 3 provides a qualitative analysis of the interactions between banks and shadow banks.

[1] The combination of securitization and repo financing is sometimes referred to as "securitized banking" (Gorton and Metrick, 2010, 2012).

2 The Model

2.1 The environment

This section presents the structure of the model and the optimization problems faced by the economy's agents. Time is discrete, and one period corresponds to a quarter. The economy comprises three types of agents: households, and two classes of financial intermediaries–banks and shadow banks. There are two goods in the economy: final goods, produced by competitive firms using installed capital and labor, and investment goods, produced by separate competitive firms using capital and final goods as inputs.

The two types of financial intermediaries possess complementary skills. First, (traditional) banks have access to investment projects (lending opportunities) and to a technology that enables them to screen and evaluate the quality of these projects. They finance such projects by extending loans to project managers, using a combination of household deposits and their own net worth. In some circumstances, they experience shocks that gives them strong incentives to raise new funds, even though their access to financing sources has been closed. Second, shadow banks are agents that have access to alternative funding sources, both in timing and in provenance, but who lack the capacity to screen.

Taken together, the banks' screening abilities but limited access to financing, on the one hand, and the shadow banks' flexible access to funds but lack of screening technology, on the other, give rise to mutually beneficial trading opportunities, wherein banks might wish to sell (securitize) the loans they originated to shadow banks. We now describe in detail the behavior of these two types of agents. Appendix A provides a useful timeline of model events occurring during one typical period.

2.2 Banks

Bankers are a class of agents with access to investment projects and a screening technology. They finance these projects using a combination of household deposits, denoted d_t^b, and their own accumulated net worth, a_t (bank capital). A given project requires an investment of $\tilde{k}t$ units of investment goods, each priced at q_t, for a total initial outlay of $q_t\tilde{k}t$. If the bank's internal resources are insufficient–that is, if $q_t\tilde{k}_t > a_t$–the banker must raise external funds from depositors to finance the project. This initial outlay can be interpreted as a loan commitment to a firm undertaking the investment project.

Project returns are subject to both idiosyncratic and aggregate uncertainty. First, a project-specific shock $\omega \in 0, R$ determines the physical outcome of the investment. With probability p_t, the project is successful and yields $k_{t+1} = R\tilde{k}t$ units of productive capital at the beginning of period $t + 1$; with probability $1 - p_t$, the project fails and yields no productive capital, $kt + 1 = 0$.

Second, conditional on success, an aggregate shock determines the economic return on the capital. A successful project thus generates revenues equal to $\nu_{t+1}R\tilde{k}t$ in period $t + 1$, where the gross return to capital $\nu t + 1$ is defined as:

$$\nu_{t+1} = r_{t+1}^k + (1 - \delta)q_{t+1},$$

with r_{t+1}^k denoting the (aggregate) rental rate of capital, and $(1 - \delta)q_{t+1}$ representing the market value of undepreciated capital.[2]

[2] An alternative formulation would allow failed projects to recover some residual value. Specifically, a failed project could yield 0 in flow returns but retain a salvage value of $(1 - \delta)q_{t+1}\tau\tilde{k}_t$ with $\tau \in [0, 1)$ capturing capital recovery

Looking ahead, since all banks are assumed to screen projects with identical intensity, they share a common success probability p_t. Accordingly, the aggregate capital stock available at the beginning of period $t+1$ is given by $K_{t+1} = p_t R \tilde{K}_t$, where $\tilde{K}_t$ denotes the aggregate volume of investment projects undertaken in period t.

A share R_t^h of the expected return from a successful project is pledged to depositors, leaving a residual share $R_t^b = R - R_t^h$ for the bank. The bank's expected financial return is thus $\nu_{t+1}^e R_t^b \tilde{k}_t$, while the expected income pledged to depositors is $\nu_{t+1}^e R_t^h \tilde{k}_t$, where $\nu_{t+1}^e = E_t[\nu_{t+1}]$ denotes the expected aggregate return to capital. A key feature of the model is that banks possess a technology for screening and monitoring projects. These efforts are privately observed and confer informational advantages that are central to the model's frictions.

First, banks can influence the project success probability through the intensity of screening effort, denoted Υ_t. Specifically, we assume that the probability of success p_t is an increasing, concave function of screening intensity, $p(\Upsilon_t)$, satisfying $p(0) = p_0 \geq 0$, $p'(\cdot) > 0$, $p''(\cdot) < 0$, and $\lim_{\Upsilon \to \infty} p(\Upsilon) = 1$. Screening thus allows banks to exclude lower-quality projects from their portfolio. Second, monitoring provides the bank with perfect private information about the idiosyncratic project shock ω, allowing it to learn ex ante whether a project will succeed or fail. However, the informational advantage provided by screening and monitoring is costly: screening at intensity Υ_t incurs a real resource cost equal to $c, \Upsilon_t q_t \tilde{k}_t$, where $c > 0$ is a proportional cost parameter.

After screening and learning the project's quality, the bank may be privately affected by a liquidity shock, which captures unexpected increases in the opportunity cost of honoring its existing loan commitments. One interpretation of this shock is that banks occasionally receive private access to alternative investment opportunities. Although these are typically inferior in expectation, they may occasionally offer a strictly higher return than the existing commitment. Let l denote the probability of such an event, and $\lambda > 1$ the return on the alternative investment. A bank experiencing this shock seeks to liquidate its existing commitment in order to redeploy capital toward the higher-return opportunity.

Together, these decisions and private shocks give rise to an agency problem between the bank and its counterparties. First, since screening effort is unobservable, the bank may exert less effort than promised to reduce costs, thereby lowering the project's success probability and undermining the ability to meet promised returns to depositors. Second, the private nature of both the liquidity shock and the information acquired during screening creates adverse selection in the secondary loan market described below. A bank that attempts to sell a loan commitment may be doing so either because it has learned the project is of low quality, or because it faces a better outside opportunity–neither of which is observable to potential buyers.[3] These incentive and selection frictions will play a central role in the financial contracting environment analyzed in the sections that follow.

2.2.1 The financial contract between banks and depositors

We focus on equilibria in which financial contracts provide sufficient incentives for banks to exert the agreed-upon level of screening effort. Consistent with the literature on financial frictions (Bernanke et al., 1999), we also assume inter-period anonymity, which restricts agents to one-period contracts.

The financial contract has the following structure. It determines the investment scale $\tilde{k}_t$, as well as the contributions to the project's costs from the bank (a_t) and from its depositors (d_t^b).

costs. In this paper, we focus on the case $\tau = 0$, implying full capital loss upon failure but extensions to $\tau < 1$ are straightforward and would enrich the model's treatment of downside risk. See Choi and Cook (2012) for further discussion.

[3]This adverse selection problem follows the frameworks of Parlour and Plantin (2008) and Plantin (2015).

It allocates the expected return from a successful project between these two parties by pledging a share R_t^h to depositors and a residual share $R_t^b = R - R_t^h$ to the bank. Recall that the total expected financial return from a successful project is $R\,\nu_{t+1}^e \tilde{k}_t$, so that the bank accordingly expects to earn $R_t^b\,\nu_{t+1}^e \tilde{k}_t$ and the depositors are promised $R_t^h\,\nu_{t+1}^e \tilde{k}_t$.[4] The contract also specifies the bank's screening intensity Υ_t, which determines the project's success probability $p_t = p(\Upsilon_t)$. Limited liability implies that neither party incurs negative returns.

The objective of the contract is to maximize the expected return accruing to the bank, $p_t R_t^b \nu_{t+1}^e \tilde{k}_t$, subject to incentive, participation, and resource constraints. Formally, the contract solves the following optimization problem:

$$\max_{\{\tilde{k}_t, R_t^b, R_t^h, d_t^b, p_t\}} \; p_t\, R_t^b \nu_{t+1}^e\, \tilde{k}_t, \tag{1}$$

subject to:

$$p_t(1-l)(1-r_t)R_t^b \nu_{t+1}^e \tilde{k}_t \geq c\Upsilon_t q_t \tilde{k}_t, \tag{2}$$

$$p_t R_t^h \nu_{t+1}^e \tilde{k}_t \geq (1+r_t^b)d_t^b, \tag{3}$$

$$a_t + d_t^b - c\Upsilon_t q_t \tilde{k}_t \geq q_t \tilde{k}_t, \tag{4}$$

$$R_t^b + R_t^h = R, \tag{5}$$

$$R_t^b, R_t^h \geq 0, \tag{6}$$

$$p_t = p(\Upsilon_t). \tag{7}$$

Constraint (2) ensures the bank has an incentive to screen at the agreed-upon intensity. The left-hand side represents the bank's expected payoff from a successful project, adjusted for the probability $1-l$ that it does not face a liquidity shock and the price r_t at which it could sell the loan on the secondary market. This expected gain must exceed the cost of screening, $c\Upsilon_t q_t \tilde{k}_t$.[5]

Constraint (3) is the depositors' participation constraint, requiring that the expected return they receive meets or exceeds the market return on bank deposits, r_t^b. Constraint (4) states that the combined funding from the bank and depositors, net of screening costs, must be sufficient to cover the project's resource requirements. Equation (5) ensures that the total return from a successful project is fully allocated between the two stakeholders. Inequality (6) reflects limited liability by imposing non-negative project shares while equation (7) captures the technological relationship between screening intensity and project success probability.

2.2.2 Bank Leverage and Regulation

The system of equations defined by constraints (1)-(7) can be used to characterize the financial contract's implications for bank leverage–that is, the ratio of project size to the bank's own capital contribution. To this end, first impose that the bank's incentive compatibility constraint (2) binds with equality, yielding:

$$R_t^b = \frac{c\Upsilon_t q_t}{p(\Upsilon_t)(1-l)(1-r_t)\nu_{t+1}^e}\,. \tag{8}$$

This states that the share R_t^b of the project's return allocated to the bank must be sufficiently high to ensure the bank exerts the agreed-upon screening effort. Importantly, note that an increase in r_t–the secondary market price of loans, see below–raises R_t^b, because a higher r_t increases the bank's potential gain from selling underperforming loans, thereby worsening the agency problem the bank

[4] The notation reflects that the contract is set in period t while payoffs are realized at the beginning of period $t+1$.

[5] See Appendix B for the derivation of (2). Note that since $r_t \in (0,1)$, the left-hand side of (2) is strictly positive.

and its stakeholders. As it does, the bank must be promised a bigger part of the project's proceeds to screen as intensely as agreed. We return to this key mechanism below.

Next, using (8) in the return-sharing condition (5) determines the residual return available to depositors:

$$R_t^h = R - \frac{c\Upsilon_t q_t}{p(\Upsilon_t)(1-l)(1-r_t)\nu_{t+1}^e}, \tag{9}$$

while substituting (9) into the depositors' participation constraint (3), and assuming it binds with equality, yields:

$$d_t^b = \frac{p(\Upsilon_t)\nu_{t+1}^e}{1+r_t^b}\left(R - \frac{c\Upsilon_t q_t}{p(\Upsilon_t)(1-l)(1-r_t)\nu_{t+1}^e}\right)\tilde{k}_t. \tag{10}$$

This expression determines the maximum amount depositors are willing to provide given the project's characteristics and return structure. Notably, deposit funding is more forthcoming when the project success probability $p(\Upsilon_t)$ or expected capital return ν_{t+1}^e is higher; conversely, higher deposit rates r_t^b or higher screening costs reduce the bank's ability to attract external funds.

Finally, combining (10) with the resource constraint (4) and rearranging yields the bank's leverage ratio κ_t^b, defined as the ratio of the project's total cost to the bank's equity contribution a_t:

$$\kappa_t^b \equiv \frac{q_t\tilde{k}_t}{a_t} = \frac{1}{1 + c\Upsilon_t - \frac{p(\Upsilon_t)\nu_{t+1}^e}{q_t(1+r_t^b)}\left(R - \frac{c\Upsilon_t q_t}{p(\Upsilon_t)(1-l)(1-r_t)\nu_{t+1}^e}\right)}. \tag{11}$$

Expression (11) reveals important economic mechanisms at play in the model. First, bank leverage κ_t^b is independent of bank net worth a_t, which simplifies aggregation. Second, an important the trade-off arises bank screening effort and leverage. When the bank commits to very low screening ($\Upsilon_t \to 0$), the associated agency problem is minimal, and so a smaller share of the project return is needed to incentivize the bank. This enables depositors to receive a larger share, increasing the amount of external funding and resulting in high leverage. However, the low screening effort also results in a low success probability and lower expected returns. As Υ_t increases, so does $p(\Upsilon_t)$ and the project's expected value. But higher screening intensifies the moral hazard problem, as the bank's effort is unobservable. To restore incentive compatibility, depositors require the bank to finance a larger portion of the project itself, thereby reducing leverage.

So far, the discussion has abstracted from any regulatory constraints on the choices made by banks and depositors and the equilibrium leverage obtained above is therefore entirely market driven. Now assume that the regulator imposes a maximum leverage ratio $\overline{\kappa}_t^b$ that banks cannot exceed. Then expression (11) must satisfy:

$$\frac{1}{1 + c\Upsilon_t - \frac{p(\Upsilon_t)\nu_{t+1}^e}{q_t(1+r_t^b)}\left(R - \frac{c\Upsilon_t q_t}{p(\Upsilon_t)(1-l)(1-r_t)\nu_{t+1}^e}\right)} \leq \overline{\kappa}_t^b. \tag{12}$$

This constraint may or may not bind. If $\overline{\kappa}_t^b$ exceeds the leverage banks would choose in the absence of regulation, then it has no effect. This can occur when expected capital returns are modest or screening costs are high. In contrast, when (12) binds–i.e., when expected returns are high or screening costs are low–it restricts the feasible leverage and thus implicitly pins down the minimum screening intensity Υ_t and success probability p_t consistent with regulation. The assumed properties of the function $p(\Upsilon_t)$ ensure that a unique Υ_t exists that satisfies the constraint.

Figure 1 illustrates the situation. First, the black solid curve depicts the negative relationship between screening intensity and leverage when no regulation is present and choices are entirely market-based. As indicated above, higher screening intensifies the moral hazard problem and in turn reduces leverage as depositors require the bank to finance a larger portion of the project itself. The dashed purple line represents a binding regulatory ceiling $\overline{\kappa}_t^b$, which identifies the required screening effort and therefore the endogenous success probability p_t. Naturally, further restricting accepted leverage (lowering the purple line) results in increased screening efforts by the bank.

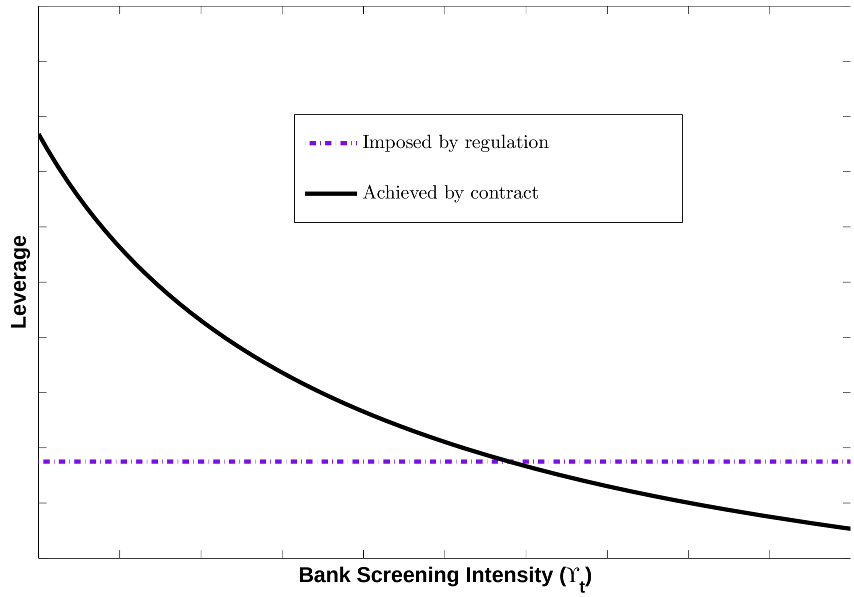


Figure 1: Screening intensity Υ_t and Leverage

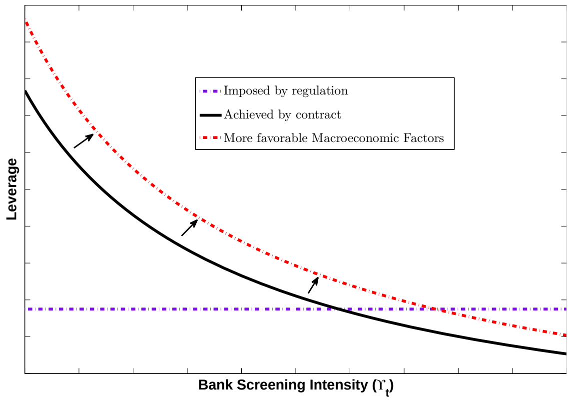
We now consider how macroeconomic conditions affect this interaction between regulation and financial contracting. One the one had, favorable macroeconomic shocks, like an increase in the future expected return to capital ν_{t+1}^e or a decrease in the opportunity cost of deposits r_t^b, improve bank-depositor alignment by making it easier for banks to credibly promise returns to external source of funds. This shifts the contract curve outward, increasing feasible leverage and, if regulation remains binding, leads to higher equilibrium screening effort. This is illustrated by the outward (red dashed) shift in Figure 2 (panel a).

In contrast, an increase in r_t, the secondary market price of loans, has the opposite effect. It exacerbates the agency problem by making it more attractive for banks to offload poorly screened loans. To maintain incentives, banks must invest more of their own capital, reducing leverage. This inward shift in the contract curve (see Figure 2 panel b) lowers the screening intensity if regulation remains binding.

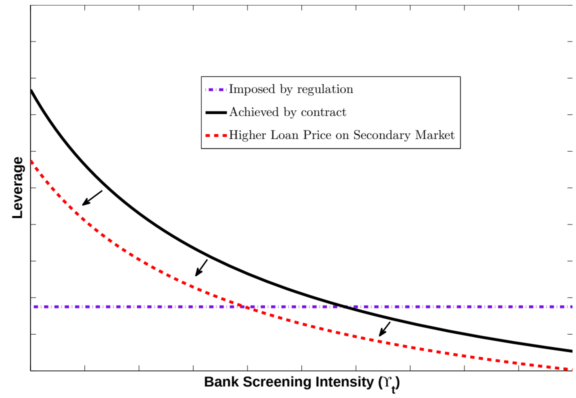
2.3 Shadow banks

Shadow banks are financial intermediaries that have access to alternative sources of funding compared to traditional banks. In the model, this differentiated access to funding is captured by assuming that shadow banks can raise funds later within a given period and tap into deposit bases that are typically unavailable to regulated banks. We interpret this as broader and more flexible access to funding, allowing shadow banks to diversify the sources of capital available for investment in the economy.

Shadow banks participate in the secondary loan market by purchasing loan commitments that



(a) Favorable macroeconomic shocks



(b) Increase price when securitizing loans

Figure 2: Screening Intensity and Regulation

banks choose to sell (securitize). On this market, a typical bank may seek to sell its stake in a project, valued at $\nu^e_{t+1}R^b_t\tilde{k}_t$. The prevailing market price for this claim is denoted r_t, implying that a shadow bank must pay $S^{sb}_t = r_t\nu^e_{t+1}R^b_t\tilde{k}_t$ in cash to acquire the claim.[6]

Expected revenues for the shadow bank are $\nu^e_{t+1}R^b_t\tilde{k}_t$ times the probability that the securitized loan bought from the bank is successful in the next period. Considering the adverse selection problem described above wherein a bank sells loans both (i) when its private information about the project indicates it is of low quality and will thus fail and (ii) when it has received profitable alternative investment opportunities, that probability is $p_tl/(p_tl+1-p_t)$. Total expected revenues for the shadow banks are therefore

$$\frac{p_tl}{p_tl+1-p_t}\nu^e_{t+1}R^b_t\tilde{k}_t.$$

Shadow banks finance these purchases through short-term debt D^{sb}_t, which we interpret as instruments similar to *repos*, a key component of shadow banking expansion in recent decades. This debt carries a gross cost of $1+r^{sb}_t$. The shadow bank's resource constraint is then:

$$S^{sb}_t = D^{sb}_t. \tag{13}$$

The shadow banking sector is competitive, and thus shadow banks earn zero expected profits. Equating expected revenues to the cost of funds and rearranging yields the equilibrium price of securitized loans:

$$r_t = \left(\frac{p_tl}{p_tl+1-p_t}\right)\left(\frac{1}{1+r^{sb}_t}\right), \tag{14}$$

Expression (14) highlights two mechanisms affecting the secondary loan market. First, a decline in l–the probability that a bank has received an outside opportunity–lowers r_t, because the likelihood that a securitized loan is of high quality falls, worsening adverse selection. Second, an increase in r^{sb}_t, the cost of funds for shadow banks, also reduces r_t, as shadow banks require greater compensation for funding purchases. This, in turn, diminishes the attractiveness of securitization for banks, reducing their ability to reallocate capital toward high-return alternative investments.

[6]We assume that the quality of the loan cannot be credibly signaled and that transactions between banks and shadow banks are not publicly observable. Moreover, bad-type banks mimic good ones, reinforcing the adverse selection problem.

2.4 Bankers and the evolution of banking net worth

A continuum of risk-neutral bankers operates in the economy. Each period unfolds in the following sequence for bankers. First, they receive revenues generated from the previous period's investment activities and these revenues form their net worth. Next, they use this accumulated net worth to finance new lending. After arranging the loans, they choose a screening intensity and observe the quality of the project. Conditional on this private information and on receiving a liquidity shock (i.e., an alternative investment opportunity), the bank may sell its loan on the secondary market. At the end of the period, a fraction $1 - \tau^b$ of bankers receive an exit signal and permanently leave the economy.[7] Bankers who exit consume their entire wealth if they were successful; otherwise, they exit with zero assets. Exiting bankers are replaced by new entrants who start with no assets.[8]

The net worth available to a bank in order to organize funding depends on the realization of the idiosyncratic shocks and the banker's screening decisions in the preceding period. In such a context, the following four scenarios are possible with respect to the flow revenues accruing to this banker:

1. With probability $p_{t-1}(1-l)$, the banker had a successful project but did not receive the outside opportunity. Flow revenues are thus $\nu_t R^b_{t-1}\tilde{k}_{t-1}$, and the net worth of that bank is

$$a_t = \nu_t R^b_{t-1}\tilde{k}_{t-1}. \tag{15}$$

2. With probability $p_{t-1} \cdot l$, the banker received a profitable outside opportunity and securitized the (ultimately successful) loan, to reallocate capital towards that opportunity (rate of return λ). The net worth of the bank is therefore

$$a_t = \lambda r_{t-1}\nu_t R^b_{t-1}\tilde{k}_{t-1}. \tag{16}$$

3. With probability $(1-p_{t-1})(1-l)$, the banker did not receive a more profitable outside opportunity but nevertheless sold the loan (because of the knowledge that it was ultimately going to be a failure) and invested the proceeds at the standard rate of return. Net worth for this banker is

$$a_t = r_{t-1}\nu_t R^b_{t-1}\tilde{k}_{t-1}, \tag{17}$$

4. Finally, with probability $(1-p_{t-1})l$, the banker received a profitable outside opportunity and sold the loan (which was going to fail in any case) to invest the proceeds at the superior rate of return λ. Net worth for this agent is

$$a_t = \lambda r_{t-1}\nu_t R^b_{t-1}\tilde{k}_{t-1}. \tag{18}$$

The evolution of the aggregate stock of bank net worth takes into account these four possible scenarios and the different probabilities become the relative frequencies of each scenario. To aggregate across all banks, we make use of the fact that individual banks differ only by the scale of their project but have common screening intensities, probability of success and sharing rules. In addition, recall that a fraction $1 - \tau_b$ of bankers exit the economy at the end of each period: these exiting

[7]This setup follows Bernanke et al. (1999). In the presence of financing constraints and a high internal rate of return on retained earnings, bankers would otherwise accumulate wealth until the constraints do not bind. A constant exit probability prevents this accumulation and ensures a stationary distribution of net worth.

[8]Entering bankers begin the period with a non-zero but quantitatively negligible wealth transfer so that they have positive net worth to start organize lending during the period.

agents consume the total value of their net worth. Conversely, surviving agents (a fraction τ_b of all bankers) save all available net worth because of its high internal rate of return. The aggregate level of banking net worth available in the economy at the beginning of period t is therefore

$$A_t = \tau_b \Big[p_{t-1}(1-l) + r_{t-1} \left(l\lambda + (1-p_{t-1})(1-l) \right) \Big] \nu_t R^b_{t-1} \tilde{K}_{t-1}, \tag{19}$$

where $\tilde{K}_{t-1}$ is the aggregate stock of investment goods that banks purchased in period $t-1$ for their projects.

2.5 Aggregation in investment projects

The four cases listed above have counterparts when describing the evolution of the total stock of physical capital. In the first two cases analyzed, the project was ultimately successful and therefore produced $R\tilde{k}_{t-1}$ units of productive capital at the beginning of period t.[9] In Cases 3 and 4, the project was ultimately unsuccessful and produced no units of productive capital. Taken together, the two cases that produce positive amounts deliver a total quantity $(p_{t-1}(1-l) + p_{t-1}l)\, R\tilde{k}_{t-1}$ or $p_{t-1}R\tilde{k}_{t-1}$ units of physical, productive capital.

Meanwhile, in the three cases where banks securitized and sold their loan, they redeployed the capital freed up by this transaction towards a technology that produces final goods in the current period. As each of the three cases where banks securitized generates revenues $x_{t-1} = r_{t-1}\nu_t R^b_{t-1}\tilde{k}_{t-1}$. In Case 2, they have access to a technology that generates λx_{t-1} in final goods in period t. In Case 3, their technology only allows them to generate x_{t-1} units of final goods. Finally, in Case 4, again they have access to the technology delivering λx_{t-1} units of final goods. Upon aggregating up the output from these three cases, the extra consumption goods created by the redeployment of capital sums up to

$$X_t \equiv \left[l\lambda + (1 - p_{t-1}(1-l)) \right] x_{t-1}, \; with \; x_{t-1} = r_{t-1}\nu_t R^b_{t-1}\tilde{k}_{t-1} \tag{20}$$

2.6 Production of final goods

The rest of the model is standard and follows the structure familiar to the financial frictions literature (Bernanke et al., 1999). First, competitive firms produce the final (consumption) good using the production function

$$Y_t = z_t K_t^{\theta_k} H_t^{\theta_h} H_t^{b\,\theta_b}, \tag{21}$$

where K_t and H_t are the amount of capital and labor services, respectively, used by the representative firm. In addition, H^b_t represents labor services from bankers.[10] Constant returns to scale in production implies that $\theta_k + \theta_h + \theta_b = 1$. Further, z_t is an aggregate technology shock following the autoregressive process

$$\log z_t = \rho_z \log z_{t-1} + \varepsilon_{zt}, \tag{22}$$

where $\rho_z \in (0,1)$ and ε_{zt} is *i.i.d.* with mean 0 and standard deviation σ_z.

Final-good producers are price-takers in the market for the four inputs, with market prices for these inputs denoted r^k_t, w_t and w^b_t, respectively. Profit maximization implies the following three

[9] When analyzing the evolution of the aggregate capital stock, whether the capital was put in place by the bank that originated the loan (Case 1) or the shadow bank that bought that project (Case 2) is irrelevant.

[10] The labor input of bankers is added to the production function to ensure all bankers, whether entering or unsuccessful, can count on a minimum level of net worth (see footnote 8 above). The parameter θ_b is calibrated to a very small number.

first-order conditions for these inputs:

$$r_t^k = z_t \theta_k K_t^{\theta_k - 1} H_t^{\theta_h} H_t^{b\,\theta_b}; \tag{23}$$

$$w_t = z_t \theta_h K_t^{\theta_k} H_t^{\theta_h - 1} H_t^{b\,\theta_b}; \tag{24}$$

$$w_t^b = z_t \theta_b K_t^{\theta_k} H_t^{\theta_h} H_t^{b\,\theta_b - 1}. \tag{25}$$

2.7 Production of capital goods

As in Bernanke et al. (1999), we assume the existence of competitive capital good producers that combine final goods I_t and the existing (installed) stock of capital K_t to produce new capital goods according to the production function $\phi(I_t/K_t)K_t$, where $\phi'(\cdot) > 0$ and $\phi''(\cdot) < 0$. Adding these new capital goods to the undepreciated part of the existing stock $(1-\delta)K_t$, available capital goods at the end of the production process are

$$\tilde{K}_t = \phi(I_t/K_t)K_t + (1-\delta)K_t, \tag{26}$$

Capital good producers operate under perfect competition and take the price of capital goods q_t as given. Accordingly, their first-order condition for the choice of I_t is

$$q_t \phi'(I_t/K_t) = 1, \tag{27}$$

which, in the aggregate equilibrium, implicitly defines the price of (installed) physical capital q_t.

2.8 Households

A continuum of households is present in the economy. While households do not have direct access to investment projects, they can indirectly fund them by channeling their savings through financial intermediaries. In addition, households supply labor to final good producers and consume.

Households can allocate their savings either to banks or to shadow banks. We aim to capture a situation in which distinct segments of the economy's savings pool naturally prefer one type of intermediary over the other. For example, some savings may be directed towards traditional banks due to deposit insurance and perceived safety, while others–typically with larger savings–may be attracted to shadow bank financing arrangements, where structures such as repos replicate certain features of deposit insurance (Gorton and Metrick, 2012).

To operationalize this idea without introducing explicit heterogeneity, we follow a tractable specification. Let households be uniformly distributed along the unit interval $[0, 1]$, where position $i \in [0, 1]$ identifies a typical household. Each household incurs utility cost $\phi^b(i)$ if they invest their savings in a bank, and a cost $\phi^{sb}(i)$ if they instead use a shadow bank.[11] We assume $\phi^b(0) = 0$ and $\phi^b(1) = +\infty$ while $\phi^{sb}(0) = +\infty$ and $\phi^{sb}(1) = 0$, so that banks and shadow banks each have a "natural" clientele. The marginal household, who is indifferent between both options and is identified by i^*, is endogenous and may vary with macroeconomic conditions.

Household i earns labor income $w_t^h h_t$ in period t and receives financial returns from prior savings. If household i allocated their savings to a bank in period $t-1$ (i.e., $\xi_{t-1}(i) = 1$), then they receive $(1+r_{t-1}^b)\, d_{t-1}(i)$; if they used a shadow bank ($\xi_{t-1}(i) = 0$), they receive $(1+r_{t-1}^{sb})\, d_{t-1}(i)$. Households

[11]This approach is based on Dotsey and Ireland (1995), who used a similar framework to study consumers' choices between cash and credit.

allocate these resources between consumption and new savings, and decide whether to save with a bank or a shadow bank. Their optimization problem is:

$$\max_{c_t^h, d_t(i), \xi_t(i), h_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[log(c_t^h - bc_{t-1}^h) - \psi \frac{h_t^{1+\eta}}{1+\eta} - \xi_t(i)\phi^b(i) - (1-\xi_t(i))\phi^{sb}(i) \right], \tag{28}$$

subject to the budget constraint:

$$c_t^h + d_t(i) = \Big((1 + r_{t-1}^b)\xi_{t-1}(i) + (1 + r_{t-1}^{sb})\xi_{t-1}(i) \Big) d_{t-1}(i) + w_t^h h_t; \ \ (\lambda_t) \tag{29}$$

with associated Lagrange multiplier λ_t.

The first-order conditions for consumption c_t^h, labor supply h_t and savings choice $d_t(i)$ are:

$$\frac{1}{c_t^h - bc_{t-1}^h} + \beta E_t \left[\frac{1}{c_{t+1}^h - bc_t^h} \right] = \lambda_t; \tag{30}$$

$$\psi h_t^\eta = \lambda_t w_t^h; \tag{31}$$

$$\lambda_t + \phi^{sb}(i) = \beta(1 + r_t^{sb}) E_t \lambda_{t+1}, \ \ \xi_t(i) = 0 \tag{32}$$

$$\lambda_t + \phi^b(i) = \beta(1 + r_t^b) E_t \lambda_{t+1}, \ \ \xi_t(i) = 1 \tag{33}$$

Observing first order condition (32) and (33) reveals that $\xi_t(i) = 1$ whenever

$$\beta(1 + r_t^b) E_t \lambda_{t+1} - \lambda_t - \phi^b(i) > \beta(1 + r_t^{sb}) E_t \lambda_{t+1} - \lambda_t - \phi^{sb}(i) \tag{34}$$

or

$$\beta E_t \lambda_{t+1} (r_t^b - r_t^{sb}) > \phi^b(i) - \phi^{sb}(i). \tag{35}$$

Following Dotsey and Ireland (1995), we assume the following functional forms for utility costs:

$$\phi^b(i) = \chi^b \left(\frac{i}{1-i} \right)^{\theta_b}, \quad \phi^{sb}(i) = \chi^{sb} \left(\frac{1-i}{i} \right)^{\theta_{sb}}.$$

These specifications imply that the right-hand side of (35) approaches $-\infty$ as $i \to 0$ and $+\infty$ as $i \to 1$. Hence, a unique interior solution i^* exists that defines the marginal household indifferent between banks and shadow banks. For this household, the condition holds with equality:

$$\beta E_t \lambda_{t+1} (r_t^b - r_t^{sb}) = \phi^b(i^*) - \phi^{sb}(i^*). \tag{36}$$

Aggregating across all households, the supply of financing for banks and for shadow banks are as follows:

$$D_t^b = \int_0^{i^*} d_t(i) di; \tag{37}$$

$$D_t^{sb} = \int_{i^*}^1 d_t(i) di. \tag{38}$$

2.9 The competitive equilibrium

A competitive equilibrium for the economy consists of decision rules for (i) c_t^h, h_t, $\xi_t(i)$, $d_t(i)$ (households' optimization problem); for (ii) I_t and $\tilde{K}_t$ (optimization problem of the investment good producers); for (iii) K_t, H_t, and H_t^b (problem of the final good producers); (iv) for D_t^{sb}

(optimization problem of the shadow banks) and (v) for $\tilde{k}_t$, R_t^b, R_t^h, a_t and d_t and Υ_t that solve the maximization problem associated with the financial contract (1)-(6). These decision rules must be compatible with the following market-clearing conditions:

• In the market for labour services:

$$H_t = h_t; \tag{39}$$

• In the market for goods:

$$Y_t + X_t = C_t^h + C_t^b + I_t + c\Upsilon_t q_t \tilde{K}_t; \tag{40}$$

with

$$X_t = [l\lambda + (1 - p_{t-1}(1-l))]\, r_{t-1}\nu_t R_{t-1}^b \tilde{K}_{t-1}; \tag{41}$$

• Law of motion for capital:

$$K_{t+1} = p_t R \tilde{K}_t; \tag{42}$$

with

$$\tilde{K}_t = \phi(I_t/K_t)K_t + (1-\delta)K_t; \tag{43}$$

• In the market for deposits:

$$D_t^b = \int_0^{i^*} d_t(i)di \;\; D_t^{sb} = \int_{i^*}^1 d_t(i)di \tag{44}$$

3 Banks and Shadow Banks: Qualitative Analysis

Before presenting our quantitative results, we first offer a qualitative discussion of the interaction between banks, shadow banks, the macroeconomy, and bank regulation. This section highlights the economic mechanisms at play, particularly the dual role played by shadow banks in the financial system.

The presence of shadow banks has two key effects. First, it enables banks to redeploy capital toward alternative projects when such opportunities arise–a potentially socially beneficial mechanism, captured in the model by assuming $\lambda > 1$. However, the ability to sell loans on the secondary market may also weaken banks' incentives to screen investment projects, increasing banking sector risk. Before turning to our full general equilibrium analysis of this tradeoff, we present three important partial equilibrium insights.

• *Shadow banks and the secondary loan market facilitate the accumulation of bank net worth, thereby supporting credit expansion.*:

This result follows from equation (19), which governs the accumulation of aggregate bank net worth. Consider a counterfactual world with no shadow banks or secondary loan market. In this case, net worth accumulation reduces to:

$$A_t = [p_{t-1}]\, \nu_t R_{t-1}^b \tilde{K}_{t-1}. \tag{45}$$

Comparing (19) to (45) illustrates that bank net worth accumulates more rapidly when shadow banks are present, provided λ is sufficiently greater than 1. This faster accumulation of capital enhances the banking sector's ability to extend credit through the capital channel of monetary transmission discussed in Chen (2001) and Meh and Moran (2010).

• *Shadow banks reduce banks' screening incentives and increase banking sector risk by lowering the equilibrium probability of project success, p_t.*

Although the access to a secondary market for loans can be beneficial ex post, by allowing banks to redeploy capital to profitable projects, it has an impact on ex-ante choices for screening. Specifically, (8) shows that the ability to sell a non-performing loan at a positive price ($r_t > 0$) lowers incentives for banks to screen intensively. This worsens the agency problem between banks and depositors in financial markets and (12) shows that the equilibrium response of banks is to screen less intensively. In turn, the probability of success p_t decreases, ie banking-sector risk rises. Figure 3 can be used to provide graphical intuition for this effect. It shows that removing shadow banks from the economy (or equivalently lowering r_t) shift outwards the contract curve (dot-dashed curve), which leads to more intense screening and higher probability of success of projects.

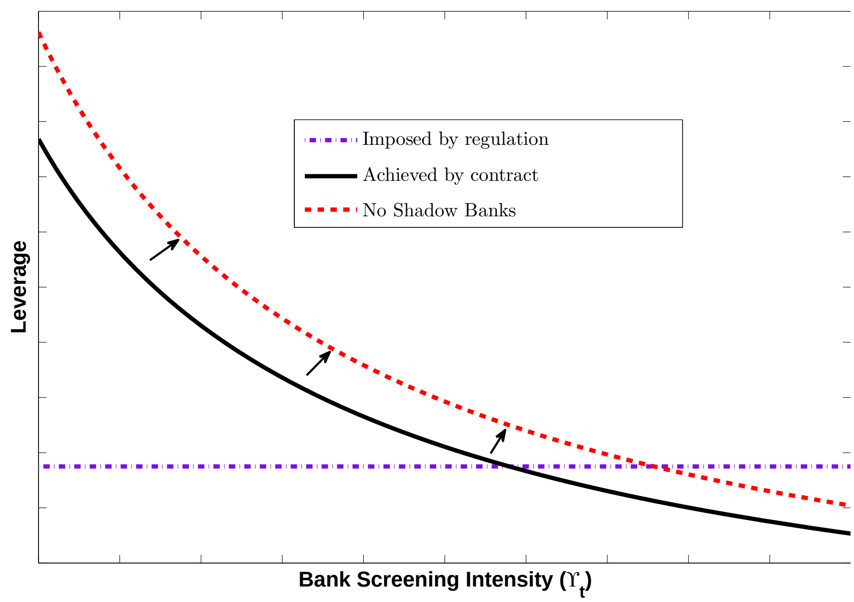


Figure 3: Influence of Shadow Banks on the choice of screening intensity Υ_t

• *Lower funding costs for shadow banks (a decrease in r_t^{sb}) raise the price of securitized loans and reduce banks' screening efforts.*

This effect follows from combining equation (14), which shows how a reduction in r_t^{sb} raises the price r_t of securitized loans, with the earlier result that higher r_t weakens banks' screening incentives. As shadow banks gain easier access to short-term debt, they are more willing to purchase loans on the secondary market. Anticipating this, banks are less motivated to screen investment projects thoroughly, leading to a decline in p_t–that is, a deterioration in average loan quality and an increase in banking-sector risk.

This mechanism aligns with empirical observations from the period preceding the global financial crisis, where rapid growth in the capacity of shadow banks to attract savings was accompanied by declining underwriting standards and rising systemic risk (Adrian and Shin, 2010).

4 Quantitative Analysis

This section illustrates how our model can be used to investigate the quantitative implications of interactions between traditional banks, shadow banks, and financial regulation. After calibrating the model, we examine its steady-state properties under various assumptions regarding the stringency of banking regulation and the scope of shadow banking activity. We then analyze the model's dynamic response to shocks, emphasizing how outcomes are shaped by the interplay between banks and shadow banks.

4.1 Calibration

We begin by describing the calibration of the model. The household, intermediate-good, and capital-good production sectors are broadly consistent with standard formulations of New Keynesian models (Christiano et al., 2005) and the literature on financial frictions (Bernanke et al., 1999). Consequently, most of the associated parameters follow conventional values in that literature.

Assuming a model period represents one quarter, we set the household discount factor to $\beta = 0.99$. The weight on leisure, ψ, is chosen such that the steady-state labor supply is 0.3, and the Frisch elasticity parameter η is set to 1, following Christiano et al. (2005). The habit formation parameter is set to $b = 0.6$, again following Christiano et al. (2005). The tax rate t^b is set at a low value (0.05), and the scaling parameter χ_1 in the banking regulation function $\phi(\cdot)$ is calibrated to ensure compliance with regulated leverage in steady state.[12]

On the production side, we use conventional values for the factor shares: $\theta_k = 0.36$ and $\theta_h \approx 0.64$.[13] The technology shock follows an AR(1) process with $\rho_z = 0.95$. For capital adjustment costs, we set $\varphi''(\delta) = 0.25$, consistent with Bernanke et al. (1999), and the depreciation rate is fixed at $\delta = 0.02$.

Calibrating parameters related to the financial sector is more uncertain. We adopt a benchmark calibration that targets key economic moments and rely on values from the existing literature, while subjecting results to robustness checks. The relationship between screening effort Υ_t and project success p_t takes the following functional form:

$$p(\Upsilon_t) = \frac{1}{1 + \omega \Upsilon_t},$$

with $\omega = 0.05$, yielding a steady-state success probability $p_t \approx 0.97$, in line with values used in financial accelerator models (Carlstrom and Fuerst, 1997).

The unit cost of monitoring is set to $c = 0.05$, and the banker survival rate to $\tau_b = 0.95$, following Meh and Moran (2010). The return factor R is pinned down by the requirement that the steady-state price of finished capital is normalized to one ($q = 1$), which implies $R = 1/p$. Lastly, we set $\lambda = 1.01$, implying modest gains from capital redeployment to capture the notion that such reallocation can be socially beneficial without dominating all investment choices.

Three important parameters remain. First, we set χ_2, which governs the elasticity of the bank regulation function $\phi(\cdot)$, such that this elasticity equals one in steady state. Second, the steady-state leverage ratio is set to $\kappa^b = 5.0$–equivalent to a 20% net worth-to-assets ratio. Although the model highlights bank net worth, its empirical counterpart should encompass both bank and entrepreneurial wealth, justifying a leverage calibration consistent with both Gertler and Karadi

[12] In the baseline case with $l = 0.25$ and a leverage cap of $\overline{\kappa}^b = 5.0$, this requires $\chi_1 = 0.0592$ (see Table 2).

[13] We assume bankers receive a small positive wage and accordingly set $\theta_b = \epsilon$ and $\theta_h = 0.64 - \theta_b$.

Table 1: Baseline Parameter Calibration

Household Preferences					
b	β	ψ	η	χ_1	t^b
0.6	0.99	9.05	1.0	0.0592	0.05
Final Good Production					
θ_k	θ_h	θ_b	ρ_z	δ	$\varphi''(\delta)$
0.36	0.63999	0.0001	0.95	0.02	0.5
Investment and Financing					
ω	c	τ_b	R	λ	τ_b
0.05	0.05	0.90	$1/p$	1.01	0.9

(2011) and entrepreneurial finance studies. Finally, the redeployment parameter l is set to either 0.25 or 0.5 in alternative scenarios to assess the implications of more or less significant capital reallocation capacity. Table 1 summarizes the baseline calibration of model parameters.

4.2 Steady State Implications

Tables 2 and 3 present the steady-state characteristics of the model economy, emphasizing how key outcomes depend on the scope for shadow banking (governed by parameter l) and the tightness of bank leverage regulation (parameter $\overline{\kappa}^b$).

Table 2 explores the effects of varying l, the parameter that governs the economic potential for redeploying capital through shadow banks. The first column reports steady-state outcomes when $l = 0.25$, while the second corresponds to a case with $l = 0.5$. A low value of l implies limited scope for profitable redeployment of capital, both economically and as a signal: projects offered for sale on the secondary market are more likely to be of poor quality, which lowers the equilibrium price of loans (see equation 14).

The comparison across columns supports this intuition. As l increases, the economy exhibits (i) Lower screening effort by banks (Υ), (ii) a modest decline in project success probability ($p(\Upsilon)$), (iii) a higher equilibrium price of loans (r), due to improved expectations regarding capital redeployment and (iv), finally, a decrease in the threshold i^*, indicating that a larger share of households prefer shadow banks. In turn, these changes translate into a higher capital stock, stronger output in the consumption-good sector (X), and higher aggregate consumption and GDP.

Table 2: The Economy's Steady State

Variables	Less Scope for Shadow Banks ($l = 0.25$)	More Scope for Shadow Banks ($l = 0.5$)
Regulated Bank Leverage ($\overline{\kappa}^b$)	5.0	5.0
Screening (Υ)	0.44	0.21
Success Prob. ($p(\Upsilon)$)	0.97	0.96
Price of Loans (r)	0.87	0.91
Threshold (i^*)	0.94	0.88
Capital Stock	1.57	1.67
Consumption Good Production (X)	0.09	0.19
GDP	0.59	0.67
Consumption	0.50	0.59

The economy with $l = 0.5$ therefore can and needs to rely more extensively on redeployment of capital brought about by the presence of shadow banks. As a result, the division of the savings markets tilts towards these financial intermediaries and the threshold $i*$ indicating the separation between banks and shadow banks decreases. Overall the increased redeployment capabilities augment the economy's possibilities for creating capital and only create a slight decrease in banking sector risk. Accordingly, the steady-state capital stock is higher in the second economy, as are other macroeconomic indicators (GDP, consumption). Note also that, naturally, the higher redeployment potential results in a sharp increase in X, the part of GDP arising from the consumption-good production linked to banks' alternative projects.

Next, Table 3 analyzes the impact of leverage requirements on traditional banks. The table is divided in two panels. On the left, an experiment is reported where regulated leverage is increased ($\overline{\kappa}^b$ goes from 5 to 10) in an economy where the potential scope for shadow banks is limited ($l = 0.25$); on the right, the same experiment occurs in an economy where $l = 0.5$.

Table 3: The Economy's Steady State

Impacts of Regulated Leverage

Variables	Less Scope for S.B. ($l = 0.25$)		More Scope for S.B. ($l = 0.5$)	
	Low Leverage	High Leverage	Low Leverage	High Leverage
Bank Leverage ($\overline{\kappa}^b$)	5.0	10.0	5.0	10.0
Screening (Υ)	0.44	0.25	0.21	0.11
Success Prob. ($p(\Upsilon)$)	0.969	0.963	0.961	0.957
Price of loans	0.87	0.85	0.91	0.90
Threshold (i^*)	0.94	0.97	0.88	0.94
Capital Stock	1.57	1.98	1.67	2.09
Good Production (X)	0.09	0.06	0.18	0.11
GDP	0.60	0.62	0.67	0.66
Consumption	0.50	0.53	0.59	0.59

Allowing higher leverage has a direct impact on the screening effort of banks: since banks will be less invested in a given-size project, the financial contract in Section 2.2.1 predicts that the screening intensity compatible with this less-involved role in lending is much lower, a prediction that is indeed present in both panels of Table 3. As a result, in both panels, both the probability of success and the price of loans on the secondary market decrease. In addition, less involvement per unit of project from bank net worth implies that household deposits will take on an expanded role. As a result, the demand for depositors' savings coming from the traditional banking sector increases and the threshold i^* rises as well.

In our economy, higher leverage facilitates capital formation. As a result, the capital stock that the economy can validate increases in both panels of the table. However, the combined effects of the declines in screening intensity, in the probability of success and in the price of loans on the secondary market make the successful redeployment of capital by banks more difficult and as a result, the contribution to GDP arising from such redeployment (X) is lower in both panels. Allowing higher leverage therefore has positive economic effects on capital formation but, because of its negative impacts on bank screening, negative impacts related to redeployment. In the left panel of Table 3, the positive effects dominate the negative ones, and both GDP and consumption per head increase as the result of allowing $\overline{\kappa}^b$ to increase from 5.0 to 10.0. However, the right panel of Table 3 indicates that in some circumstances, perhaps when the economic potential from redeployment are high, allowing traditional banks to increase their leverage might affect the secondary market so much as to render negative the net effect on the economy.

4.3 Business Cycle Implications

This section describes the results of several impulse response experiments. These experiment help document how our model economy responds to various shocks and highlight how the interactions between traditional and shadow banks affect these responses. Throughout, we concentrate on the responses computed under the assumption that leverage regulation on traditional banks is exactly binding.

Technology shocks

Figure 4 presents the effects of a one-percent positive technology shock on the model economy. The favorable technology shock induces a persistent increase in the productivity of the intermediate-good production function, which raises the expected return from physical capital in future periods. This translates into a positive shift in the demand for capital goods and puts upwards pressure on q_t, the relative price of these goods.

Under the assumption that bank regulation is always biding, banks must maintain an unchanged leverage ratio throughout the episode, even though the upward pressure on q_t has created favorable conditions for financing projects (if banks were to keep their screening intensity Υ unchanged, leverage would rise over the regulated level). Banks are thus compelled by the regulation to increase their capital participation in (given-sized) investment projects and this serves to limit the rise in leverage. The expanded involvement of banks in financing entrepreneurs manifests itself in a sharp increase in their screening intensity, which also results in increases in the probability of success of projects (a decrease in banking-sector risk). In the following periods, the *bank capital channel* described in Meh and Moran (2010) helps propagate the effects of the shock: higher bank earnings in the impact period translate into higher levels of bank net worth in the next period, which sets the stage for second-round, positive effects on bank lending and investment because higher bank capital further facilitates the ability of banks to attract loanable funds and fund projects (recall the

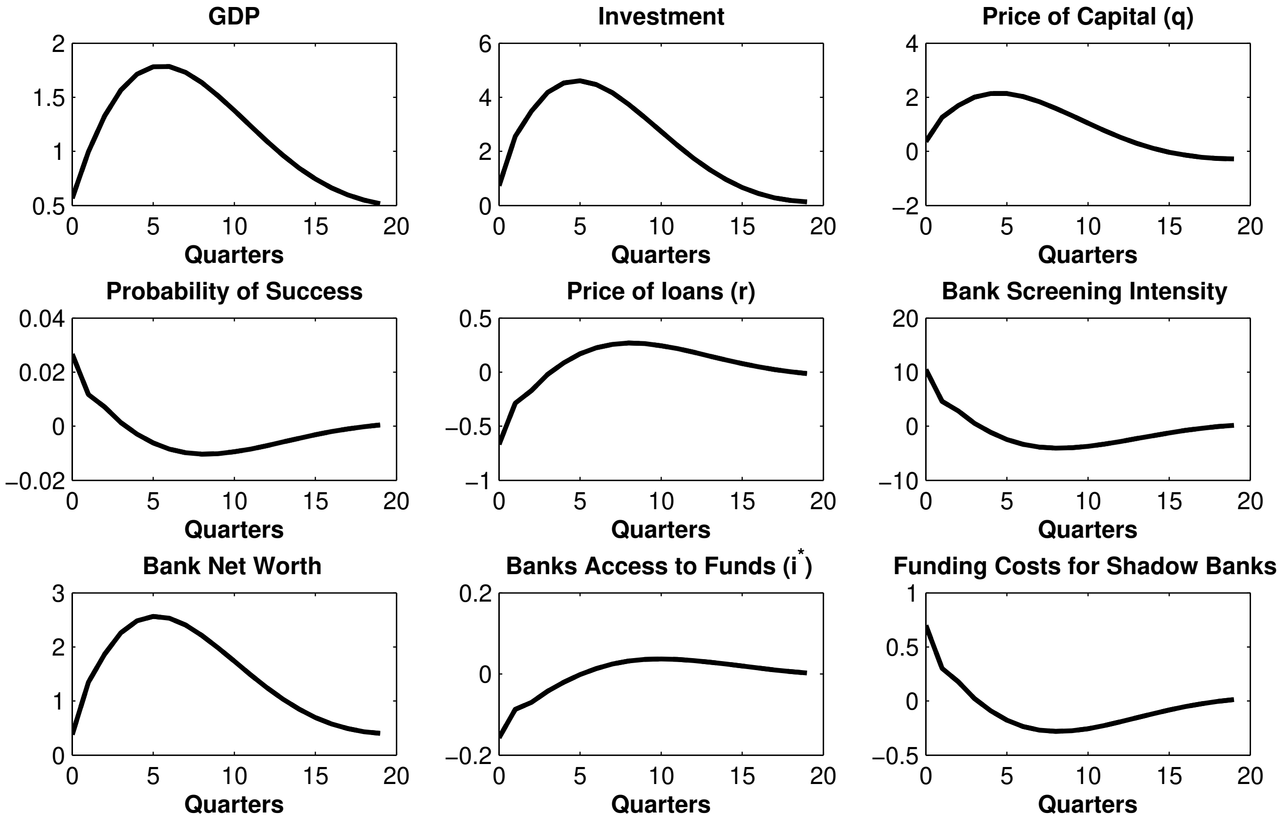


Figure 4: Responses to a Favorable Technology Shock

law of motion for bank capital in (19)). This propagation effect persists for several periods.

The interest rates in the economy (the cost of funds for banks and shadow banks) increase during the episodes. Recall that, in contrast to a New Keynesian model where monetary policy could limit the rise in real interest rates during a boom, here the link between the rental rate of capital and interest rates is more direct. In turn, the rise in interest rates has an impact on the price of loans on the secondary markets, which decreases to reflect the higher opportunity cost of the loanable funds that make capital redeployment through the secondary market possible.

Shocks to shadow banks' access to funds

Figure 5 depicts the impacts of a shock that makes it easier for shadow banks to attract funding. This shock could be interpreted as a proxy for a legislative change or a technological innovation that allows the business model of securitizing loans to function more easily.[14]

Cheaper access to funds by shadow banks facilitates their operations on the secondary market for loans and bids up loan prices r_t. As discussed above, this lowers banks' incentive to screen and as a result, both the screening intensity and the probability of success of projects decline (ie. banking-sector risk increases). The shock, however, also has important beneficial impacts on the economy.

[14]Technically, this shock is implemented by lowering the schedule $\phi(\cdot)$ representing the transaction cost of directing savings towards a shadow bank (see Section 2.8).

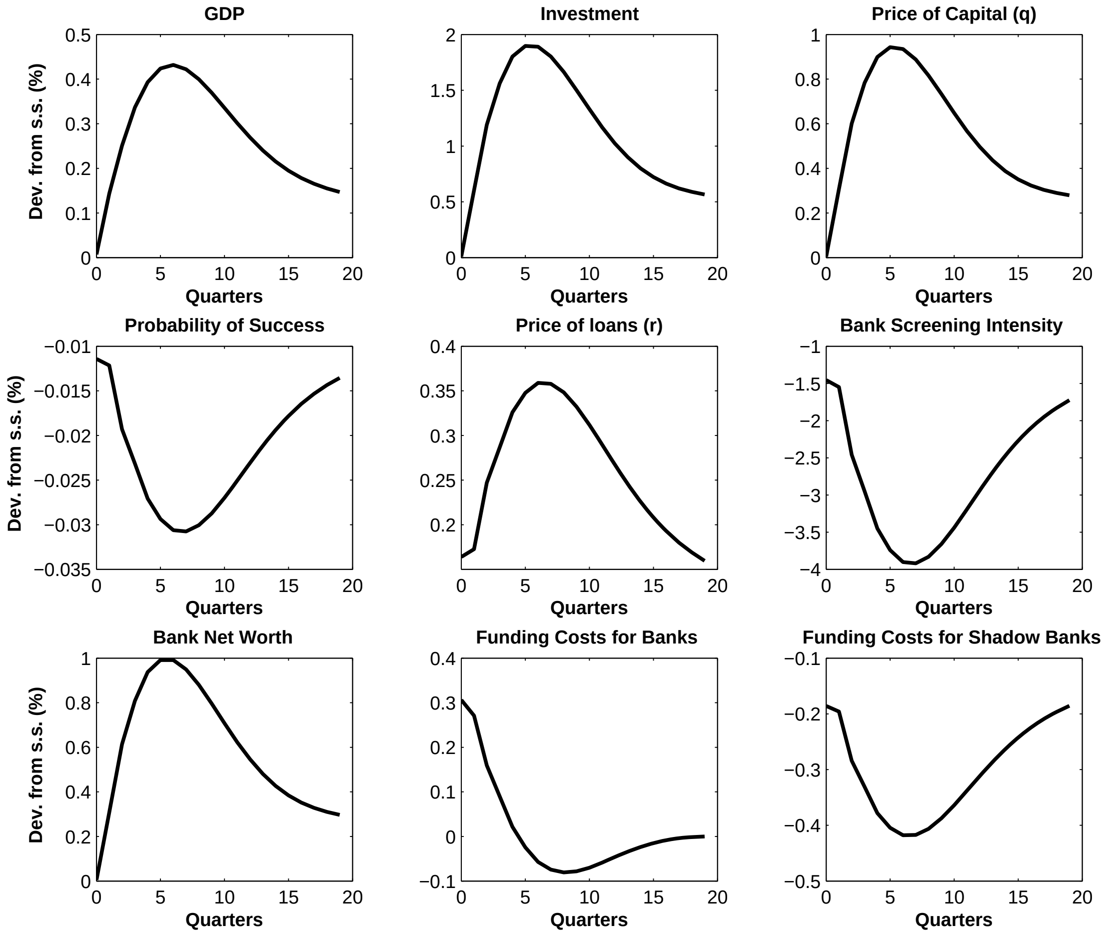


Figure 5: Responses to an Increase in the Availability of Funds for Shadow Banks

The increase in price reduces the extent of the moral hazard between banks and stakeholders and allows to meet more easily the leverage constraint. Absent regulation, leverage would increase but instead here banks engage attract more deposits and engage in bigger projects while saving on screening costs. Aggregate investment increases sharply in the impact period as a result, with corresponding increases in bank earnings. In the following periods, once again the bank capital channel helps propagate the effects of the shock with the increases in bank earnings translating into higher bank net worth and second-round, positive effects on bank lending and investment. Once again, this propagation effect persists for several periods

Regulation Shocks

Figure 6 reports the consequences for the economy of a tightening in the leverage regulation affecting traditional banks (recall that in our benchmark calibration, leverage over net worth $\overline{\kappa}_t^b$ cannot exceed 5). We consider throughout that regulation continues to bind.

Tightened regulation requires that banks engage more of their own net worth per unit of investment project; to make such a situation compatible with the financial contract of Section 2.2.1, the

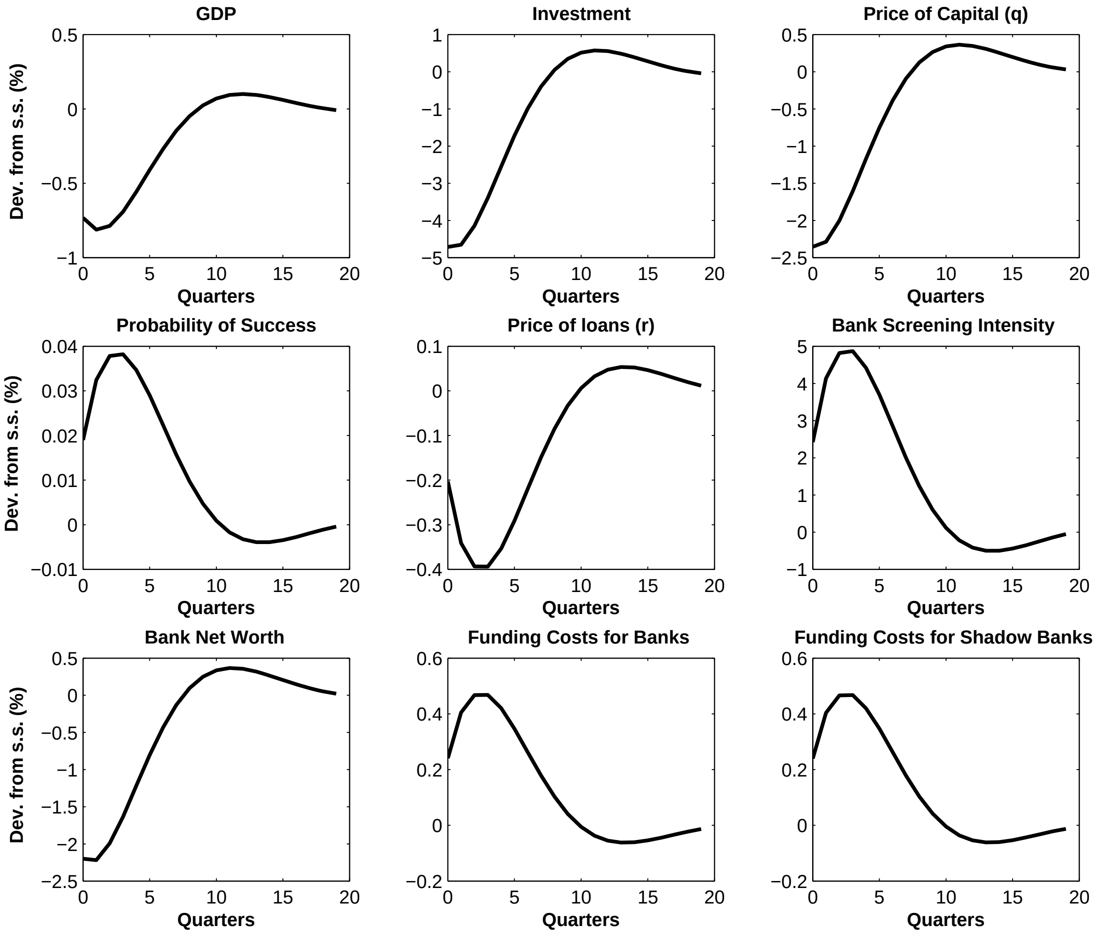


Figure 6: Responses to an Increase in the Availability of Funds for Shadow Banks

screening intensity of banks has to be increased substantially. Increased screening intensity implies that the probability of project success increases (ie banking-sector risk decreases).

However, bank capital can only be accumulated gradually, and thus the stock available at the impact period is not so high as to enable banks to comply with tightened regulation with unchanged asset levels. Therefore the tightened regulation is met partly by decreasing the asset denominator, ie.e by financing smaller projects. This acts like a decrease in the demand for capital goods, which lowers the price of capital goods q_t and lowers aggregate investment. This reduced investment depresses bank earnings and future bank net worth, which, through the bank-capital channel discussed above, serves to propagate the negative impacts of the shocks in future periods.

5 Conclusion

Recent policy discussions at central banks and within regulatory bodies have examined changes to the structure of bank leverage regulation and how they might be affected by interactions between traditional and shadow banking institutions. Careful analysis of these issues will be greatly aided by quantitative macroeconomic frameworks in which these interactions play pivotal roles in the transmission, or the origination, of the shocks affecting economic dynamics.

This paper develops such a framework and uses it to study the impact of different configurations of bank leverage regulation, scope for shadow banking activities and macroeconomic shocks. The model emphasizes the bank capital channel of Meh and Moran (2010) and Christensen et al. (2011), in which bank capital, accumulated through banks' retained earnings, mitigates moral hazard between banks and suppliers of loanable funds and affects the ability of banks to lend and support economic activity. The model in the present paper builds up from earlier contributions by allowing a potentially beneficial societal role to shadow banks, institutions that allow capital redeployment towards profitable alternatives activities. Preliminary results show that the presence of these shadow banks. although beneficial to the economy, can lower the screening intensity of banks and lead to lower probability of success for the projects banks undertake (ie. increased banking-sector risk). Further, we show that favorable shocks to the availability of financing for these institutions increase the price of securitized loans, which also lowers bank screening and increases banking-sector risk. Finally, regulated bank leverage is shown to have two, possibly counteracting effects: increasing allowed leverage does facilitate the formation of physical capital but, through its impact on the incentive to screen, it makes redeployment of capital harder to achieve. In some specifications of the model, this second effect is shown to have quantitative importance.

Future versions of this work will consider applying leverage regulation on shadow banking institutions as well as on their traditional counterparts, to assess how a broader scope for financial regulation might affect the macroeconomy. Further, the model set-up will be embedded into a version of the *New Keynesian* framework, to make it comparable with the standard modeling tools used in central banks and financial regulators worldwide.

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A Timing of Events

Markets open - Time t begins.

1. Information: Project-specific shock $\omega \in \{0, R\}$ realized with successful projects of scale $\tilde{k}_{t-1}$ delivering $k_t = R\,\tilde{k}_{t-1}$ units of capital. Aggregate productivity shock z_t realized. Some banks learn they exit the economy at period's end.

2. Production: Final good firms rent capital K_t and labor services to produce $Y_t = z_t K_t^{\theta_k} H_t^{\theta_h} H_t^{b^{\theta_b}}$.

3. Revenue Realization: Successful projects earn $r_t^k k_t$ from capital rental and $q_t(1-\delta)k_t$ from selling undepreciated capital. Total return is thus $\nu_t = r_t^k + q_t(1-\delta)$.

4. Payoffs Distribution:
- Banks earn $R_{t-1}^b \nu_t k_t$ if successful
- Depositors receive $R_{t-1}^h \nu_t k_t$ if successful

5. Net Worth Update:
- Successful bank: $a_t = R_{t-1}^b \nu_t q_{t-1} k_t + w_t^b$
- Unsuccessful bank: $a_t = w_t^b$

6. Capital Goods Production: New capital produced: $\tilde{k}_t = (1-\delta)K_t + \phi(I_t/K_t)K_t$

7. Project Setup: Non-exiting banks invest $q_t\tilde{k}_t$ using a_t and d_t^b. Exiting bankers consume a_t.

8. Financial Contracting: Contract specifies R_t^b, R_t^h, and screening Υ_t. Resource constraint: $a_t + d_t^b - c\Upsilon_t q_t \tilde{k}_t = q_t \tilde{k}_t$

9. Screening and Shocks:
- Banks choose screening intensity Υ_t
- Private info on ω is revealed
- Liquidity shock hits some banks

10. Secondary Market:
- Banks with $\omega = 0$ or outside opportunity sell to shadow banks
- Shadow banks finance via equity and investor funds

Markets close - Time $t+1$ begins.

Figure 7: Timeline of Events in the Model

B Incentive constraint for the bank

Expression (2) in the main text represents the incentive compatibility constraint of a bank that finances a project of size $\tilde{k}_t$ using its own net worth a_t and deposits d_t^b from households. The bank's objective is to maximize the expected terminal value of its assets. This appendix provides the derivation and interpretation of this condition.

For convenience, we reproduce the incentive constraint here:

$$p_t(1-l)(1-r_t)R_t^b\nu_{t+1}^e\tilde{k}_t \geq c\Upsilon_t q_t\tilde{k}_t; \tag{46}$$

We begin by calculating the expected returns to a bank that screens a project at intensity Υ_t. Let $p_t = p(\Upsilon_t)$ denote the probability that the project is of good quality, which depends on the bank's screening effort. There are four possible scenarios:

1. **Good project, outside opportunity available** ($p_t \cdot l$): With probability p_t, the project is of good quality and with probability l, the bank receives an outside investment opportunity with a return premium $\lambda > 1$. The bank sells the loan on the secondary market for $r_t R_t^b\nu_{t+1}^e\tilde{k}_t$, invests the proceeds in the outside opportunity, and earns λ on that investment. Its expected return is:
$$p_t l\lambda r_t R_t^b\nu_{t+1}^e\tilde{k}_t.$$

2. **Good project, no outside opportunity** ($p_t \cdot (1-l)$): The project is good, but the bank has no alternative investment. It retains the loan and its expected terminal value of assets is:
$$p_t(1-l)R_t^b\nu_{t+1}^e\tilde{k}_t.$$

3. **Bad project, outside opportunity available** ($(1-p_t)\cdot l$): The project is bad, but the bank receives an outside opportunity. It sells the bad loan at price r_t and invests in the outside project. Its expected return is:
$$(1-p_t)l\lambda r_t R_t^b\nu_{t+1}^e\tilde{k}_t.$$

4. **Bad project, no outside opportunity** ($(1-p_t)\cdot(1-l)$): The project is bad and no outside investment is available. The bank still sells the loan and reinvests at unit return so that its expected return is:
$$(1-p_t)(1-l)r_t R_t^b\nu_{t+1}^e\tilde{k}_t.$$

Summing all scenarios, the total expected return (or terminal value) for a bank that screens at intensity Υ_t is:

$$\left[p_t(l\lambda r_t + 1 - l) + r_t(1-p_t)(l\lambda + 1 - l)\right] R_t^b\nu_{t+1}^e\tilde{k}_t.$$

Now consider the bank's payoff from not screening. In that case, it avoids the cost $c\Upsilon_t q_t\tilde{k}_t$, but guarantees that the project is of bad quality ($p_t = 0$). Still, it can sell the project on the secondary market for $r_t R_t^b\nu_{t+1}^e\tilde{k}_t$. With probability l, it reinvests at return λ; otherwise, at return 1. The expected return from not screening is therefore:

$$c\Upsilon_t q_t\tilde{k}_t + (l\lambda + 1 - l)r_t R_t^b\nu_{t+1}^e\tilde{k}_t.$$

For screening to be incentive-compatible, the expected return from screening must be at least as high as that from shirking so that the following inequality must hold:

$$[p_t(l\lambda r_t + 1 - l) + r_t(1 - p_t)(l\lambda + 1 - l)]\, R_t^b \nu_{t+1}^e \tilde{k}_t \geq c\Upsilon_t q_t \tilde{k}_t + (l\lambda + 1 - l) r_t R_t^b \nu_{t+1}^e \tilde{k}_t. \qquad (47)$$

Rearranging the inequality:

$$[p_t(l\lambda r_t + 1 - l) - p_t r_t(l\lambda + 1 - l)]\, R_t^b \nu_{t+1}^e \tilde{k}_t \geq c\Upsilon_t q_t \tilde{k}_t; \qquad (48)$$

Simplifying the expression in brackets:

$$p_t(1 - l)(1 - r_t) R_t^b \nu_{t+1}^e \tilde{k}_t \geq c\Upsilon_t q_t \tilde{k}_t,$$

which matches the form shown in the main text as equation (46).