Stabilization vs. Growth

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Abstract

Should firms in financial distress be saved to stabilize an economy, even if less productive ones are kept alive, possibly reducing economic growth? To assess this fundamental stabilization-vs.-growth trade-off, we develop a new dynamic general equilibrium model with business cycles, endogenous growth, and innovation externalities. We discipline key parameters using microeconomic data and an instrumental-variable approach that links firm productivity growth to R&D expenditure. Based on the calibrated model, we find that economies that save distressed firms with credit guarantees, debt restructuring, or loan evergreening experience lower volatility but also slower growth. Even though welfare is higher in an economy without such interventions, the various "soft credit" regimes can still arise as equilibrium outcomes when a benevolent government intervenes in credit markets under discretion.

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1 Introduction

A number of policy interventions and lending practices in credit markets imply a fundamental trade-off: they can stabilize business cycle fluctuations at the expense of future economic growth. As a concrete example, consider the business funding programs during the COVID-19 recession, such as the Paycheck Protection Program in the United States. These programs aimed to save firms in financial distress and prevent them from going bankrupt, thereby stabilizing employment and economic activity. At the same time, the programs may have kept less productive firms alive, possibly reducing economic growth in the medium to long term. Thus, how should such firm credit programs be designed if a policymaker takes both stabilization and growth effects into account?

In this paper, we aim to answer this question, not only for business credit subsidies, but also for lending practices where a similar stabilization-versus-growth trade-off may be present. A restructuring or reorganization of distressed businesses reduces the existing debt burden, as, for example, Chapter 11 in the United States, again possibly stabilizing an economy in downturns while also keeping less productive firms alive. Similar effects can be associated with so-called "evergreening" or "zombie-lending" practices which allow struggling firms to roll-over their debt at possibly favorable terms (Peek and Rosengren, 2005; Caballero, Hoshi and Kashyap, 2008). To analyze the trade-off for various policy interventions and lending practices, a framework is needed that includes business cycles, financial intermediation that channels funds from savers to businesses, firm heterogeneity with endogenous exit and default decisions, as well as endogenous growth. Existing macroeconomic models typically fall short along at least one of these dimensions. We therefore develop a new framework that incorporates all of these features and remains tractable to account for firm heterogeneity in general equilibrium with aggregate shocks.

Our model has two important features. First, firms differ in their productivity, and some may choose to default and exit. However, lenders and policymakers can steer firms' default decisions by reducing their legacy debt (restructuring), easing credit conditions (evergreening), or by directly issuing credit guarantees to firms. We show that a lender's decision to evergreen or restructure distressed firms arises as the optimal solution to a profit-maximization problem. Intuitively, a lender may rather offer a distressed firm more favorable loan terms and thereby recover at least part of the outstanding debt than allow default and recover only the collateral backing the loan. Second, aggregate total factor productivity (TFP) is endogenous and shaped by firms' decision to exit and to invest in research and development (R&D). We posit that firms learn from or imitate each other, which is reflected in the fact that their R&D costs depend negatively on the

average productivity of incumbent firms. As a result, if low-productivity firms exit the economy, the R&D costs for all subsequent firms are affected, a mechanism similar to the "cleansing effect" that can lead to more innovation and growth (Schumpeter, 1939).

We tightly calibrate the model to various empirical moments for the U.S. economy, such as lending spreads, default rates, loan recovery rates, and the typical relative productivity of exiting versus continuing firms. Most importantly, we use firm-level data to pin down the elasticity of firm productivity growth to R&D investment and the innovation externalities that drive the learning between firms. To this end, we employ an instrumental-variable approach that instruments firm R&D expenditure with variation in state-level R&D tax credits (Wilson, 2009; Bloom, Schankerman and Van Reenen, 2013). We find that a 1% increase in R&D expenditure, or a 1% higher productivity of a firm's peers' relative to its own productivity, each leads to firm productivity growth of around 0.3% over the next year.

Based on these parameter estimates, we first consider an economy where neither lenders nor policymakers intervene ex-post to save firms from default. By analogy to the "soft budget constraint" literature (Kornai, Maskin and Roland, 2003), we refer to this as the "hard credit" economy. Relative to this benchmark, we consider three counterfactual economies where credit terms are softened after idiosyncratic firm productivities realize: an economy where lenders can write off a fraction of the firms' legacy debt ("restructuring economy"), an economy where lenders lower interest rates on new borrowing while leaving the legacy debt unchanged ("evergreening economy"), and an economy where firms receive credit guarantees from the government ("guarantee economy"). Each of these interventions is designed such that a firm that would default without additional support receives a subsidy just large enough to continue operating.

Across the various counterfactuals, one common pattern emerges. Each intervention reduces the share of firms exiting in each period, thereby raising output and employment all else equal. This, in turn, reduces output growth volatility overall, as well as the response of output to adverse aggregate shocks. However, by keeping less productive firms alive, the average productivity of incumbents falls. Given the calibrated innovation externality, this raises R&D costs for other firms all else equal, lowering R&D investment and growth. As a result, the hard credit economy features around 0.33%-0.39% higher GDP growth per year compared with the counterfactual economies. To illustrate the importance of the differential growth rates, consider the number of years it takes to double GDP. In the hard credit economy, this milestone is achieved after around 30.5 years, while it takes around 5 to 6 years longer in the counterfactual economies.

To assess the stabilization-vs.-growth trade-off, we compute aggregate welfare for all

four economies. To make the counterfactual economies comparable, we pick parameters to equalize the share of subsidized firms across the three economies and choose the same initial states. We find that welfare in the hard credit economy is largest due to higher economic growth. Relative to this benchmark, the restructuring and the guarantee economies deliver around 2.3% lower welfare in terms of consumption-equivalent variation, while the evergreening economy features 3% lower welfare. The relatively poor performance of the evergreening economy is explained by the fact that the relaxed credit terms in this economy distort firm labor choices, leading to relatively higher labor demand and increased wages. In turn, firm profits are lower, and firms invest less in R&D, further reducing economic growth.

We next decompose welfare into contributions from average levels and volatility. The bulk of the welfare differences is accounted for by higher average consumption levels of the hard credit economy, reflecting its stronger long-run growth. However, in the first few periods, average consumption and output levels are in fact higher in the soft-credit economies, as firm exit is reduced. Thus, stabilization policies also affect initial *levels*. Welfare rankings are therefore not solely driven by long-run growth and volatility, and can be sensitive to parameters. To illustrate this point, we show that soft credit regimes can deliver higher overall welfare when innovation externalities are smaller than implied by our estimation strategy.

Finally, we study the optimal design of credit regimes. We begin with a benevolent government that can commit to a constant policy. Across the counterfactual economies, the optimal ex-ante allocation features no ex-post interventions: a policymaker with commitment would choose the hard credit regime. This naturally raises the question: if hard credit is welfare-dominant, why are soft credit arrangements so prevalent in advanced economies? To answer this question, we turn to a policymaker who chooses the extent of ex-post intervention under discretion, re-optimizing period by period without commitment to future policies. We find that, in each soft-credit economy, such a policymaker chooses on average more aggressive ex-post interventions than under our baseline calibrated allocation, yielding even larger welfare losses of around 4.2 to 5.2 percent relative to the hard credit economy. This exercise therefore provides an intuitive reason for the existence of soft credit regimes: in the absence of commitment, policymakers behave as if they were focused on short-term gains, since future policies will be re-optimized, leading them to favor saving distressed firms.

Related Literature. Our paper relates to an extensive literature at the intersection of innovation, growth, and corporate finance. Our main contribution to this literature is a

tractable framework that includes business cycles, financial intermediation, firm heterogeneity with default, and endogenous growth with innovation externalities. The model allows us to study welfare and policy in a fully specified dynamic general equilibrium setting, and we show how to leverage micro data to carefully calibrate the model to important empirical moments.

Starting with the literature on innovation and growth, Aghion and Howitt (1992) provide the canonical Schumpeterian model of creative destruction in which growth is driven by quality-improving innovations that arrive endogenously through R&D and destroy incumbents' rents. In subsequent work, Klette and Kortum (2004), Lentz and Mortensen (2008), and others take this framework closer to the data by matching firm-level facts on R&D, patents, productivity, growth, as well as entry and exit. What unites these and many other papers is that the pace of innovation is determined by how quickly newer products or firms replace older ones. In contrast, our mechanism rests on the idea that firms learn from each other, and that growth accelerates when low-productivity firms exit more frequently. In this sense, the direction of causality differs: the destruction of certain firms accelerates innovation in our framework, as opposed to the innovation by some firms leading to the destruction of others as in Aghion and Howitt (1992).

Building on these frameworks, several papers explore the interplay between finance and growth. For example, Aghion et al. (2010), Aghion, Howitt and Levine (2018), Celik (2023), and Ottonello and Winberry (2024) study the role of financial frictions for firm innovation and growth. While our framework incorporates financial frictions in the form of borrowing constraints and endogenous firm default, our focus is rather on the effects of ex-post interventions by lenders or governments to save firms in distress (Kornai, Maskin and Roland, 2003). This theme is shared by Aghion et al. (2025) who embed a soft budget constraint mechanism into a Schumpeterian growth model. They show that the reduction in interest expenses after the Great Financial Crisis can explain about 54% of the observed slowdown in French growth, as it crowded out the entry of skilled innovators. Compared to Aghion et al. (2025), (i) our modeling setup with heterogeneous firms and endogenous borrowing and default differs from their Schumpeterian setup, (ii) we incorporate productivity spillovers between firms, and (iii) we analyze the stabilization-vs.-growth trade-off of the various interventions we mention.

We also connect with the literature on the "cleansing effect of recessions," which holds the view that recessions intensify selection and reallocation by forcing low-productivity firms to contract or exit, potentially raising aggregate productivity due to an improved composition of surviving activity (Caballero and Hammour, 1994). However, subsequent work also argued that such a cleansing effect of downturns can be weakened if fewer

high-quality job matches are created or if job reallocation is reduced during recessions (Barlevy, 2002; Caballero and Hammour, 2005). We contribute to this literature by introducing a new mechanism for the cleansing view of recessions grounded in learning and imitation among firms, and we show how this mechanism can be muted by credit market interventions. Our main finding that credit market interventions can encourage the survival of less productive firms is also shared by Acemoglu et al. (2018) who show that broad R&D subsidies can have such effects.

Our analysis further relates to a long-standing question in macroeconomics: whether to prioritize business cycle stabilization or economic growth. Lucas (1987) famously showed that the welfare gains from reducing business cycle volatility are relatively small compared to the large gains from enhancing growth. While we arrive at the same conclusion, we start out quite differently: from a micro-founded model of firm heterogeneity and by posing the question whether distressed firms should be saved. Our approach reveals that stabilization policies not only have growth and volatility effects but also lead to differences in consumption levels on the transition, which matter for welfare rankings.

Turning to the empirical literature, a number of studies relate productivity gains to higher firm exit, consistent with our findings. For example, Bartelsman and Doms (2000) and Foster, Haltiwanger and Krizan (2001) highlight the importance of entry and exit for the aggregate economy, since they associate around a quarter of aggregate productivity growth with the exit and entry of firms. And, more recently, Adhami (2025) documents a positive relationship between industry productivity growth and firm exit rates.

Finally, we relate to an extensive literature that estimates rates of return to R&D investment and technology spillovers between firms. The most common approach starts with a production function that includes knowledge capital (see, e.g., Hall, Mairesse and Mohnen, 2010). Instead, we derive the relation between productivity growth and R&D from a cost function for R&D expenditures, and we find sizable effects based on our instrumental variable approach. Our empirical strategy also yields estimates for the speed of learning or technology adoption between firms, which complements earlier work by Bloom, Schankerman and Van Reenen (2013) on spillovers from R&D investment. Based on comparative statics, we highlight the importance of such knowledge spillovers for aggregate productivity and growth, a finding we share with Atkeson and Burstein (2019), Akcigit, Hanley and Stantcheva (2022), and Akcigit and Ates (2023).

2 Model

Time is discrete and infinite, $t = 0, 1, \ldots$. The economy consists of three types of agents: (i) a unit mass of firms that are heterogeneous within each period, (ii) a unit mass of lenders, each matched one-to-one with a firm, and (iii) a representative household that supplies labor, deposits with financial intermediaries, and ultimately owns all financial claims in the economy. Two central features characterize the model: (i) the institutional arrangement governing the lender-borrower relationship, which can give rise to ex-post interventions in equilibrium; and (ii) endogenous firm innovation decisions, which determine future productivity and economic growth.

2.1 Firms

Technology. Firms produce using a decreasing returns-to-scale production function

$$y = a^{1-\eta}(\zeta k)^{\alpha} n^{\eta}, \tag{1}$$

where y denotes output, k is physical capital that depreciates at rate δ, ζ is an aggregate capital quality shock (as in Brunnermeier and Sannikov, 2014, for example), and n is labor. Firm-level productivity is given by $a = z\varepsilon$, where z represents fundamental productivity, which reflects firms' accumulated technological knowledge, and ε is an i.i.d. shock across firms and time drawn from a distribution $F[0, \infty)$. Fundamental productivity evolves through costly R&D investment, where the next period z' is chosen subject to a cost

$$\phi \times \left(\frac{z'}{z^{1-\rho}(a^*)^{\rho}} \right)^{\kappa}, \tag{2}$$

with ϕ denoting the level costs of R&D.[1] The parameter κ governs the curvature of R&D costs, and a^* is the average productivity of operating firms, that is, the average product of the fundamental and idiosyncratic component for firms that produced this period.

The term a^* introduces a spillover effect in innovation. Higher average productivity for operating firms reduces R&D costs through a learning externality parameterized by $\rho \in [0, 1]$. This relates to the literature on learning, imitation, and growth, where the relative costs of innovation are tied to the productivity of other agents in the economy. Our setup is closest to Monge-Naranjo (2019), following a large tradition that emphasizes

[1] The choice of future productivity subject to a cost is found, for example, in Greenwood, Han and Sánchez (2022) or Vereshchagina (2023). We assume that level costs scale with a measure of productivity; this is necessary for the existence of a balanced growth path as further explained in Section 2.6.

the importance of knowledge spillovers for economic growth (Jovanovic and MacDonald, 1994; Luttmer, 2007; Lucas, 2009; Perla and Tonetti, 2014; Lucas and Moll, 2014; Hopenhayn and Shi, 2020). Firms observe their own z and ε separately: while the latter affects production, it is not taken into consideration for investments going forward. However, firms cannot disentangle fundamental and idiosyncratic productivity of other firms, and only observe their realized productivity a. Thus, the cost of R&D does not depend on ε of the firm itself but on the average ε^*, as $a^* = Z\varepsilon^*$, where Z is the aggregate level of fundamental productivity. When $\rho = 0$, innovation is independent from average idiosyncratic productivity and depends only on internal factors, while it depends only on average (external) economy-wide productivity when $\rho = 1$.

Financial Frictions. Firms borrow in two types of debt: intraperiod debt ℓ and interperiod debt b. Intraperiod debt is risk-free and used to satisfy a working capital constraint on total payroll expenses (as in Christiano, Eichenbaum and Evans, 2005, for example):

$$\ell \geq wn. \tag{3}$$

Firms borrow and repay this loan in the same period, at the gross interest rate $1 + i$.

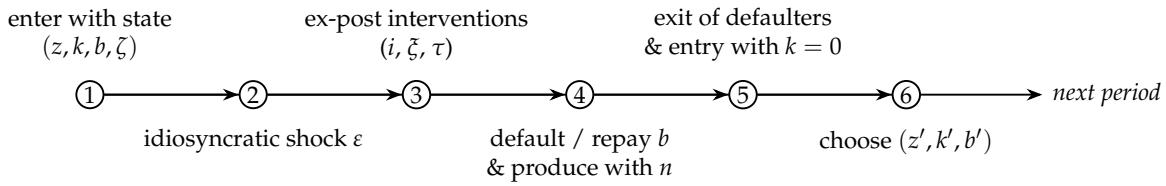
Interperiod debt finances physical capital and R&D investments. Firms borrow qb', and repay b' in the next period, where q^{-1} is the interest rate on interperiod debt. Borrowing in interperiod debt is subject to a collateral constraint defined over physical capital:

$$b' \leq \theta k'. \tag{4}$$

Finally, firms have limited liability and may default on interperiod debt and exit. This occurs at the beginning of each period after aggregate and idiosyncratic shocks are realized but before production takes place. In case of default, creditors recover a fraction of the firm's capital stock $(1 - \lambda)\zeta' k'$, where λ represents the fraction that is lost in default.

Interventions. Our model baseline is called the *hard credit economy* (HC) and is characterized by the absence of ex-post interventions that may support firms in distress. We compare this benchmark to three soft-credit (SC) economies that each feature a different type of ex-post intervention: (i) the *evergreening economy*, where lenders may offer favorable interest rates on intraperiod debt i to distressed firms, (ii) the *restructuring economy*, where lenders can write off a fraction ξ of a firm's legacy debt b, and (iii) the *guarantee economy*, where the fiscal authority deploys credit guarantees τ to save distressed firms.

Figure 1: Intraperiod timing of firm decisions and shocks.



Timing. The model setup is such that, in equilibrium, all firms choose the same state variables across periods—capital, interperiod debt, and fundamental productivity—but may differ within a period. The exact timing assumptions are summarized in Figure 1.

Firms enter the period with endogenous states and a realization of the capital quality shock, $s \equiv (z, k, b, \zeta)$. At the beginning of each period, firms are hit with a purely idiosyncratic productivity shock $\varepsilon \sim F$. Additionally, they need to take on an intraperiod loan to finance labor hiring. Depending on the terms of this intraperiod loan and potential ex-post interventions by policymakers and lenders, they may choose to default on their interperiod debt and exit. If they choose not to exit and repay their debt b, firms hire labor n at wage rate w to produce subject to the working capital constraint (3). Exiting firms are replaced by entrants with zero capital who do not produce in their period of entry.[2] Surviving firms and entrants choose (z', k', b') subject to the collateral constraint (4).

These timing assumptions generate intraperiod heterogeneity, but this heterogeneity does not carry over to the point when firms undertake dynamic decisions. Thus, the model ensures aggregation and identical choices (z', k', b') as all firms enter the period with the same s. This setup is similar to that of Gomes, Jermann and Schmid (2016). Although the assumption that firm-level productivity is i.i.d. is stark, it keeps the dimensionality of the state space manageable. In previous work (Faria-e-Castro, Paul and Sánchez, 2024), we developed a model of evergreening and industry dynamics with persistent firm-level productivity. The complexity of that framework, however, makes it impractical to extend it simultaneously to incorporate endogenous growth, aggregate shocks, and optimal policy.

Value Functions. The firm takes as given the following objects, determined by the aggregate state S, the firm's individual state s, and the idiosyncratic shock ε: the intraperiod rate $i(s, \varepsilon; S)$, the interperiod price of debt $q(s, S)$, the share of debt write-off $\xi(s, \varepsilon; S)$, the transfer $\tau(s, \varepsilon; S)$, the wage $w(S)$, the average productivity $a^*(S)$, the representative

[2] The model can be extended to account for endogenous entry, by including a free-entry condition. The main qualitative results of the model remain unchanged, but this version of the model adds an extra state variable (the mass of firms) which makes solving the model more burdensome.

household's stochastic discount factor $M(S)$, and the law of motion for the aggregate state, $S' = \Pi(S)$. To simplify notation, we suppress the dependence of these objects on the aggregate state S and on its transition $S' = \Pi(S)$. In equilibrium, all firms make identical choices, so the individual state coincides with the aggregate state, $s = S$. The value of the firm at the beginning of the period, after the idiosyncratic shock ε is realized, is

$$V_0(s, \varepsilon) = \max\{0,\, V^p(s, \varepsilon)\},$$

where 0 is the normalized value of default and exit, and V^p denotes the value of repaying interperiod debt b and continuing production. This continuation value is given by:

$$V^p(s, \varepsilon) = \max_{n,\ell} \; (z\varepsilon)^{1-\eta}(\zeta k)^{\alpha} n^{\eta} - wn + \ell - (1+i)\ell - b(1-\xi) + (1-\delta)\zeta k - \nu + \tau + V_1(s)$$
$$\text{s.t.} \qquad \ell \geq wn.$$

The firm produces and sells output y, hires labor at cost wn, takes on a working-capital loan ℓ, and repays it with interest $(1+i)\ell$. It also repays legacy debt $b(1-\xi)$, sells the undepreciated portion of capital $(1-\delta)\zeta k$, incurs the fixed operating cost ν, and may receive a transfer τ if it benefits from a credit guarantee. All profits are paid immediately as dividends to the representative household, and there are no costs of issuing equity.

Finally, the continuation value $V_1(s)$ of the firm is

$$V_1(s) = \max_{z', k', b'} \; -\phi \left(\frac{z'}{z^{1-\rho}(a^*)^{\rho}} \right)^{\kappa} - k' + qb' + \mathbb{E}_{\zeta', \varepsilon'}[\, M \cdot \, V_0(s', \varepsilon')\,] \tag{5}$$
$$\text{s.t.} \quad b' \leq \theta k'.$$

The firm chooses next period's productivity z' through R&D investment, accumulates capital k', and selects its debt position b' subject to a collateral constraint. Future value depends on next period's state (s', ε') and is discounted using the household's stochastic discount factor, M.

Solution to Intraperiod Problem. To solve the firm's problem, it is helpful to begin with the static decisions on labor and intratemporal debt. We assume that the working capital constraint always binds.[3] Setting $\ell = wn$, the static decision on labor yields an optimal

[3] This is guaranteed as long as $i \geq 0$. As we show later, $i < 0$ can arise in equilibrium, which requires us to impose this assumption to prevent unbounded borrowing.

labor choice and an expression for sales minus labor costs:

$$n(z,k,\varepsilon,i) = z\varepsilon\left[\frac{\eta(\zeta k)^{\alpha}}{w(1+i)}\right]^{\frac{1}{1-\eta}}$$

$$\Rightarrow \quad (z\varepsilon)^{1-\eta}(\zeta k)^{\alpha}n^{\eta} - wn(1+i) = z\varepsilon(\zeta k)^{\frac{\alpha}{1-\eta}}\left[\frac{\eta}{w(1+i)}\right]^{\frac{\eta}{1-\eta}}(1-\eta) \equiv z\varepsilon\,\pi(k,\zeta,i).$$

Given this expression, we can characterize the default decision as a threshold rule. A firm defaults if and only if $\varepsilon < \bar{\varepsilon}$, where the threshold value solves $V^p(s,\bar{\varepsilon}) = 0$ and is given by

$$\bar{\varepsilon}(s,i,\xi,\tau) = \frac{b(1-\xi) - (1-\delta)\zeta k + \nu - \tau - V_1(s)}{z\,\pi(k,\zeta,i)}. \tag{6}$$

We refer to this object as the *distress threshold*, and it plays an important role for the various economies we analyze.

2.2 Lenders

Each firm is matched with a risk-neutral lender. To fund interperiod lending, lenders raise deposits from households. For intraperiod lending, they have access to technology that allows them to raise funds at a linear cost of ω; we assume these are not true resource costs but are directly rebated to the representative household. Following the notation above, we denote by W_0 the lender's value at the beginning of the period when choosing intraperiod loan terms, and by W_1 the lender's value at the end of the period when making dynamic decisions. We assume free entry of lenders at both stages of lending.

Interperiod Problem. The dynamic problem for interperiod lending is given by

$$W_1(s) = \max_{q,d'} \mathbb{E}_{\zeta',\varepsilon'}\{\, M \cdot [\, W_0(s',\varepsilon') - d' \,]\,\}$$
$$\text{s.t.} \qquad qb' \leq Q^d d'.$$

The lender maximizes its discounted future profits, which equal the expected payoff from the intraperiod stage minus the repayment of deposits. The lender chooses the price of interperiod debt q and the amount of deposits d' to be raised. We assume that lenders hold no capital, so all lending must be fully deposit-funded. For simplicity, we also assume that the lender cannot commit to q when offering i, and vice versa.

In equilibrium, the funding constraint binds, $d' = qb'/Q^d$. Free entry of lenders at the

interperiod lending stage implies that expected lender profits must be zero:

$$W_1(s) = 0 \quad \Rightarrow \quad q = \frac{\mathbb{E}_{\zeta',\varepsilon'}\{ M \cdot W_0(s',\varepsilon') \}}{b'}. \tag{7}$$

where we use the fact that $Q^d = \mathbb{E}(M)$, which we show later. This condition simplifies the intraperiod lending problem below, which becomes static once we impose $W_1(s) = 0$.

Intraperiod Problem. Lenders offer the intraperiod interest rate i and the debt write-off ξ after the idiosyncratic productivity ε is observed, but before the firm chooses to default on interperiod debt b. This timing assumption creates incentives to evergreen or restructure debt.[4] Lenders may choose to influence the firm's default decision to recover b. Intuitively, a lender may prefer this option to recovering the capital stock at $(1-\lambda)\,\zeta k$, as it yields a higher overall payoff. Lenders make take-it-or-leave-it offers which depend on ε. The problem for a lender at the intraperiod stage is

$$W_0(s,\varepsilon) = \max_{i\in[i^{reg},\omega],\,\xi\in[0,\xi^{reg}]} \overbrace{\mathbf{1}[\varepsilon \geq \bar{\varepsilon}(s,i,\xi,\tau)]\{\, b(1-\xi) + (i-\omega)w\, n(z,k,\varepsilon,i) + W_1(s)\}}^{\text{Repayment}} \tag{8}$$

$$+\ \underbrace{\mathbf{1}[\varepsilon < \bar{\varepsilon}(s,i,\xi,\tau)](1-\lambda)\,\zeta k}_{\text{Default}}.$$

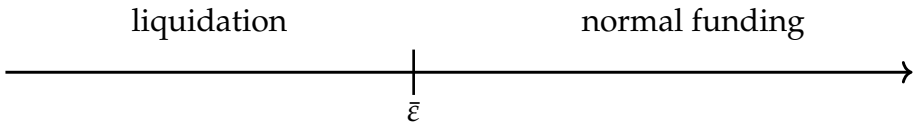
We assume the firm is free to seek a new intraperiod lender and borrow at ω, which constrains the feasible set for the incumbent bank to be $i \leq \omega$. In (8), i^{reg} is an exogenous lower bound for the interest rate that the lender is allowed to charge and ξ^{reg} is the maximum amount of debt write-off. Such limits may exist for institutional or regulatory reasons, and we treat these limits as parameters for now. Later on, we consider how a benevolent policymaker chooses these limits without commitment.

The hard credit economy features $i^{reg} = \omega$, $\xi^{reg} = 0$, and $\tau^{reg} = 0$, defined accordingly. Relative to this benchmark, the evergreening economy allows for $i^{reg} < \omega$, the restructuring economy permits $\xi^{reg} > 0$, and the guarantee economy features transfers up to $\tau^{reg} > 0$. Thus, the parameters $(i^{reg}, \xi^{reg}, \tau^{reg})$ govern the strength of the ex-post interventions in the various economies. Note that, while we define the general intraperiod problem for a lender in (8), we consider only one type of intervention at a time.

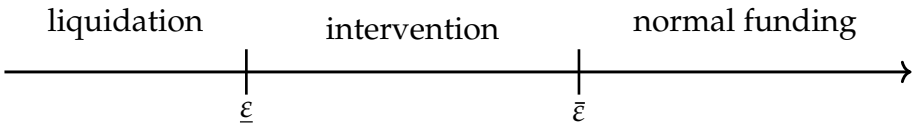
[4] The timing assumption is similar to the one in Faria-e-Castro, Paul and Sánchez (2024), with the difference that lenders offer interest rates on new interperiod debt in that setting.

Figure 2: Structure of intraperiod equilibria under hard and soft credit.

(a) **Intraperiod equilibrium under hard credit.**



(b) **Intraperiod equilibrium under soft credit.**



2.3 Intraperiod Lending Equilibrium

We next characterize the intraperiod equilibrium in the various economies according to realizations of the idiosyncratic shock ε.

Hard Credit Economy. In the hard credit economy, we can express the firm's default decision by evaluating (6) at $i = \omega$, $\xi^{reg} = 0$, and $\tau^{reg} = 0$, giving the default threshold $\bar{\varepsilon}(s, \omega, 0, 0)$. Firms with $\varepsilon \geq \bar{\varepsilon}(s)$ are able to borrow at $i = \omega$, while firms with $\varepsilon < \bar{\varepsilon}(s)$ default and exit. The structure of the intraperiod equilibrium is illustrated in Figure 2a.

Evergreening Economy. In the evergreening economy, we allow lenders to condition their offer of i on the firm's state (s, ε), but free entry of lenders implies that $i \leq \omega$. Since we focus on one soft-credit mechanism at a time, we set $\xi = \tau = 0$ and write $\bar{\varepsilon}(s, i, 0, 0)$ simply as $\bar{\varepsilon}(s, i)$. Given these conditions, we can rewrite the intraperiod problem (8) as

$$W_0(s, \varepsilon) = \max_{i \in [i^{reg}, \omega]} (1 - \lambda)\zeta k + \mathbf{1}[\varepsilon \geq \bar{\varepsilon}(s, i)] \underbrace{\left\{ b - (1 - \lambda)\zeta k + (i - \omega) w\, n(z, k, \varepsilon, i) \right\}}_{\equiv \widetilde{W}_0(s, \varepsilon, i)}.$$

Importantly, the lender internalizes that the distress threshold $\bar{\varepsilon}(s, i)$ depends on i. The following proposition characterizes the intraperiod equilibrium under evergreening:

Proposition 1. *Let the liquidation threshold for the evergreening economy be given by:*

$$\underline{\varepsilon}_z(s) = \max \left\{ \tilde{\underline{\varepsilon}}_z(s), \bar{\varepsilon}(s, i^{reg}) \right\}, \tag{9}$$

where $\tilde{\underline{\varepsilon}}_z(s)$ is the ε that solves $\widetilde{W}_0(s, \varepsilon, i^{max}) = 0$ with i^{max} being implicitly determined by $V^P(s, i^{max}, \varepsilon) = 0$. The intraperiod equilibrium is then characterized as:

1. *if* $\varepsilon \geq \bar{\varepsilon}(s)$, *the firm borrows at the competitive rate* $i = \omega$.

2. *if* $\varepsilon \in [\underline{\varepsilon}_z(s), \bar{\varepsilon}(s))$, *the lender evergreens the firm's debt and* $i < \omega$.

3. *if* $\varepsilon < \underline{\varepsilon}_z(s)$, *the firm is liquidated.*

An evergreening region exists if and only if $\omega > i^{reg}$ *and* $b > (1-\lambda)\zeta k$.

The proof is in Appendix A.1. Figure 2b illustrates the common structure of the intraperiod equilibrium under the different soft credit regimes. When ε is sufficiently high, above $\bar{\varepsilon}$, the firm funds itself at the competitive rate $i = \omega$. If $\varepsilon \in [\underline{\varepsilon}_z(s), \bar{\varepsilon}(s))$, it is optimal for the lender to offer $i < \omega$ such that the firm is indifferent between exiting or not with $V^p(s, \varepsilon, i) = 0$.[5] While the lender makes a loss on the intraperiod lending contract, this loss is smaller than the difference between the value of debt repayment and the default recovery value. The threshold for the liquidation region $\underline{\varepsilon}_z(s)$ in (9) is either determined by the exogenous lower bound i^{reg} with $\bar{\varepsilon}(s, i^{reg})$ or by the point $\tilde{\underline{\varepsilon}}_z(s)$ at which the lender's benefit to evergreening $\widetilde{W}_0 = 0$ and the firm is indifferent to defaulting $V^p = 0$. For sufficiently low ε below $\underline{\varepsilon}_z(s)$, the interest rate i that would ensure repayment needs to be so low that the lender rather prefers to liquidate the firm. Appendix Figure 9 illustrates the intraperiod equilibrium under evergreening.

One important consequence of evergreening is that the choice of i affects the amount of labor the firm hires. To the extent that some firms that would otherwise default are now supported by evergreening, total demand for labor expands, all else constant. Moreover, not only total labor demand but also its distribution changes. Firms that have lower levels of productivity benefit from lower interest rates and thus demand relatively more labor. Evergreening is therefore a source of static misallocation.

Restructuring Economy. We now consider the case in which lenders are allowed to write off a fraction $\xi(s, \varepsilon) \in [0, 1]$ of outstanding firm debt b. As in the evergreening economy, lenders may find it optimal to restructure debt ex-post whenever the recovered value under restructuring exceeds that obtained through liquidation. We again impose a limit ξ^{reg} on the extent of intervention, requiring $\xi(s, \varepsilon) \leq \xi^{reg}$.The proposition below characterizes the intraperiod equilibrium:

[5] We assume that firms are indifferent between exiting and continuing to operate in the evergreening region, which ensures that firm value is weakly increasing in productivity. If firms instead retained part of the surplus in this region, a firm with productivity just below the distress threshold could have a higher value than one just above it.

Proposition 2. *Let the liquidation threshold for the restructuring economy be given by*

$$\underline{\varepsilon}_x = \bar{\varepsilon}\big(s, \omega, \min(\xi^{\max}, \xi^{reg}), 0\big),$$

where $\xi^{\max}$ is the maximum haircut the bank is willing to offer, which is given by

$$\xi^{\max}(k, b, \zeta) = 1 - \min\left\{\frac{(1-\lambda)\zeta k}{b}, 1\right\}.$$

The intraperiod equilibrium can then be characterized by three regions for ε:

1. *if $\varepsilon \geq \bar{\varepsilon}(s)$, the firm receives normal funding and no restructuring occurs;*
2. *if $\varepsilon \in [\,\underline{\varepsilon}_x(s), \bar{\varepsilon}(s)\,)$, the firm's debt is restructured, $\xi > 0$;*
3. *if $\varepsilon < \underline{\varepsilon}_x(s)$, restructuring is not feasible and the firm is liquidated.*

The proof and a graphical illustration is again left to Appendix A.1. The equilibrium follows the same structure as in Figure 2b. For intermediate levels of ε, the lender offers a haircut that generates a higher repayment than default recovery, and it is therefore optimal to restructure. One key difference is that restructuring does not distort the intraperiod lending rate and, in turn, the labor demand decision.

Guarantee Economy. Finally, we consider the case where a fiscal authority issues transfers to support businesses in distress, thereby implicitly offering loan guarantees. These transfers are financed with non-distortionary lump-sum taxes on households. Such a program resembles interventions at the onset of the COVID-19 pandemic, such as the Paycheck Protection Program (PPP). However, an important difference is that we consider an intervention that is directly targeted at firms in financial distress, with an amount just large enough to save a firm from default, and that occurs even outside of recessions.

We assume that firms in distress are eligible to receive a transfer that may depend on their own states, $\tau(s, \varepsilon)$. The size of the transfer is such that firms are indifferent between continuing and defaulting, with an upper bound τ^{reg} per firm. That is, the transfer is just large enough for the firm to repay the interperiod debt. Similar to the previous economies, firms outside of distress with $\varepsilon > \bar{\varepsilon}(s)$ are not eligible for transfers. The following proposition characterizes the equilibrium:

Proposition 3. *Let the liquidation threshold for the guarantee economy be given by*

$$\underline{\varepsilon}_\tau = \bar{\varepsilon}(s, \omega, 0, \tau^{reg}).$$

The intraperiod equilibrium can then be characterized by three regions for ε, which again follow the same general structure depicted in Figure 2b:

1. *if $\varepsilon \geq \bar{\varepsilon}(s)$, firms survive and receive no transfers;*
2. *if $\varepsilon \in [\underline{\varepsilon}_\tau(s), \bar{\varepsilon}(s))$, firms receive fiscal support and fully repay their debt;*
3. *if $\varepsilon < \underline{\varepsilon}_\tau(s)$, the firm cannot survive without a transfer larger than the limit and therefore exits (without receiving a transfer).*

See Appendix A.1 for details and a graphical illustration.

Dynamic Decisions. The full intraperiod equilibrium conditions and the dynamic decisions of lenders and firms are stated in Appendices A.2 and A.3. Importantly, when choosing investment, innovation, and debt, the firm does not internalize any future states in which it is distressed, $\varepsilon' < \bar{\varepsilon}(s')$, even if it survives through evergreening, restructuring, or fiscal support. That is because in these states, the firm is indifferent to defaulting and its value function is therefore equal to zero.[6]

2.4 Households

The representative household has preferences over consumption and labor as in King, Plosser and Rebelo (1988). Utility, in sequential form, is:

$$\mathcal{U} = \mathbb{E}_0 \sum_{t=0}^{\infty} (\beta)^t \frac{C_t^{1-\sigma} \left[1 + (\sigma - 1) \frac{N_t^{1+\varphi}}{1+\varphi}\right]^{\sigma}}{1-\sigma}, \tag{10}$$

where σ is the inverse elasticity of intertemporal substitution and φ is the inverse Frisch elasticity. As discussed below, the model features balanced growth, which constrains the class of utility functions we can use. Importantly for our purposes, King, Plosser and Rebelo (1988) preferences are consistent with balanced growth and stable hours worked along the balanced growth path.[7] The household supplies labor and bank deposits, and is

[6] We can further show that the firm's borrowing constraint (5) always binds. To see this, combine the price of intertemporal debt in (24) with the firm's first-order condition for debt in (22). Since the firm and the lender share the same stochastic discount factor, the expected repayment cancels out, leaving a strictly positive expected recovery term, which implies a positive Lagrange multiplier on the borrowing constraint.

[7] Flow utility becomes equal to $\log C_t - N_t^{1+\varphi}/(1+\varphi)$ in the limit $\sigma \to 1$. This is the only separable utility function over consumption and hours that is consistent with balanced growth and does not require a trend for the disutility of labor. See Boppart and Krusell (2020) for an extended discussion.

the ultimate owner of all financial claims in the economy, receiving net profits from both firms and financial intermediaries. The household's period budget constraint is given by

$$C + Q^d D' = wN + D + \Psi - T,$$

where Ψ are net transfers from firms and financial intermediaries, and T are lump-sum taxes. We assume that the government runs a balanced budget, and so T equals total expenditures with credit guarantees. The household problem yields two optimality conditions: a labor supply condition and an Euler equation, given by

$$\sigma C N^{\varphi} = w \left[1 + (\sigma - 1)\frac{N^{1+\varphi}}{1+\varphi}\right],$$
$$Q^d = \mathbb{E}\left\{\beta \frac{\left[1 + (\sigma - 1)\frac{(N')^{1+\varphi}}{1+\varphi}\right]^{\sigma}(C')^{-\sigma}}{\left[1 + (\sigma - 1)\frac{N^{1+\varphi}}{1+\varphi}\right]^{\sigma}(C)^{-\sigma}}\right\} \equiv \mathbb{E}(M).$$

2.5 Aggregate Resource Constraint

Next, we derive the aggregate resource constraint. The joint intraperiod payoff for a firm-bank pair is given by:

$$(z\varepsilon)^{1-\eta}(\zeta k)^{\alpha} n^{\eta} - (1+\omega)wn + (1-\delta)\zeta k - \nu + \tau. \tag{11}$$

Liquidated firms yield a joint payoff equal to $(1-\lambda)\zeta k$. Let Λ denote aggregate joint payoffs plus labor income. We can write this term as:

$$\Lambda = \int_{\underline{\varepsilon}(s)}^{\infty}\left[(z\varepsilon)^{1-\eta}(\zeta k)^{\alpha} n^{\eta} - (1+\omega)wn + (1-\delta)\zeta k - \nu + \tau\right] \mathrm{d}F(\varepsilon)$$
$$+ \int_{0}^{\underline{\varepsilon}(s)} (1-\lambda)\zeta k \,\mathrm{d}F(\varepsilon) + (1+\omega)wN.$$

Total income to the household from labor and net transfers from the banking and corporate sectors is thus given by:

$$\Lambda + Q^d D' - D - K' - \phi\left[\frac{z'}{z(\varepsilon^*)^{\rho}}\right]^{\kappa} - T.$$

The aggregate resource constraint is obtained by combining this constraint with the household's budget constraint, and the government's balanced budget constraint, yielding:

$$C + K' + \phi \left[\frac{z'}{z(\varepsilon^*)^\rho} \right]^\kappa = \Lambda - T.$$

Consumption plus aggregate investment in physical capital and R&D equals labor earnings plus total net transfers from the corporate and financial sectors.

2.6 Balanced Growth Path

We define a competitive equilibrium in Appendix A.4. Under suitable parameter restrictions, a balanced growth path exists with detrending factor $z_t^{\frac{1-\eta}{1-\alpha}}$. We express all equilibrium conditions in terms of detrended variables $x_t = \tilde{x}_t \cdot z_t^{\frac{1-\eta}{1-\alpha}}$ and we assume that both the fixed cost paid by firms and the level cost of R&D grow at the same rate as the rest of the economy, thus $\nu = \tilde{\nu} \cdot z_t^{\frac{1-\eta}{1-\alpha}}$ and $\phi = \tilde{\phi} \cdot z_t^{\frac{1-\eta}{1-\alpha}}$. Letting $G_z \equiv z_{t+1}/z_t$ denote the growth rate of the common component of productivity, the growth rate of all real quantities in the economy—including output—equals $G_z^{\frac{1-\eta}{1-\alpha}}$. The complete set of detrended equilibrium conditions is provided in Appendix A.5.

An expression for the gross rate of productivity growth G_z can be obtained by rewriting the firms' dynamic decision (23), shown in Appendix A.3, in its detrended form as:

$$\frac{z'}{z} = (\varepsilon^*)^{\frac{\rho\kappa(1-\alpha)}{\kappa(1-\alpha)-(1-\eta)}} \times \left\{ \frac{\mathbb{E}[M \cdot \int_{\bar{\varepsilon}(s')}^{\infty} \frac{\partial V_0(s',\varepsilon')}{\partial z'} \mathrm{d}F(\varepsilon')]}{\kappa\tilde{\phi}} \right\}^{\frac{(1-\alpha)}{\kappa(1-\alpha)-(1-\eta)}} \equiv G_z, \tag{12}$$

where

$$\frac{\partial V_0(s',\varepsilon')}{\partial z'} = \varepsilon'(\zeta'\tilde{k}')^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}'(1+\omega)} \right]^{\frac{\eta}{1-\eta}} (1-\eta) + (1-\rho)\kappa\tilde{\phi} \left[\frac{G_z'}{(\varepsilon^{*\prime})^\rho} \right]^\kappa.$$

Expression (12) shows the growth rate of the common productivity component is the product of two terms. The first is a function of the average productivity of incumbents, ε^*, and highlights the key role of the innovation externality, governed by the parameter ρ: the more productive the surviving firms, the faster the common component of productivity grows. The second term reflects the private benefits of innovation relative to its costs. These benefits include the marginal profit from an extra unit of z', as well as the perceived reduction in the future cost of innovation, of which the firm privately internalizes only a

fraction, $1-\rho$. Importantly, the benefits are only internalized in states of the world where $\varepsilon' \geq \bar{\varepsilon}(s')$. Thus, an expansion of the evergreening, restructuring, or transfer region that is associated with an increase in the distress threshold $\bar{\varepsilon}(s)$ can result in lower incentives to invest in R&D.

Equation (12) demonstrates that as long as there is an innovation externality, $\rho > 0$, the productivity of current incumbents directly impacts the growth rate of the economy. This resonates with the literature on creative destruction and imitation. For example, in Aghion and Howitt (1992), new entrants innovate over incumbent technology at fixed steps. In Perla and Tonetti (2014), firms learn from each other in equilibrium. With such relations, the average productivity of incumbents generates externalities that affect economy-wide productivity.

2.7 Key Frictions and Policy Counterfactuals

The model features four main inefficiencies from the perspective of a planner who maximizes household welfare subject only to technological constraints. We briefly summarize each of these distortions in turn.

Learning Externalities. The first inefficiency arises from the learning externalities governed by ρ. An unconstrained planner would internalize two effects that individual firms neglect. First, innovation undertaken today reduces the future cost of innovation one-for-one, rather than only by the private factor $1-\rho$. Second, the planner internalizes the dynamic selection margin embedded in average productivity ε^*. The first channel suggests that firms underinvest in R&D. The second implies that firm exit, and therefore the extent of selection, may also be inefficient.

Input Congestion. The second inefficiency is related to congestion in input markets. This externality, emphasized by Caballero, Hoshi and Kashyap (2008), operates through factor prices. When more firms survive under soft credit regimes, labor demand rises, putting upward pressure on wages. Higher wages, in turn, lower profits, which has two effects: (i) lower incentives to invest, and (ii) raise liquidation thresholds, which may improve selection. At the same time, firm exit is itself socially costly: exiting firms have already invested, yet their capital is no longer used in production, and it depreciates at rate λ, which we assume exceeds δ. Exit therefore generates both idle capital and additional depreciation losses.

Default. The third inefficiency arises due to limited liability and costly default (Cooley and Quadrini, 2001). Limited liability implies that firms do not fully internalize payoffs in states in which they default, or in which ex-post interventions prevent default by setting their payoff to zero. Because firms internalize returns only in a subset of states, they invest too little in both physical capital and R&D. This mechanism can also be interpreted through the lens of debt overhang: when firms understand that part of the return to current investment will accrue to lenders in future states, they optimally scale back investment in capital and R&D.

Borrowing Constraints. The fourth inefficiency stems from the borrowing constraints. First, the working capital constraint distorts firms' labor choices. More importantly, however, the intertemporal borrowing distorts the composition of investment away from R&D and toward physical capital, as firms have an incentive to tilt investment toward assets that are pledgeable and expand borrowing capacity. From the standpoint of an unconstrained planner, for whom financing constraints are irrelevant, this creates an inefficient composition effect: firms invest too much in physical capital and too little in R&D.

Given these various frictions, we tightly calibrate the model to important empirical moments and conduct policy counterfactuals within this environment. Rather than directed at the specific frictions themselves, the policy experiments resemble interventions of lenders and governments in practice that are targeted to save distressed firms. Our framework allows us to quantitatively assess these interventions and therefore evaluate their macroeconomic effects.[8]

3 Calibration and Solution

In this section, we describe our strategy for calibrating the model to annual U.S. data and the method we use to solve the model. Our framework encompasses a series of parameters that are standard in the macro-finance literature but a few parameters that are unique to our model. For this reason, we adopt a multi-step approach. First, we directly estimate the parameters governing the innovation cost function (2), κ and ρ, by combining theoretical relations derived from the model with firm-level micro data. Second, we externally calibrate parameters that are standard in the literature, or that have obvious counterparts

[8]The first-best allocation would reduce firm exit and significantly increase R&D investment to raise the economy's growth rate. This allocation, however, requires large equity injections to sustain low-productivity firms with negative profits, making it quantitatively unrealistic.

in the data. Finally, we jointly calibrate all remaining parameters to match a series of empirical targets. Next, we describe these three steps in more detail.

3.1 Direct Estimation

To obtain estimates for ρ and κ, we start from the R&D investment cost function (2). To take this equation to the data, we rewrite the expression with time-, industry-, and firm-specific subscripts as

$$R\&D_{i,s,t} = \phi_t \left(\frac{z_{i,s,t+1}}{z_{i,s,t}^{1-\rho} (a_{i,s,t}^*)^{\rho}} \right)^{\kappa}, \tag{13}$$

where we associate the productivity and R&D costs with firms denoted by subscript i. We assume for now that the scale ϕ_t has the same time trend for all firms, whereas firms learn from the industry-specific average productivity a^* that is specific to their industry s, and we vary both restrictions below.[9] Taking logs and rearranging (13) yields the equation

$$\log z_{i,s,t+1} - \log z_{i,s,t} = \frac{1}{\kappa} \cdot (\log R\&D_{i,s,t} - \log \phi_t) + \rho \cdot \log \frac{a_{i,s,t}^*}{z_{i,s,t}}. \tag{14}$$

We transform this expression into a regression specification by using time fixed effects χ_t to absorb the time trend ϕ_t, predetermined values for the productivity terms to align those with the timing in the model, and by allowing for random variation $u_{i,s,t}$

$$\log z_{i,s,t+1} - \log z_{i,s,t-1} = \chi_t + \beta_1 \cdot \log R\&D_{i,s,t} + \beta_2 \cdot \log \frac{a_{i,s,t-1}^*}{z_{i,s,t-1}} + u_{i,s,t}, \tag{15}$$

where β_1 corresponds to $(1/\kappa)$ and β_2 to ρ, which measure the elasticity of firm productivity growth to log-variation of firm R&D expenses and the log-differences between a firm's peers' productivity relative to its own.

When estimating this regression on firm micro data, we would be concerned about the possible endogeneity of $\log R\&D_{i,s,t}$. For example, young firms may conduct less R&D since they have less skilled labor for such purposes at the beginning of their life. At the same time, younger firms exhibit higher productivity growth, leading to biased estimates of β_1 when firm age is omitted from the regression.

To address the possible endogeneity of $\log R\&D_{i,s,t}$, we proceed with an instrumental variable approach. As an instrument, we use state-level R&D tax credit rates following

[9] When computing a^*, we omit a firm's own value, such that a^* is specific to firm i.

Wilson (2009) and Bloom, Schankerman and Van Reenen (2013).[10] For the various regression specifications considered below, we find that firms headquartered in states with higher R&D tax credits report more R&D expenses, and that the instrument passes typical tests for weak instruments with first-stage F-statistics close to 20.

In contrast, the possible endogeneity of $\log(a^*_{i,s,t-1}/z_{i,s,t-1})$ is less central to our analysis since the associated coefficient simply measures the pace of convergence if ex-ante productivity levels diverge. To continue the example above: younger firms may have lower productivity levels than their peers, while they show higher productivity growth, leading us to find $\beta_2 > 0$, which measures the pace at which younger firms catch up. Thus, the age of the firm can explain why firms converge and we do not need to control for it in our regression. More importantly, we interpret such convergence as resulting from learning. Younger firms learn from their peers and *therefore* have relatively faster productivity growth. While we interpret learning as a broad mechanism underlying productivity convergence, Section 6 examines the robustness of our main results to alternative values of ρ. We also show that our baseline calibration of ρ generates joint dynamics of firm exit and productivity that align more closely with the data than those produced by a model without innovation externalities ($\rho = 0$).

Data and TFP Estimation. We use annual firm data from S&P's Compustat database for publicly-traded corporations for the years 1982-2023.[11] We compute a firm's capital stock based on the perpetual inventory method as in Ottonello and Winberry (2020) and deflate the values using the nonresidential fixed investment good deflator from the NIPA tables. All other nominal variables are deflated using the GDP deflator. Given these data, and assuming a Cobb-Douglas production function of the form (1), we estimate the following regression

$$\log(\text{value added}_{i,t}) = \alpha + \beta_{1,s} \cdot \log(\text{capital}_{i,t-1}) + \beta_{2,s} \cdot \log(\text{employees}_{i,t}) + u_{i,t}, \quad (16)$$

[10] We use the updated data provided by Glaeser and Yoo (2025), available for the years 1982-2023. Bloom, Schankerman and Van Reenen (2013) document large cross-sectional variation in R&D tax credits that is seemingly uncorrelated with economic and political variables, providing pseudo-random variation to R&D expenditures (see Appendix B.3 therein). We directly use the R&D tax credit rate as an instrument as opposed to the user cost of R&D capital as in Wilson (2009), which we find yields nearly identical results.

[11] We restrict the sample to firms headquartered in the United States, that operate outside of the utilities and finance sectors, and do not show acquisitions larger than 5% of total assets per year.

where we allow the coefficients β_1 and β_2 to vary by industry s using two-digit SIC codes. We recover the log-TFP estimates as

$$\log(TFP_{i,t}) = (\hat{\alpha} + \hat{u}_{i,t})/(1-\eta). \tag{17}$$

Note that we divide by our calibration for $(1-\eta)$, stated below, to align the estimates with our assumed production function in (1).[12]

Results. Equipped with the firm micro data and the TFP estimates, we estimate regression (15) using the outlined instrumental variable approach. The results are shown in Table 1. Column (i) portrays our baseline estimates of 0.35 for β_1 and 0.29 for β_2, which are both statistically significant at the 1 percent confidence level. Whereas β_2 directly corresponds to the parameter ρ, β_1 implies a value of around 3 for κ, and we use these numbers in our baseline calibration. These values imply that a 1% increase in R&D expenditure, or a 1% higher productivity of a firm's peers' relative to its own productivity, each leads to firm productivity growth of around 0.3% over the next year.[13]

Robustness. The remaining columns in Table 1 show the estimation results from various robustness checks. Column (ii) uses industry-time fixed effects to allow for the possibility that ϕ_t in equation (13) also varies by industry, which gets absorbed into these fixed effects.[14] Column (iii) uses an alternative TFP definition, which simply employs the calibration mentioned below to recover TFP, as opposed to estimating the parameters first and obtaining TFP based on these parameters as described above. Column (iv) assumes that firms learn not only from their industry peers but more broadly from all firms in the economy, such that $a^*_{i,t-1}$ does not vary by industry in (15). Column (v) uses net property, plant, and equipment as a measure of the firm's capital stock. And finally, in column (vi), we test the robustness of our findings to using the method by Ackerberg, Caves and

[12]Since Compustat does not separately identify prices and quantities of goods sold, our TFP measure reflects both physical productivity and markups. However, as long as markups are slow-moving and do not strongly covary with physical productivity in the cross-section, the identified variation based on regression (15) can be associated with physical productivity.

[13]The regression specification (15) is derived from the R&D cost function (2), which implies that R&D $=$ 0 is associated with $z' = 0$. Firms reporting zero R&D are therefore not well characterized, and we implicitly exclude such observations by using $\log(\text{R\&D})$ as a regressor. Estimating (15) using $\log(1 + \text{R\&D})$ instead yields similar results. However, as shown by Chen and Roth (2023), this transformation gives estimates that depend on the units of measurement when the underlying variable has a mass point at zero.

[14]Intentionally, we do not include firm fixed effects since $\log(R\&D_{i,s,t})$, as well as the state-level tax credit rates, have a positive time trend and the inclusion of such fixed effects imply a within-transformation that subtracts an average firm-specific value across periods, while the dependent variable in (15) is defined in log-differences.

Table 1: Estimates R&D Cost Function.

	(i) Baseline	(ii) Fixed Effects	(iii) TFP-Def.	(iv) Learning	(v) Capital	(vi) ACF-2015
β_1 $(= 1/\kappa)$	0.35***	0.51***	0.41***	0.53***	0.24***	0.37***
	(0.09)	(0.13)	(0.12)	(0.14)	(0.07)	(0.10)
β_2 $(= \rho)$	0.29***	0.39***	0.39***	0.39***	0.23***	0.31***
	(0.02)	(0.03)	(0.05)	(0.04)	(0.01)	(0.02)
Time FE	✓		✓	✓	✓	✓
Industry-Time FE		✓				
First-Stage F-Stat	19	18	15	16	24	18
R-squared	0.12	0.17	0.12	0.14	0.11	0.12
Observations	34,556	34,243	34,556	34,556	35,519	38,868
Number of Firms	4,847	4,823	4,847	4,847	5,380	5,010
Number of Industries	46	41	46	46	47	47

Notes: Estimation results for regression (15). Standard errors in parentheses are clustered by firm. Sample: 1982-2023. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Frazer (2015) to estimate production functions and hence TFP. This approach deals with the concern that firms observe part of their own productivity when choosing inputs, rendering those inputs to be endogenous regressors that are correlated with the error term in (16).[15] Across the various robustness checks, we find estimates for β_1 and β_2 ranging between 0.24-0.51 and 0.23-0.39, respectively, with our baseline estimates falling roughly in the middle of those ranges.[16]

Comparison to Literature and Further Evidence. In Appendix B, we compare the results of our regression approach to alternative ones used in the prior literature and provide a range of further evidence. The comparison exercise shows that our identification approach yields similar effects of R&D investment on firm productivity growth relative to previous studies and also highlights the importance of addressing the endogeneity of firm R&D expenditures via instrumental variables. The additional tests show that our main findings remain robust to: (i) changing the timing of the dependent variable in (15),

[15] This method requires the choice of a dependent variable and we use value added in accordance with the production function in (16). Similarly, we choose employees as the labor input and the capital stock as the state variable. We pick the costs of goods sold as the proxy variable, but obtain similar results for net investment (difference of capital stock between two periods).

[16] Another potential concern may be that firms operate in multiple states and relocate their R&D expenditures to places with higher R&D tax credits without raising their overall expenditures (see, e.g., Wilson, 2009). However, in the presence of such R&D expenditure shifting, our instrument should not predict higher firm R&D spending, in contrast to our first-stage results.

(ii) using labor productivity instead of TFP estimates, (iii) obtaining alternative standard errors via a bootstrap or a different clustering approach, (iv) assuming that firms learn from other parts in the productivity distribution than the average, and (v) weighting the state-level tax credit rates by R&D expenditure activity of firms proxied by the location of their patent filings.

3.2 External Calibration

Table 2 presents the values for the externally calibrated parameters of the model. We assume standard values in growth models for the Frisch elasticity, $\varphi = 1$, an inverse EIS equal to $\sigma = 2$, and a discount factor of $\beta = 0.98$ (Acemoglu et al., 2018). For the firm production function (1), we set the factor shares α and η equal to $0.36 \times \psi$ and $0.64 \times \psi$, respectively, consistent with the standard assumption of a capital share of around $1/3$. The parameter ψ governs the degree of returns to scale and is internally calibrated to match a profit share in the data, as explained below. The depreciation rate is set to a standard value of 8% at an annual frequency. We assume a borrowing constraint parameter equal to $\theta = 1$ to achieve a ratio of debt-to-fixed assets of 1 based on the empirical evidence in Faria-e-Castro, Paul and Sánchez (2024).

For financial intermediaries, we set the loss given default parameter to 0.35, which is in line with loss given default (LGD) rates reported by U.S. banks in the FR Y-14Q data.[17] Note that λ coincides with the LGD in equilibrium given our choice of $\theta = 1$.[18] We set the intraperiod lending cost to 2% annually, consistent with the average external bond premium reported by Gilchrist and Zakrajsek (2012). We view this as a reasonable target since it is a measure of the cost of borrowing that is purged of default risk, which corresponds to the risk-free intraperiod debt in our model.

3.3 Internal Calibration

The next calibration step requires us to choose which of the economies is our calibration benchmark. Based on the empirical evidence in Faria-e-Castro, Paul and Sánchez (2024),

[17] The FR Y-14Q is a dataset maintained by the Federal Reserve for the purpose of stress-testing large bank holding companies. Specifically, our empirical moment is drawn from Schedule H.1, a quarterly loan-level dataset that contains detailed information on all credit facilities with balances over 1 million. For details, see https://www.federalreserve.gov/publications/fr-y-14-qas/y-14-qas.htm.

[18] More generally, and assuming a binding borrowing constraint, the LGD would be given by $1 - (1 - \lambda)/\theta$. The implied recovery rate based on our LGD value is higher than the recovery rates for capital that are typically estimated in the literature, as in Kermani and Ma (2020), for example. Our goal of choosing this alternative target is to capture intermediaries' perceived expected losses from delinquency in the context of our model, rather than the physical recovery rates on liquidated capital.

Table 2: Externally Calibrated Parameters.

Parameter	Description	Value	Target/Reason
		Households	
β	Discount factor	0.98	Acemoglu et al. (2018)
σ	Inverse EIS	2	Acemoglu et al. (2018)
φ	Inv. Frisch elasticity	1	Standard
		Firms	
α	Capital share	$0.36 \times \psi$	Standard
η	Labor share	$0.64 \times \psi$	Standard
δ	Depreciation rate	0.08	Standard
θ	Collateral constraint	1	Debt-to-fixed-assets of 1, FPS (2024)
		Financial Intermediaries	
λ	Loss given default	0.35	Y-14 data
ω	Lending cost	0.02	2% yearly, GZ (2012)

Notes: FPS (2024) refers to Faria-e-Castro, Paul and Sánchez (2024) and GZ (2012) refers to Gilchrist and Zakrajsek (2012).

who show that U.S. banks have been evergreening loans even in normal times in recent years, we pick the evergreening economy as the main counterpart to the data.

Given the direct estimation and the external calibration, we jointly choose the seven remaining parameters such that simulated model averages are close to seven empirical target moments: the productivity of exiting firms relative to continuing firms, the typical historical firm exit rate, an average credit spread, a firm profit share, average GDP growth, as well as its annual persistence and conditional volatility. Table 3 describes the parameters and targets.

We assume that idiosyncratic productivity follows a lognormal distribution, and that its mean is equal to 1, hence $\log \varepsilon \sim \mathcal{N}(-0.5\sigma_\varepsilon^2, \sigma_\varepsilon^2)$. The dispersion parameter is set to $\sigma_\varepsilon = 0.406$ to match the evidence in Lee and Mukoyama (2015) regarding the productivity of exiting firms. Using one of their TFP measures, the authors find that the average TFP of exiting firms is about 65% of that of continuing firms.[19] The fixed cost $\tilde{v}$ is set to -0.226, targeting an exit rate of 5% in the baseline economy with evergreening. Since not all exits correspond to defaults in the data, we target this rate as an average between firm exit rates in the U.S., which have been around 7.5% in recent decades (Crane et al., 2022), and

[19] Targeting this moment is particularly important in the context of our model as it implies that we match the empirical productivity of firms that exit on average, regardless of how exit is selected in the model.

Table 3: Internally Calibrated Parameters.

Parameter	Description	Value	Moment	Source	Data	Model
σ_ε	Std. dev. of iid prod.	0.406	Relative TFP exiters	LM (2015)	0.65	0.65
$\tilde{\nu}$	Fixed cost	-0.226	Exit/default rate	See text	5.0%	4.9%
i^{reg}	Lower bound int. rate	-0.105	Credit spread	Y-14 data	2.0%	2.0%
ψ	Returns to scale	0.860	EBITDA/Value Added	Compustat	30.0%	30.0%
$\tilde{\phi}$	Level cost of R&D	0.358	GDP pc growth	U.S. data	2%	2%
ρ_ζ	Capital quality persistence	0.736	GDP growth rate	U.S. data	0.16	0.16
σ_ζ	Capital quality volatility	0.035	GDP growth rate	U.S. data	0.02	0.02

Notes: LM (2015) refers to Lee and Mukoyama (2015).

the average probability of loan default reported in the FR Y-14Q data which is around 2.5% (Faria-e-Castro, Paul and Sánchez, 2024).

The lower bound on interest rates, i^{reg}, is set to -10.5% to match an average credit spread of 2% for variable-rate loans in the FR Y-14Q data. We further choose the level of returns ψ to scale to match the average EBITDA-to-value-added ratio among Compustat firms, which is 30%. The level cost of R&D $\tilde{\phi}$ is set to target a real GDP growth rate of 2%, roughly the average value of U.S. per capita GDP growth since 1960. Finally, the persistence and conditional volatility parameters for the exogenous process are set to match the persistence and conditional volatility of U.S. GDP growth over the same period.

3.4 Solution Method

We obtain a global nonlinear solution to the model via time iteration over a set of policy functions that depend on the model's state variables. We start by casting the equilibrium as a function of current states, a system of forward-looking difference equations that contain expectations over future shocks. We guess functional forms for the model's policy functions as a function of the (aggregate) endogenous and exogenous state variables: (k, ζ).[20] For each point in the grid, we solve for the values of policy functions at date t, interpolating over the guesses to compute expectations. We then update the interpolants with the newly solved policy functions and repeat the process until convergence.[21]

[20] Note that z is not a state variable for the detrended economy, and the fact that the borrowing constraint always binds implies that we do not need to keep track of k and b separately.

[21] See, for example, Faria-e-Castro (2024), for a description and application of this method. Our focus on higher-order moments and discretionary policy exercises requires a global nonlinear solution. However, the model's treatment of intraperiod heterogeneity and binding constraints is sufficiently tractable that it could be incorporated in a larger-scale DSGE model and analyzed with standard tools such as Dynare.

4 Quantitative Analysis

In this section, we compare the different economies in terms of aggregate moments, responses to aggregate shocks, and conduct further analysis based on simulations.

4.1 Aggregate Moments

To begin, we simulate the various economies and compute aggregate moments that are reported in Table 4. Our baseline calibration for the evergreening economy results in a share of saved firms equal to 5%. This is approximately in line with the evidence in the dataset assembled by Albuquerque and Iyer (2024), which reports an average zombie share of 7.7% among U.S. publicly listed firms and 2.2% among private firms. A simple average of these two values yields 5%. To make the different SC economies comparable, we calibrate ξ^{reg} and τ^{reg} for the restructuring and guarantee economies such that the share of firms that are saved is equalized to the one in the evergreening economy.[22] Of course, that share is zero in the HC economy where ex-post interventions are not permitted.

Exit and Growth. The absence of these interventions implies that the HC economy features almost twice as much firm exit relative to the various SC economies. In turn, more exit of low-productivity firms raises the average idiosyncratic productivity of all surviving firms ε^* which lowers the R&D costs of subsequent firms through the innovation externality. As a result, productivity growth rises, leading to GDP growth that is between 0.33 and 0.39 p.p. higher in the HC economy than in the SC economies. The evergreening economy lags behind on GDP growth, which is around 0.05 p.p. lower relative to the restructuring and the guarantee economies due to its slightly lower exit rate.

Volatility. However, higher growth in the HC economy comes at the cost of higher growth volatility. For example, relative to the evergreening economy, the standard deviation of GDP growth in the hard credit economy is almost 0.8 p.p. higher. This pattern also carries over to consumption, which shows similar differences across HC and SC economies, though these effects are less pronounced quantitatively.

Cost of Credit. The possibility of saving distressed firms ex-post also affects the pricing of intertemporal credit. Across SC economies, lenders charge a spread on intertemporal

[22] The resulting values are $\xi^{reg} = 0.0198$ and $\tau^{reg} = 0.0413$. We normalize the share of subsidized firms across interventions rather than their implied costs since the various interventions differ in their efficiency to save distressed firms.

Table 4: Model moments across credit regimes.

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	8.86	4.91	4.92	4.96
ε^*	1.05	1.03	1.03	1.03
GDP growth	2.39	2.00	2.05	2.06
$\sigma(g_Y)$	2.81	2.03	2.27	2.25
$\sigma(g_C)$	2.70	2.50	2.62	2.58
Real interest rate, $1/Q^d - 1$	6.59	5.92	5.95	5.97
Lending spread, $(1/q - 1/Q^d)$	3.55	2.02	2.05	2.00
Detrended wage, $\tilde{w}$	0.73	0.78	0.78	0.78
K/Y	1.41	1.62	1.63	1.62
Avg. intraperiod rate, i (%)	2.00	1.69	2.00	2.00
Avg. debt restructured, ξ (%)	0.00	0.00	0.05	0.00
Guarantees over GDP (%)	0.00	0.00	0.00	0.08
$corr(R\&D, Y)$	0.69	0.90	0.85	0.90

credit of around 2%. When this possibility is removed in the HC economy, spreads rise to 3.55%. As credit becomes less flexible, lenders more often face steeper losses when firms are in the default region.

Capital and Wages. These differences in credit spreads, which by and large originate from changes in loan rates, affect firms' intertemporal capital choices. As the cost of borrowing declines, firms borrow and invest more in physical capital in the SC economies. In turn, the capital-to-output ratio increases relative to the HC economy. Thus, while the HC economy features higher productivity and GDP growth, physical capital investment is relatively lower. Appendix Figure 12 visually illustrates these patterns, showing the firm policies for capital and productivity investment as a function of the stock of capital for the various economies. In contrast to intertemporal credit, the rate of interest on the working capital loan is the same across all economies at 2%, apart from the evergreening economy where lenders use this rate to influence firm default decisions.

When saving firms in distress, a larger set of firms produces, raising labor demand and pushing up wages all else equal. This effect is visible in Table 4 as the aggregate detrended wage is higher in the SC economies relative to the HC economy. A higher wage also reduces firm profits all else equal, partly depressing investment in R&D and physical capital. While this effect does not dominate the incentive to invest more in physical capital due to lower spreads in the SC economies, it does impact the liquidation and distress

thresholds as shown in Appendix Figure 13. Relative to the HC economy, the distress threshold in the SC economies is slightly higher for the idiosyncratic shock ϵ due to the wage effect that depresses firm profits.

Cyclicality of Innovation. The last line of Table 4 reports the measured correlation between the cyclical components of R&D expenditures and GDP growth, computed using an HP-filter calibrated for annual data. Notably, this correlation is significantly lower in the HC economy relative to the SC regimes. This is partly explained by the cleansing effect of recessions: since exit is countercyclical, so is ε^*. Thus, innovation becomes cheaper during recessions, and this effect is quantitatively more significant in the HC economy. This observation is important for the welfare decompositions we conduct in Section 5.

4.2 Responses to Aggregate Shocks

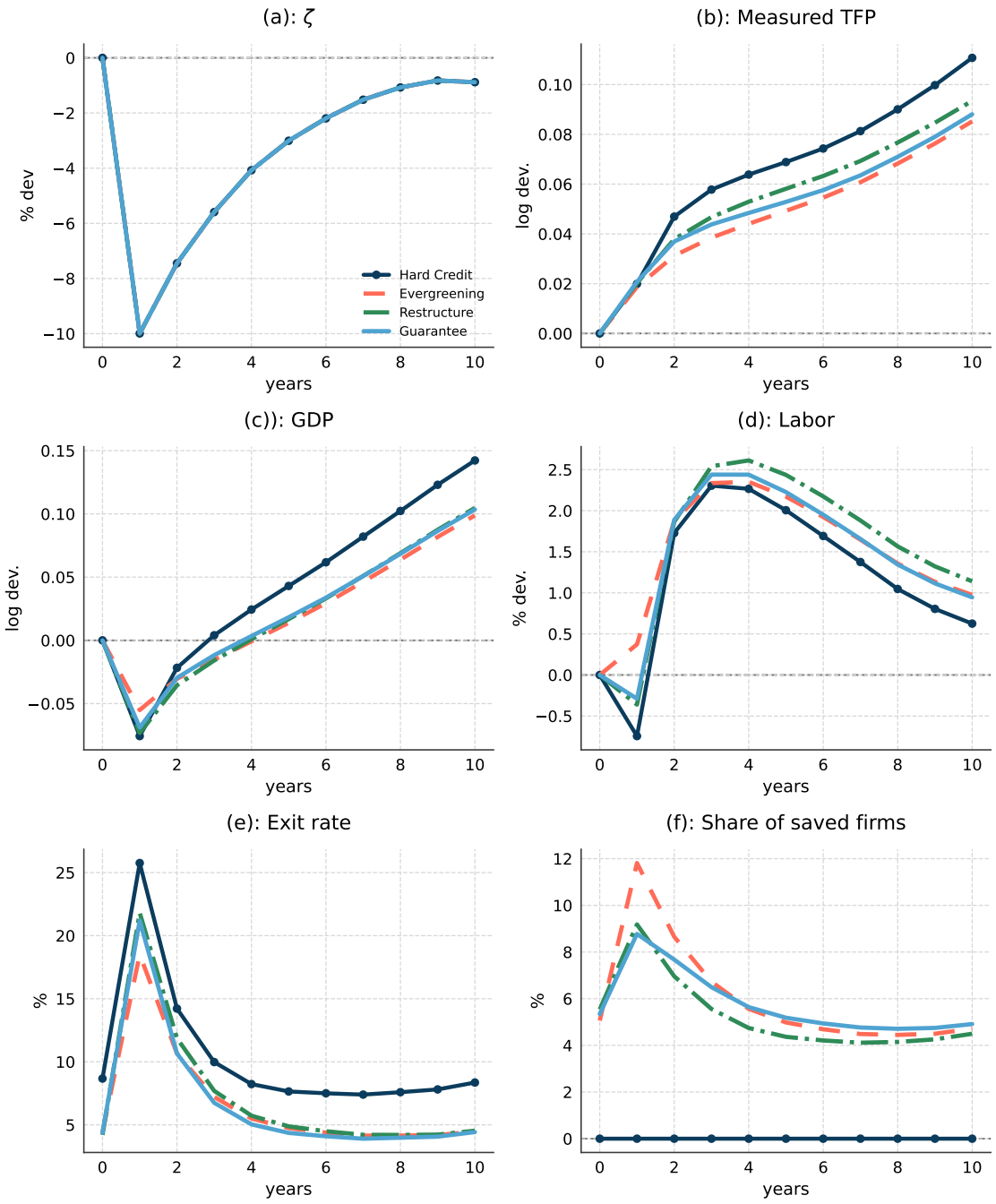
Having described the average behavior of each economy, we now examine how differences in credit regimes influence the economy's response to the aggregate shock: a disturbance to the capital quality level ζ.

Since the model is nonlinear, responses to shocks are state-dependent, and the various economies differ in their balanced growth paths, we compute generalized impulse response functions starting from the stochastic steady state of each respective economy. To this end, we simulate the various economies many times, and for each of the paths we compute a counterfactual where the capital quality level is perturbed with a given shock. The impulse responses that we report are the averages of these shocked paths across simulations.

Figure 3 plots the response of selected endogenous variables to a 10% shock to capital quality across the different economies. Since the economies have different balanced growth paths, we initialize them with $z_0 = 1$, and plot the simulated paths of TFP and GDP as log deviations from the initial level, as opposed to reporting differences from the balanced growth path. The first panel shows the response of the shock ζ. Panel (b) plots the path of measured TFP, defined as $Y/[(\zeta k)^\alpha N^\eta]$, and therefore comprising not only fundamental productivity z but also the effects of selection via ε^*. On impact, there is only a small effect on TFP. However, while TFP for the HC economy continues to grow at a similar rate, the SC economies experience a more pronounced slowdown.

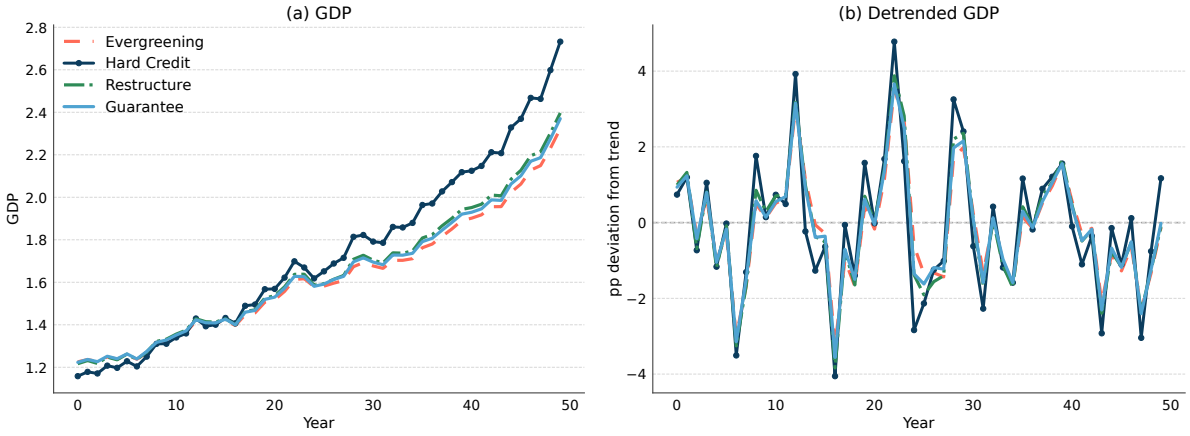
Panels (c) and (d) plot the paths of GDP and labor. At the time the shock realizes, both fall more in the HC economy compared with the SC economies. This difference is particularly pronounced for the evergreening economy, where labor does not fall but rises

Figure 3: Generalized impulse response functions.



in response to the shock. However, over time, the HC economy catches up and its level of output surpasses that of the other economies due to its faster growth. These panels highlight the stabilization vs. growth trade-off that arises across different credit regimes, with the HC economy showing a higher sensitivity to aggregate shocks but also a higher growth rate of GDP.

Figure 4: Illustration of GDP data simulation.



Panels (e) and (f) shed light on why output and labor drop by less: while the exit rate rises on impact in all economies, it increases by less in the SC economies, as the share of firms that are subsidized increases. These firms still produce and hire labor, unlike those that exit, which is reflected in the aggregate statistics of those variables. Thus, our model illustrates how different lending regimes can amplify or buffer the effects of business cycle shocks.

4.3 Simulation analysis

To complement the IRF analysis, it is also instructive to study a particular simulation path in which all economies experience the same sequence of aggregate shocks and start from the same level of capital and the same $z_0 = 1$.[23] Panel (a) of Figure 4 shows the GDP index for each economy, to illustrate differences in GDP dynamics. Panel (b) shows the HP-filter detrended GDP data that we use to compare business cycles across the different economies. The left panel illustrates that the HC economy grows faster, while the bottom panel shows that its business cycles are more volatile, with this economy experiencing stronger expansions but also deeper recessions relative to the SC economies. Both of these observations are consistent with the patterns inferred from the impulse responses in Figure 3. Panel (a) also shows a noticeable feature that we return to below: the SC regimes initially have higher GDP than the HC economy due to lower firm exit. In Appendix D, we further study typical recessions based on the various simulations, giving consistent patterns compared with the impulse response analysis.

[23] We set the starting point to be the stochastic steady state level of capital for the HC economy, as we later use the HC economy as the benchmark and starting point for welfare comparisons.

5 Welfare Analysis

The key takeaway from the quantitative analysis is that the HC economy grows faster than the SC economies, but is also more volatile. In this section, we analyze the welfare implications of this stabilization vs. growth trade-off and present a decomposition of welfare differences across economies.

Our main measure of welfare is the expected discounted sum of utility flows for the household in equation (10). We make the following assumptions for welfare comparisons. First, we assume throughout that all economies start out with the same capital quality level $\zeta = 1$ and identical levels of fundamental TFP, which we normalize to $z_0 = 1$. This is a common assumption for welfare comparisons in endogenous growth models (e.g., Acemoglu et al., 2018). Second, to account for the impact of transitional dynamics, we assume that all economies start from the same mean capital level in the HC economy's stochastic steady state.[24]

5.1 A Second-Order Approximation to Welfare

While our global solution of the model allows us to compute welfare exactly using a recursive representation of detrended welfare, we focus on a second-order approximation as it allows for a simple and additive decomposition for the contributions of different factors. Denote ex-ante welfare for economies $k \in \{HC, SC\}$ as

$$\mathcal{U}^k \equiv \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t u(X_t^k)\right], \tag{18}$$

where X is the composite good in the King, Plosser and Rebelo (1988) preferences:

$$X(C,N) = C\left(1 + (\sigma - 1)\frac{N^{1+\varphi}}{1+\varphi}\right)^{\frac{\sigma}{1-\sigma}}.$$

This definition implies that the King, Plosser and Rebelo (1988) utility function can be written as a simple CRRA utility over this composite good, $u(X) = X^{1-\sigma}/(1-\sigma)$. As with other variables, the level of composite consumption $X_t = x_t z_t^{\frac{1-\eta}{1-\alpha}}$ is equal to the product of x_t, the stationary component of the composite good, and the stochastic trend $z_t^{\frac{1-\eta}{1-\alpha}}$. Given our assumption that $z_0 = 1$, we can write the level of the stochastic trend as

[24] We find that welfare comparisons are robust to the choice of initial steady state. We compute consumption-equivalent welfare starting from both the HC and SC steady states. While transition dynamics differ, the resulting welfare decompositions are nearly identical.

the product of all past growth rates $z_t = \prod_{s=0}^{t-1} G_{z,s}$. For each economy k and period t, we employ a second-order Taylor expansion of $u(X_t^k)$ around $\mathbb{E}(X_t^k)$:

$$u(X_t^k) \approx u(\mathbb{E}[X_t^k]) + u'(\mathbb{E}[X_t^k])(X_t^k - \mathbb{E}[X_t^k]) + \frac{1}{2}u''(\mathbb{E}[X_t^k])(X_t^k - \mathbb{E}[X_t^k])^2.$$

Taking expectations allows us to write the expected utility flow in t as the sum of two terms, one that reflects the contribution of the mean of composite consumption to utility, and another that reflects the contribution of its variance:

$$\mathbb{E}[u(X_t^k)] \approx \underbrace{u(\mathbb{E}[X_t^k)}_{\text{mean}} + \underbrace{\frac{1}{2}u''(\mathbb{E}[X_t^k])\,\text{Var}(X_t^k)}_{\text{volatility}},$$

Since this decomposition is linear, we can approximate (18) as $\mathcal{U}^k \simeq \mathcal{U}^k_{\text{mean}} + \mathcal{U}^k_{\text{vol}}$. Further note that the composite good X_t is the product of a stationary component x_t and a stochastic growth component. This means that its variance reflects both cyclical fluctuations in x_t as well as fluctuations in the stochastic trend $z_t^{\frac{1-\eta}{1-\alpha}}$. To quantify these contributions, we write $\text{Var}(X_t^k)$ as the variance of a first-order approximation of X_t around $\mathbb{E}[x_t]$ and $\mathbb{E}[z_t^{\frac{1-\eta}{1-\alpha}}]$. This allows us to decompose the variance as:

$$\text{Var}(X_t) \approx \mathbb{E}[z_t^{\frac{1-\eta}{1-\alpha}}]^2\,\text{Var}(x_t) + \mathbb{E}[x_t]^2\,\text{Var}(z_t^{\frac{1-\eta}{1-\alpha}}) + 2\mathbb{E}[x_t]\mathbb{E}[z_t^{\frac{1-\eta}{1-\alpha}}]\,\text{Cov}(x_t, z_t^{\frac{1-\eta}{1-\alpha}}).$$

Since this decomposition is linear, the volatility component of ex-ante welfare is the sum of three components: a cyclical volatility component, a growth volatility component, and the covariance between the two, that is, $\mathcal{U}^k_{\text{vol}} = \mathcal{U}^k_{\text{vol,x}} + \mathcal{U}^k_{\text{vol,z}} + \mathcal{U}^k_{\text{vol,cov}}$.

In the spirit of Lucas (1987), we report welfare differences in terms of consumption-equivalent variation (CEV) units. Since we treat the HC economy as the benchmark, the CEV numbers should be interpreted as the permanent proportional change in consumption in the HC economy that makes households indifferent between remaining in the HC and transitioning to a SC economy.

5.2 Welfare Results

Table 5 reports the results. The first line shows the total CEV of transitioning from HC to each SC economy. These numbers are negative, implying that the HC economy deliv-

Table 5: Consumption-equivalent variation measures.

	Evergreening	Restructuring	Guarantee
CEV, total	-3.13	-2.47	-2.32
CEV, mean	-2.37	-1.82	-1.62
CEV, volatility	-0.76	-0.65	-0.70
CEV, volatility from x	0.10	-0.01	0.09
CEV, volatility from z	-0.52	-0.31	-0.52
CEV, volatility from $\text{Cov}(x, z)$	-0.28	-0.27	-0.22
CEV, exact	-3.09	-2.42	-2.30

Notes: CEV volatility components may not sum to the total volatility term due to approximation error and rounding. See text for details.

ers higher welfare than any of the SC regimes.[25] To understand why, the following lines perform the approximated decomposition. The bulk of welfare gains (76%) come from the mean component, primarily reflecting the higher growth rates in the HC economy, which tend to dominate welfare calculations. Interestingly, in light of our previous discussion, the volatility component is also negative, meaning that households prefer the overall volatility in the HC economy. This seemingly counterintuitive result is explained by further decomposing the volatility component: while SC economies deliver welfare gains due to lower cyclical volatility of x, they actually experience higher volatility of the stochastic growth trend, and the latter effect ends up dominating.

The fact that the stochastic growth trend is less volatile in the HC economy was foreshadowed in the discussion of Table 4, as R&D expenditures are considerably less cyclical in the HC economy. How is this consistent with a lower volatility of GDP growth in the SC economies? Note that GDP growth can be written as the product of detrended GDP $\tilde{Y}_t$ and the growth rate of Z:

$$\text{GDP growth}_t = \frac{\tilde{Y}_t}{\tilde{Y}_{t-1}} \times G_{z,t-1}^{\frac{1-\eta}{1-\alpha}} - 1.$$

While G_z is more volatile in the SC economies, the cyclical growth component $\frac{\tilde{Y}_t}{\tilde{Y}_{t-1}}$ is much less so, which results in lower volatility of GDP growth in spite of a more volatile stochastic trend. All things considered, even though the growth component remains dominant, our model delivers nontrivial welfare gains from business cycle stabilization. Additionally, we identify risks to the economy's trend itself as having a significant welfare impact.

[25] The last line of Table 5 displays the CEV based on a value function that is computed using the globally solved policies, and evaluated at the initial transition states. The differences between these values and those in the first line are very small, showing that the approximation is accurate.

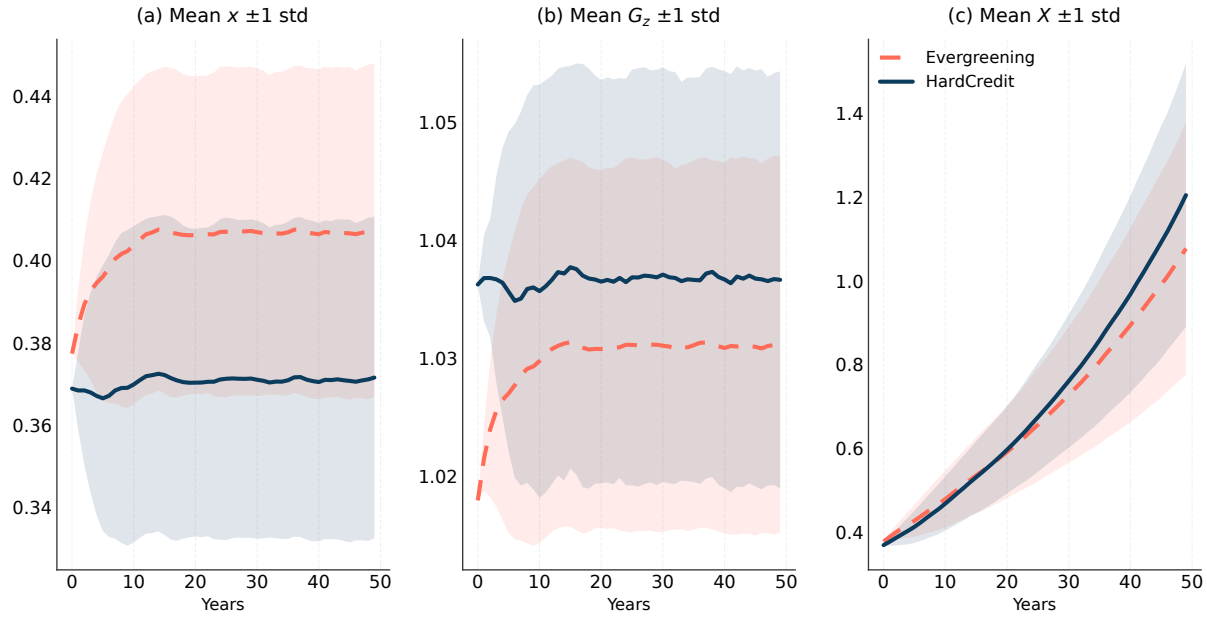
Differences Across SC Economies. Welfare losses are larger in the evergreening versus restructuring and guarantee economies. This reflects the fact that the evergreening economy features more static misallocation of inputs than the other SC economies. Under restructuring and guarantees, firms' labor choices are not distorted, and each firm hires labor proportional to its idiosyncratic productivity, just as in the HC economy. Welfare losses in these economies arise primarily from dynamic effects: since exit is lower, ε^* is lower, and so is GDP growth. In contrast, the evergreening economy features distorted labor choices for firms that receive subsidized credit: they borrow at lower intraperiod rates and thus face lower effective labor costs. This weakens the positive correlation between idiosyncratic productivity and the quantity of labor hired, as less productive firms hire relatively more labor, which contributes to making this economy more inefficient compared to the other SC regimes.

Mean Component: Levels vs. Growth. Figure 5 plots the mean paths of $x_t, G_{z,t}, X_t$ along with one standard deviation bands for the HC and evergreening economies across simulations. A few things are worth noting. First, panel (a) shows that the evergreening economy features a higher mean level for the stationary component x_t. This reflects lower exit; exit is wasteful in our model, as it results in idle capital not employed in production that depreciates at a higher rate (λ rather than δ). Second, panel (b) shows that while the growth rate G_z is lower in the evergreening economy, it quickly accelerates during the first periods of the transition. Note that the paths of x and G_z in the evergreening economy exhibit a transition in the first 10 periods, since we start all economies in the same state. Combining panels (a) and (b) results in panel (c), which shows that the utility-relevant composite X is initially higher in the evergreening economy due to the higher stationary component x, but eventually the higher growth rate in the HC economy allows it to overtake after around 15 years.

This discussion has two important implications. First, the mean component of our welfare decomposition nets two forces that offset each other: a higher detrended level in the SC economy, and a higher average growth rate in the HC economy. To the extent that the higher x reflects lower exit, it is related to stabilization. Thus the mean component does subsume some of the benefits of stabilization (or costs from the lack thereof). Second, this highlights the importance of time discounting in welfare comparisons between these two economies: for a fixed set of policy functions, sufficiently impatient households could prefer the evergreening economy for its front-loaded benefits in terms of X.[26]

[26] Appendix E further assesses the robustness of the results to changes in the discount factor β and the coefficient of relative risk aversion σ. An increase in patience magnifies the welfare differences between the

Figure 5: Simulations of composite consumption.



6 The Role of Learning Externalities

Our analysis thus far reveals that the innovation externality via the R&D cost function (2) is an important mechanism in the model, shaping productivity differences and the cleansing effect of recessions. The strength of this mechanism is determined by the parameter ρ. In this section, we study the effects of changing this parameter. Appendix H provides some insight into the quantitative effects of other frictions by also considering a version of the model without congestion in input markets.

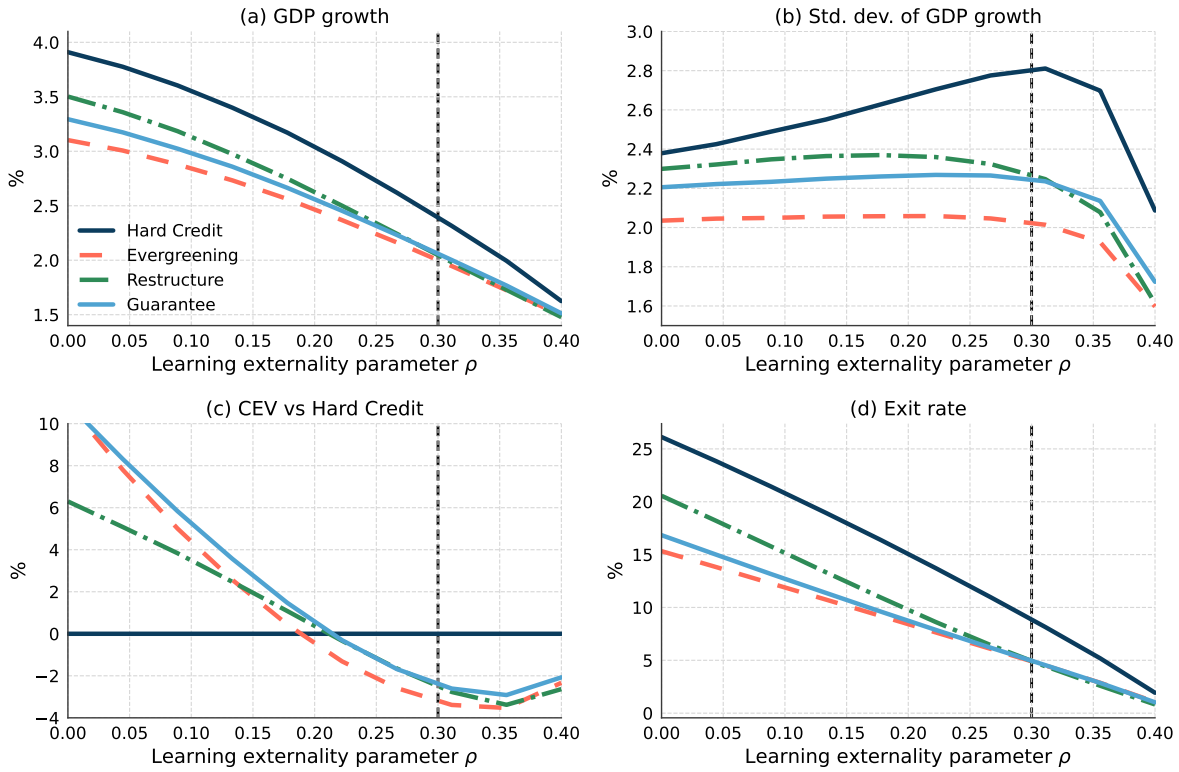
6.1 Effects of Changing ρ

Our benchmark calibration sets $\rho = 0.3$, the value estimated directly in Section 3.1. We assess the role of this parameter in two ways. First, we conduct comparative statics over $\rho \in [0, 0.4]$, holding all other parameters fixed. Second, we fully recalibrate the model for $\rho \in \{0, 0.15\}$. Figure 6 reports the comparative-statics results. Because the recalibrated exercises yield similar conclusions, we present them in Appendix G.

The stabilization-growth trade-off between HC and SC economies is robust across the values of ρ that we consider, as shown in panels (a) and (b) of Figure 6. For any given value of ρ, the HC economy features both higher GDP growth and greater GDP growth volatility than the SC economies: the solid blue line corresponding to HC lies above the

economies, while an increase in risk aversion compresses them.

Figure 6: Comparative statics with respect to ρ.



SC lines in both panels.

GDP growth declines with ρ. This result follows from equation (12). A lower value of ρ implies that firms internalize a larger share of the effect of current innovation on future innovation costs. Private incentives to invest in R&D therefore strengthen, raising the economy's growth rate. At the same time, a lower ρ weakens the role of the learning externality, making aggregate growth less sensitive to ε^*. Because ε^* is one channel through which aggregate conditions affect innovation incentives, weakening this channel also makes innovation less cyclical and reduces the volatility of GDP growth.

Although the welfare ranking is preserved near our benchmark value of $\rho = 0.3$, sufficiently low values can reverse it, as shown in panel (c). The stabilization-growth trade-off remains in place, but the transition-level effects become strong enough to dominate the long-run growth advantage of HC. Panel (d) shows that the gap in exit rates widens as ρ falls, particularly between the HC and evergreening economies. This generates larger initial differences in composite consumption that favor the SC economies. Figure 15 illustrates this mechanism for the fully recalibrated model with $\rho = 0.15$. The HC economy eventually overtakes the SC economy because of its higher growth rate, but the crossover occurs almost twice as late as in the baseline transition shown in Figure 5. The larger

initial advantage in levels can therefore make the representative household prefer the SC economy at the start of the transition. More generally, economies with stronger firm selection, such as the HC economy, benefit disproportionately from the innovation externality. Weakening that externality therefore erodes their relative welfare advantage.

6.2 Validation: Firm Exit and Productivity

As a validation exercise for the model and for the estimated value of ρ, we compare the joint dynamics of firm exit and productivity in the data with those implied by different versions of the model. To this end, we estimate local projections of the effect of changes in firm exit rates on productivity:

$$\Delta_h y_{i,t+h} = \beta_h \Delta \text{Exit Rate}_{i,t} + \sum_{\ell=1}^{L} \gamma_\ell \Delta y_{i,t-\ell} + \sum_{\ell=1}^{L} \delta_\ell \Delta \text{Exit Rate}_{i,t-\ell} + \alpha_{h,i} + \alpha_{h,t} + \varepsilon_{i,t+h}$$

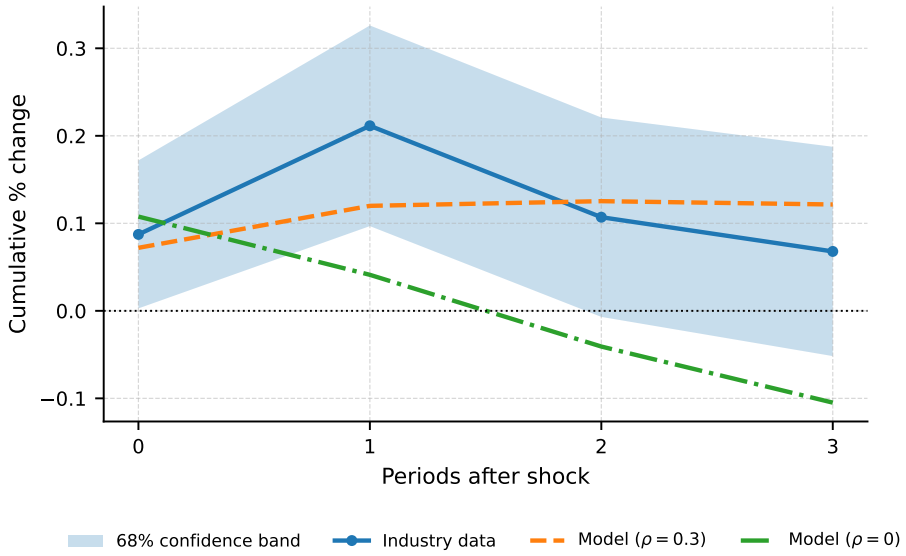
for $h = 0, 1, 2, \ldots$, where i denotes a 4-digit industry, t denotes year, and $y_{i,t}$ is an industry-level measure of productivity from the Bureau of Labor Statistics. Exit Ratei, t is the establishment exit rate in industry i, taken from the Business Dynamics Statistics of the U.S. Census Bureau. The terms $\alpha_{h,i}$ and $\alpha_{h,t}$ denote industry and year fixed effects. The outcome variable is the long difference relative to $t-1$: $\Delta_h y_{i,t+h} = \log y_{i,t+h} - \log y_{i,t-1}$. We estimate analogous local projections using simulated data from the model with evergreening, both for the baseline specification with $\rho = 0.3$ and for a counterfactual version with $\rho = 0$.[27]

We do not attach a structural causal interpretation to these estimates: changes in exit rates are endogenous both in the model and in the data. Instead, the exercise is intended to characterize the joint dynamics of productivity and firm exit over time. Figure 7 compares the estimated coefficients β_h across horizons h for the data and for the two model specifications.

The figure highlights two main results. First, in the data, an increase in the exit rate is associated with an increase in productivity on impact. Both model variants replicate this fact, reflecting selection in the model: when exit rises, the firms that leave are disproportionately those with low productivity. This compositional effect raises average productivity among surviving firms.

[27] Exit rates are taken from the Business Dynamics Statistics (BDS) provided by the US Census Bureau. We compute yearly establishment exit rates at the NAICS4 industry level. Our measure of productivity in the data is labor productivity, which we take from the Bureau of Labor Statistics (BLS), also at the 4-digit industry level. We set the number of lags to $L = 2$. Model regressions do not include FE.

Figure 7: Local projections of industry productivity on exit rates, data vs. model



Second, in the data, an increase in the exit rate is followed by hump-shaped productivity dynamics. The baseline model with innovation externalities reproduces this pattern. In that model, stronger selection today lowers future innovation costs and stimulates R&D investment, which raises productivity over time. By contrast, the model with $\rho = 0$ cannot replicate this dynamic response, since better selection today does not generate future innovation gains.

Taken together, we view this exercise as providing validation for both the way we model innovation externalities and the estimated value of ρ.

7 Optimal Policy

Our baseline calibration shows that the HC economy delivers higher welfare compared to any of the SC regimes. In this section, we explore whether these welfare rankings may change when varying parameters that control the extent of soft credit. Specifically, we consider two possible implementations: one in which a government commits to a fixed degree of SC ex-ante, and another in which the government chooses it period-by-period under discretion.

7.1 Optimal Constant Policy with Commitment

We first study an optimal policy with commitment that is constrained to be constant over time. In this problem, a perfectly benevolent government chooses at date 0 a single value of the policy instrument—either i^{reg}, ξ^{reg}, or τ^{reg}—that must remain fixed for all future periods.[28]

Figure 8 plots the results for this experiment. Since there is a monotonic relationship between each regulatory parameter and the share of subsidized firms, we show different moments across credit regimes as a function of this share to make the economies comparable. The vertical dashed lines mark our calibration benchmark for this share at 5% in the SC economies. As i^{reg} becomes more negative or ξ^{reg} and τ^{reg} rise, the share of subsidized firms increases. In contrast, as these exogenous limits approach their values in the hard credit economy, the share of subsidized firms converges towards zero.

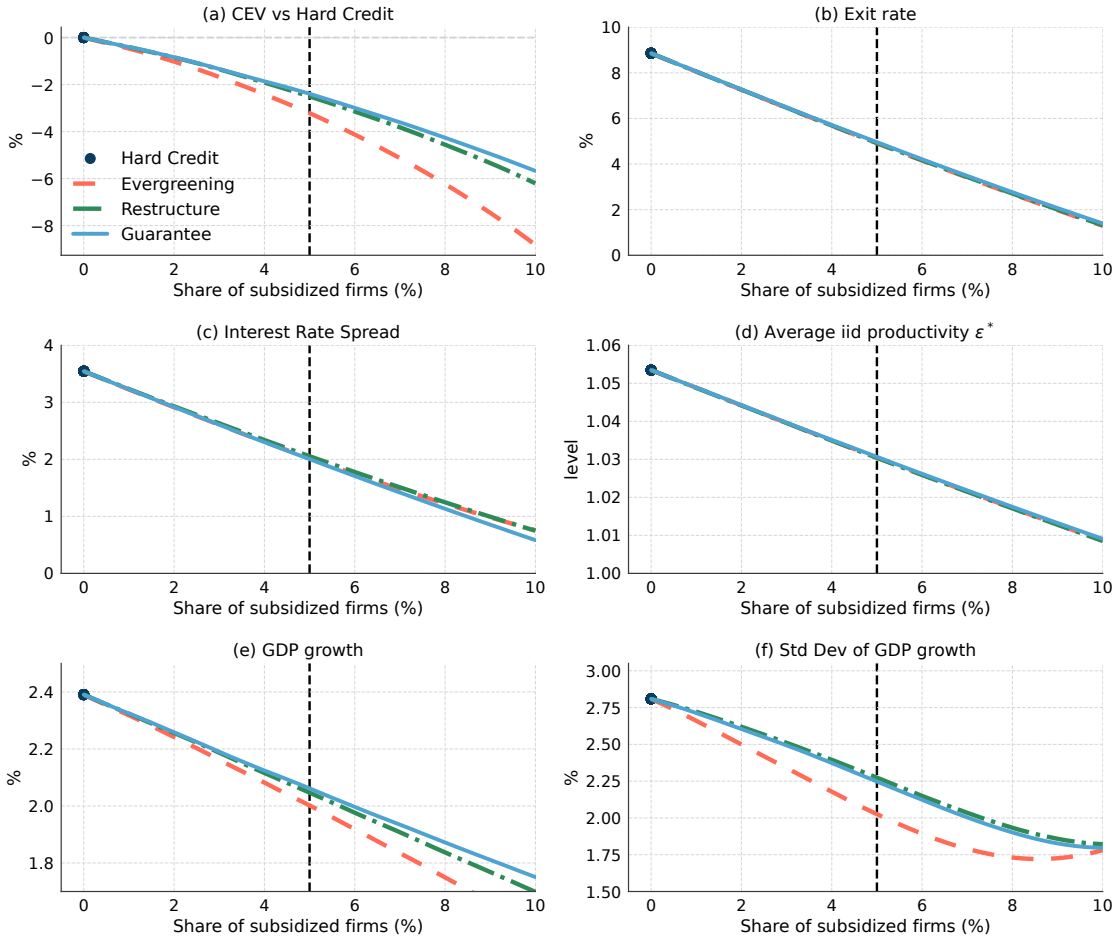
Starting with the CEV welfare measure in panel (a), the comparative statics show that the optimal constant policy is to set the share of subsidized firms to zero and replicate the HC economy. This is achieved by setting $i^{reg} = \omega$ and $\xi^{reg} = \tau^{reg} = 0$. The remaining panels help explain this result. Panel (b) shows that the exit rate is monotonically and almost linearly decreasing in the share of subsidized firms. This is reflected in lower credit spreads as visible from panel (c). However, selection also worsens. Panel (d) plots the average idiosyncratic productivity ε^* of incumbents. As more distressed firms are saved, ε^* falls, which raises the costs of innovation. This culminates in lower GDP growth, which is monotonically decreasing in the share of subsidized firms, as shown in panel (e). Finally, panel (f) shows that the standard deviation of GDP growth also declines as ex-post interventions help stabilize economies. However, this reduction in volatility is insufficient to offset the decline in growth, thus explaining the welfare patterns.

7.2 Optimal Policy without Commitment

A natural question that emerges from this analysis is the following: if the HC regime delivers higher growth and welfare, why are SC policies so prevalent in practice, as policymakers and lenders frequently implement policies that relax credit discipline? To address this question, we study an optimal policy problem without commitment. Specifically, a benevolent policymaker chooses the degree of intervention each period as a function of the current aggregate state, taking as given the continuation policy that will be chosen in

[28] Following Sargent (2019), this can be interpreted as a "constant Ramsey" policy: the Ramsey planner maximizes welfare subject to the restriction that the policy instrument cannot vary with the state of the economy.

Figure 8: Alternative values of constant policies on i^{reg}, ξ^{reg}, and τ^{reg}.



future states. Specifically, letting $\varpi^{reg} \in \{i^{reg}, \xi^{reg}, \tau^{reg}\}$, we assume that the policymaker solves the following problem:

$$\tilde{\mathcal{U}}(\tilde{k}, \zeta) = \max_{\varpi^{reg}} u(\tilde{C}, N) + \beta G_z^{(1-\sigma)\frac{1-\eta}{1-\alpha}} \mathbb{E}[\tilde{\mathcal{U}}(\tilde{k}', \zeta')]$$
$$\text{s.t.} \quad (\tilde{C}, N, \tilde{k}', G_z) \in \mathcal{Y}(\tilde{k}, \zeta; \varpi^{reg}),$$

where $\tilde{\mathcal{U}}$ is a recursive representation of the household's value function, and the constraint imposes that the tuple $(\tilde{C}, N, \tilde{k}', G_z)$ must be part of an equilibrium as defined in Appendix A.4, given states $\tilde{k}, \zeta$ and the chosen policy ϖ^{reg}.[29]

The equilibrium policy is characterized by a Markov-perfect equilibrium. In this environment, the policymaker internalizes the short-run benefits of supporting distressed firms but cannot commit to maintaining strict credit discipline in the future. As a result,

[29] See Appendix A.5 for the full list of equilibrium conditions.

Table 6: Simulated aggregate moments: optimal policy without commitment.

	Hard Credit	i^{reg}	ξ^{reg}	τ^{reg}
Share of subsidized firms (%)	0.00	7.21	7.37	7.47
Exit rate (%)	8.86	3.22	2.98	2.94
ε^*	1.05	1.02	1.02	1.02
GDP growth	2.39	1.82	1.85	1.88
$\sigma(g_Y)$	2.81	2.03	2.01	1.99
$\sigma(g_C)$	2.70	2.49	2.52	2.54
Real interest rate, $1/Q^d - 1$	6.59	5.56	5.81	5.89
Lending spread, $(1/q - 1/Q^d)$	3.55	1.50	1.15	0.94
Detrended wage, $\tilde{w}$	0.73	0.80	0.80	0.80
K/Y	1.41	1.73	1.75	1.76
Avg. intraperiod rate, i (%)	2.00	1.34	2.00	2.00
Avg. debt restructured, ξ (%)	0.00	0.00	0.10	0.00
Guarantees over GDP (%)	0.00	0.00	0.00	0.18
$corr(R\&D, Y)$	0.69	0.77	0.76	0.75
CEV, total		-5.22	-4.59	-4.22

policies that generate soft credit may arise as the time-consistent outcome, even though the economy would be strictly better off under a HC regime sustained by commitment. While the government is benevolent and maximizes household welfare, it cannot commit to future policies.

Table 6 reports the simulated aggregate moments under the optimal policy without commitment. In all three environments, the Markov-perfect policy implements substantial credit support to distressed firms, reflected in the positive share of subsidized firms (between 7.2% and 7.5%) and the relatively low exit rates (2.9 to 3.2%). The resulting allocations display moderate growth rates and financial conditions consistent with sustained credit support, including relatively low spreads and default probabilities.

Importantly, despite being the time-consistent outcome of the policymaker's problem, these allocations remain welfare dominated by the HC regime. The last row of the table reports the CEV of moving from the HC economy to any of the discretionary policy SC economies. The welfare losses range between -4.2 and -5.2% of permanent consumption, larger than those under our baseline calibration. This exercise shows that although SC emerges endogenously when policymakers are unable to commit, society would be

strictly better off under a regime that enforces hard-credit discipline.[30]

8 Conclusion

When lenders and governments intervene to save firms in financial distress, a fundamental trade-off for the overall economy tends to arise: such credit market interventions can stabilize economic activity in the short-run, but may also weigh on longer-run growth by keeping less productive firms alive. Despite the practical importance of this trade-off, the existing literature has lacked a model to assess the short-term and long-term macroeconomic effects of such interventions jointly. In this paper, we provide such a framework, featuring business cycles, firm heterogeneity, and endogenous growth.

We use this new model as a laboratory to study and compare different credit market interventions, quantify their effects on growth and volatility, and evaluate the welfare consequences of the stabilization-vs.-growth trade-off they imply. Our main finding is that an economy without interventions features faster growth and more volatility, and overall higher welfare for the economy as a whole. Nonetheless, policymakers may favor saving distressed firms in the absence of commitment, behaving as if they prioritize short-term gains. Our analysis thus provides a reason why credit market interventions are so prevalent in practice and can speak to historical episodes of insufficient banking and bankruptcy reforms that can be associated with slow economic growth (see, e.g., Bergoeing et al., 2002; Caballero, Hoshi and Kashyap, 2008).

A number of avenues for future research emerge from our paper. First, our model abstracts away from monetary policy, which, in practice, interacts closely with credit conditions and firm financing. Incorporating nominal rigidities and a central bank that sets interest rates would allow for a richer analysis of how monetary policy affects the stabilization-vs.-growth trade-off. Second, our current setup assumes that lenders are perfectly competitive and hold no capital, so that their balance sheets play no independent role. Enriching the model with intermediation frictions—where the health of bank balance sheets affects the supply and pricing of credit—would open the door to studying how financial sector distress interacts with the soft credit mechanisms we analyze. And third, the tractability of our framework lends itself to be incorporated into richer quantitative models that can be estimated on macroeconomic and financial data, enabling a joint quantitative assessment of the stabilization and growth effects of specific historical interventions such as those during the Great Financial Crisis.

[30] This result relates to Acharya, Lenzu and Wang (2025), who show that benevolent policymakers may find themselves "trapped" in low productivity equilibria due to excessive forbearance policies.

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Online Appendix for "Stabilization vs. Growth"

by Miguel Faria-e-Castro, Pascal Paul, and Juan M. Sanchez

A Model Appendix

A.1 Proofs

In this appendix, we provide the proofs to Propositions 1-3, and illustrate the intraperiod equilibria for the various soft-credit economies graphically.

A.1.1 Proposition 1: Evergreening Economy

To solve the lender's problem under evergreening, it is helpful to define the objects $i^{\min}$ and $i^{\max}$. The interest rate $i^{\min}$ is the minimum rate at which the lender is willing to lend, rather than liquidate the firm. The rate $i^{\max}$ is the maximum interest rate at which the firm is willing to borrow, rather than default.

Equivalently, $i^{\min}(s,\varepsilon)$ is defined by the lender's indifference condition between liquidation and lending, for given (s,ε):

$$b-(1-\lambda)\zeta k+(i^{\min}-\omega)\,w\,n(z,k,\varepsilon,i^{\min})=0.$$

Importantly, $i^{\min}<\omega$ whenever $b>(1-\lambda)\zeta k$. In words, if the recovery value of collateral is below the legacy debt b, a lender has an incentive to offer a subsidized intraperiod loan to prevent default and recover the full amount b.

The rate $i^{\max}(s,\varepsilon)$, on the other hand, is defined as the rate i such that $\bar{\varepsilon}(s,i^{\max})=\varepsilon$. This yields the closed-form solution

$$\begin{aligned} 0 &= z\varepsilon\,\pi(k,\zeta,i^{\max})-b+(1-\delta)\zeta k-\nu+V_1(s) \\ \Rightarrow \qquad 1+i^{\max} &= \frac{\eta}{w}\,(z\varepsilon)^{\frac{1-\eta}{\eta}}(\zeta k)^{\frac{\alpha}{\eta}}\left(\frac{1-\eta}{b-(1-\delta)\zeta k+\nu-V_1(s)}\right)^{\frac{1-\eta}{\eta}}. \end{aligned}$$

Given (s,ε), the intraperiod equilibrium can be characterized as follows:

1. if $i^{\min}<\omega<i^{\max}$, a firm is in the *normal funding region* and the lender offers $i^{*}=\omega$, the competitive rate set by outside lenders;

2. if $i^{\min} < i^{\max} < \omega$, a firm is in the *evergreening region* and the lender offers $i^* = i^{\max}$, a rate just low enough to prevent the firm from defaulting;

3. if $i^{\max} < i^{\min}$, there is no feasible contract and the firm is liquidated. Recall that $i^{\min} < \omega$, so the firm would default even if attempting to borrow from an outside lender.

Alternatively, one can more conveniently express these regions in terms of thresholds for the idiosyncratic shock ε. The threshold separating the normal funding region from the evergreening region corresponds to $i^{\max} = \omega$, which yields the same distress threshold as in the hard credit economy:

$$\bar{\varepsilon}(s, \omega, 0, 0) = \left[\frac{b + \nu - (1-\delta)\zeta k - V_1(s)}{1-\eta}\right]\left[\frac{w(1+\omega)}{\eta}\right]^{\frac{\eta}{1-\eta}} \frac{1}{z(\zeta k)^{\frac{\alpha}{1-\eta}}}. \tag{19}$$

The liquidation threshold $\underline{\varepsilon}_z(s)$ is the value of ε for which $i^{\max} = i^{\min}$:

$$b - (1-\lambda)\zeta k + (i^{\max} - \omega)\, w\, n(s, \underline{\varepsilon}_z(s), i^{\max}) = 0.$$

This implies

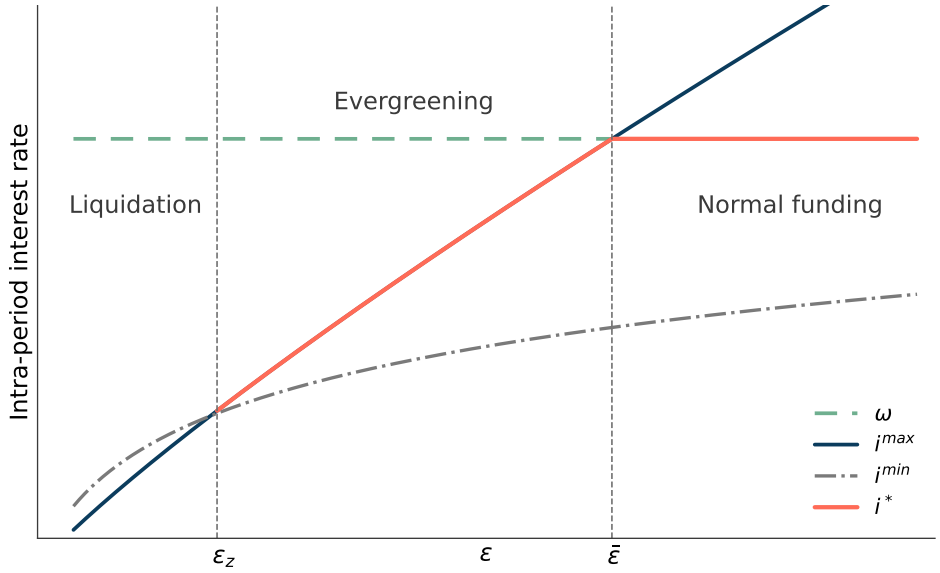
$$\begin{aligned}\underline{\tilde{\varepsilon}}_z(s) = &\left[\frac{w(1+\omega)}{b - (1-\lambda)\zeta k + \frac{\eta}{1-\eta}\left[b + \nu - (1-\delta)\zeta k - V_1(s)\right]}\right]^{\frac{\eta}{1-\eta}} \\ &\times \left[\frac{b + \nu - (1-\delta)\zeta k - V_1(s)}{(1-\eta)(\zeta k)^{\alpha}}\right]^{\frac{1}{1-\eta}} \frac{1}{z}.\end{aligned}$$

In practice, the interest rate is constrained below by i^{reg}, thus the relevant threshold is given by:

$$\underline{\varepsilon}_z(s) = \max\left\{\underline{\tilde{\varepsilon}}_z(s), \left[\frac{b + \nu - (1-\delta)\zeta k - V_1(s)}{1-\eta}\right]\left[\frac{w(1+i^{reg})}{\eta}\right]^{\frac{\eta}{1-\eta}} \frac{1}{z(\zeta k)^{\frac{\alpha}{1-\eta}}}\right\} \tag{20}$$

Figure 9 provides a graphical representation of the intraperiod equilibrium. Idiosyncratic productivity is on the horizontal axis. The blue dashed line represents ω, the competitive funding rate. The gray dot-dashed line is $i^{\min}$, the minimum interest rate at which the bank is willing to lend (i.e., such that the payoff of lending today and recovering legacy debt exceeds that of liquidation), and the solid black line is $i^{\max}$, the maximum interest at which the firm is willing to borrow and not default. For high enough ε, the firm borrows at the competitive rate. At some point, $i^{\max}$ falls below ω but is still higher than

Figure 9: Intraperiod equilibrium for the evergreening economy.



Notes: Intraperiod equilibrium for the evergreening economy as a function of idiosyncratic productivity ε. i^* denotes the equilibrium interest rate offered by the lender.

$i^{\min}$. This is the evergreening region, in which the lender is willing to lend at an intraperiod rate below the market rate. This happens because the difference between the value of repaid legacy debt and recovered capital in case of default exceeds any potential losses the lender may incur by lending below its funding cost. For low enough ε, however, the bank's minimum lending rate exceeds the maximum rate the firm is willing to pay, and so the lender prefers to liquidate the firm. The thick red line represents the rate that is offered in equilibrium as a function of ε.

A.1.2 Proposition 2: Restructuring Economy

First, note that—as in the evergreening economy—lenders offer restructuring only to firms with productivity below the distress threshold, $\varepsilon < \bar{\varepsilon}(s)$. For such distressed firms, the lender prefers restructuring to liquidation if and only if

$$(1-\xi)\, b \;\geq\; (1-\lambda)\zeta k,$$

that is, when the amount recovered under restructuring exceeds the recovery of the collateral. This condition implies that the maximum feasible restructuring is independent of

the idiosyncratic shock ε:

$$\xi^{\max}(k, b, \zeta) = 1 - \min\left\{\frac{(1-\lambda)\zeta k}{b}, 1\right\}.$$

From the point of view of a distressed firm, restructuring ensures survival if and only if

$$\varepsilon z\, \pi(k, \zeta, \omega) - (1 - \xi)\, b - \nu + (1 - \delta)\zeta k + V_1(s) \;\geq\; 0,$$

which implies that the minimum share of debt write-off needed for the firm to survive is

$$\xi^{\min}(s, \varepsilon, \zeta) = \frac{b + \nu - (1-\delta)\zeta k - V_1(s) - \varepsilon z\, \pi(k, \zeta, \omega)}{b}.$$

We assume that the lender offers a restructuring program exactly equal to this amount, leaving the firm indifferent between exiting and continuing. Restructuring is therefore feasible for a distressed firm if (i) the lender is willing to offer the required write-off needed for survival, and (ii) this amount does not exceed the regulatory limit. That is, restructuring is feasible if and only if

$$\min\{\xi^{\max}(k, b, \zeta),\, \xi^{reg}\} \;\geq\; \xi^{\min}(s, \varepsilon, \zeta).$$

The right-hand side is monotonically decreasing in ε. Hence, there exists a threshold level of productivity above which restructuring is feasible, and below which it is not:

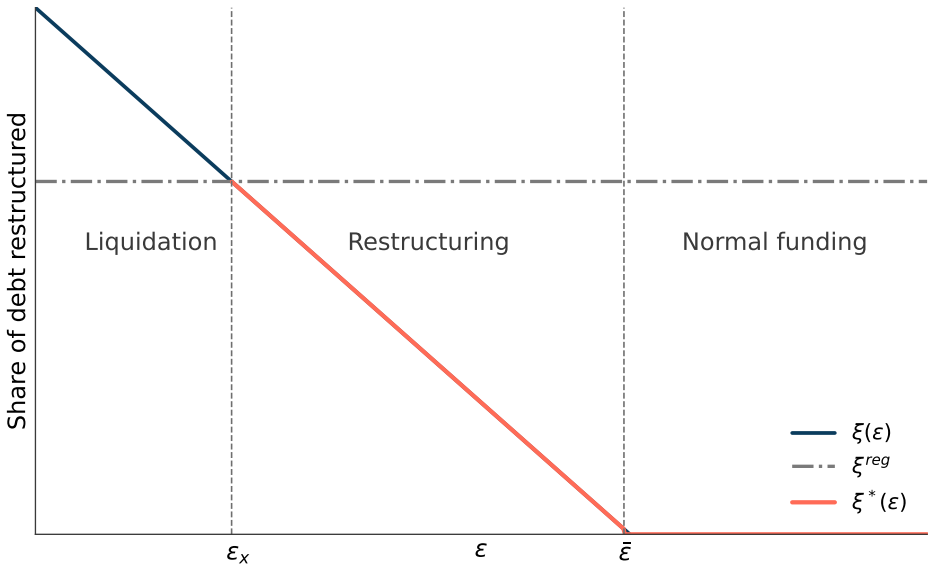
$$\underline{\varepsilon}_x(s, \zeta) = \frac{\nu - (1-\delta)\zeta k - V_1(s) + b(1 - \min\{\xi^{\max}(k, b, \zeta),\, \xi^{reg}\})}{z\, \pi(k, \zeta, \omega)}.$$

The intraperiod equilibrium is therefore again characterized by three regions:

1. if $\varepsilon > \bar{\varepsilon}(s, \zeta)$, the firm receives normal funding and no restructuring occurs;
2. if $\varepsilon \in [\,\underline{\varepsilon}_x(s, \zeta),\, \bar{\varepsilon}(s)\,]$, the firm's debt is restructured;
3. if $\varepsilon < \underline{\varepsilon}_x(s, \zeta)$, restructuring is not feasible and the firm is liquidated.

The restructuring equilibrium is depicted in Figure 10 as a function of the idiosyncratic shock ε. The horizontal dashed line represents the regulatory restructuring limit, the solid black line shows the unconstrained amount of restructuring the lender would choose, and the solid red line shows the resulting optimal restructuring policy given the constraints.

Figure 10: Intraperiod equilibrium for the restructuring economy.



A.1.3 Proposition 3: Guarantee Economy

As in the previous economies, firms that are not distressed with $\varepsilon > \bar{\varepsilon}(s)$ are not eligible for transfers (i.e., the guarantee does not trigger). A distressed firm survives if and only if the transfer is large enough:

$$z\varepsilon\,\pi(k,\zeta,\omega) - b + (1-\delta)\zeta k - \nu + V_1(s) + \tau(s,\varepsilon) \geq 0,$$

which implies that the minimum transfer required for the firm to survive is

$$\tau(s,\varepsilon) = -\left[z\varepsilon\,\pi(k,\zeta,\omega) - b + (1-\delta)\zeta k - \nu + V_1(s)\right].$$

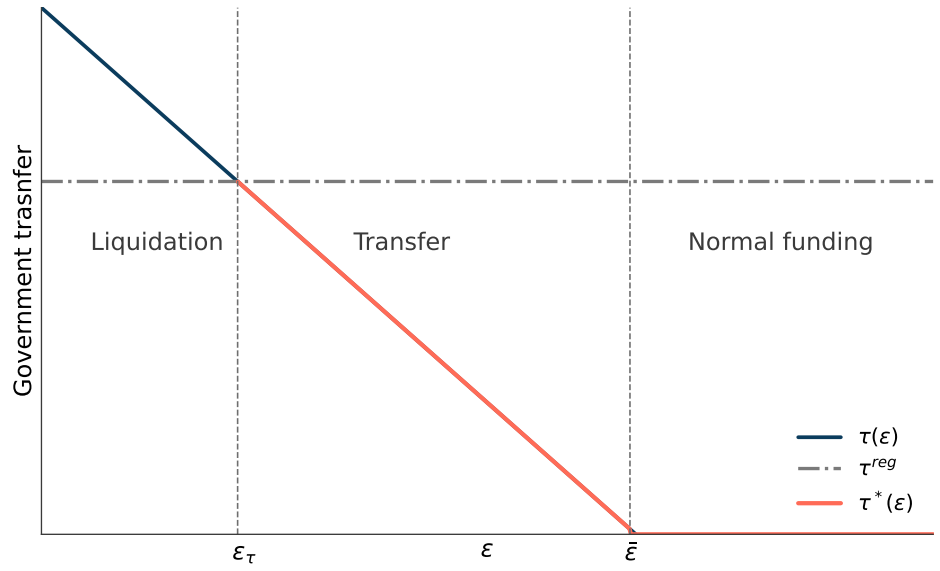
Note that the required transfer is decreasing in ε. Thus, there exists a threshold level of productivity below which a firm only survives with a transfer that exceeds the limit τ^{reg}. This threshold is given by

$$\underline{\varepsilon}_\tau(s,\zeta) = \frac{b + \nu - (1-\delta)\zeta k - V_1(s) - \tau^{reg}}{z\,\pi(k,\zeta,\omega)}.$$

The equilibrium characterization is similar to that of the restructuring economy:

1. if $\varepsilon > \bar{\varepsilon}(s,\zeta)$, firms survive and receive no transfers;
2. if $\varepsilon \in [\,\underline{\varepsilon}_\tau(s,\zeta),\ \bar{\varepsilon}(s)\,]$, firms receive fiscal support and fully repay their debt;

Figure 11: Intraperiod equilibrium for the guarantee economy.



3. if $\varepsilon < \underline{\varepsilon}_\tau(s,\zeta)$, the firm cannot survive without a transfer larger than the limit and therefore exits (without receiving a transfer).

The equilibrium is shown in Figure 11 as a function of the idiosyncratic shock ε. The solid black line represents the unconstrained level of transfers the firm would require to survive. The horizontal red dashed line depicts the transfer limit, and the solid red line represents the transfer actually offered in equilibrium.

A.2 Intraperiod Equilibrium Conditions

In this appendix, we provide a complete characterization of the intraperiod equilibrium for each of the four economies.

A.2.1 Hard Credit

1. When $\varepsilon \geq \bar{\varepsilon}$, the firm finds itself in the normal funding region. The relevant intraperiod objects are:

$$
\begin{aligned}
i &= \omega \\
n &= z\varepsilon \left(\frac{\eta(\zeta k)^\alpha}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\
V^p &= z\varepsilon(\zeta k)^{\frac{\alpha}{1-\eta}} \left(\frac{\eta}{w(1+\omega)} \right)^{\frac{\eta}{1-\eta}} (1-\eta) - b - \nu + (1-\delta)\zeta k + V_1(s)
\end{aligned}
$$

$$W_0 = b$$

2. When $\varepsilon < \underline{\varepsilon}$, the firm is liquidated, and so i is not defined:

$$\begin{aligned} n &= 0 \\ V^p &= 0 \\ W_0 &= (1-\lambda)\zeta k \end{aligned}$$

A.2.2 Evergreening

1. When $\varepsilon \geq \bar{\varepsilon}$, the firm finds itself in the normal funding region. The relevant intraperiod objects are:

$$\begin{aligned} i &= \omega \\ n &= z\varepsilon \left(\frac{\eta(\zeta k)^{\alpha}}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\ V^p &= z\varepsilon(\zeta k)^{\frac{\alpha}{1-\eta}} \left(\frac{\eta}{w(1+\omega)} \right)^{\frac{\eta}{1-\eta}} (1-\eta) - b - \nu + (1-\delta)\zeta k + V_1(s) \\ W_0 &= b \end{aligned}$$

2. When $\varepsilon \in [\underline{\varepsilon}_z, \bar{\varepsilon}]$, the firm is in the evergreening region:

$$\begin{aligned} i &= \left[\frac{\eta}{w} (z\varepsilon)^{\frac{1-\eta}{\eta}} (\zeta k)^{\frac{\alpha}{\eta}} \left(\frac{1-\eta}{b - (1-\delta)\zeta k + \nu - V_1(s)} \right)^{\frac{1-\eta}{\eta}} - 1 \right] (= i^{\max}) \\ n &= \left[\frac{b + \nu - (1-\delta)\zeta k - V_1(s)}{(1-\eta)(z\varepsilon)^{1-\eta}(\zeta k)^{\alpha}} \right]^{\frac{1}{\eta}} \\ V^p &= 0 \\ W_0 &= b + \frac{\eta}{1-\eta}[b + \nu - (1-\delta)\zeta k - V_1(s)] - (1+\omega)w \left[\frac{b + \nu - (1-\delta)\zeta k - V_1(s)}{(1-\eta)(z\varepsilon)^{1-\eta}(\zeta k)^{\alpha}} \right]^{\frac{1}{\eta}} \end{aligned}$$

3. When $\varepsilon < \underline{\varepsilon}_z$, the firm is liquidated, and so i is not defined:

$$\begin{aligned} n &= 0 \\ V^p &= 0 \\ W_0 &= (1-\lambda)\zeta k \end{aligned}$$

A.2.3 Restructuring

1. When $\varepsilon \geq \bar{\varepsilon}$, the firm finds itself in the normal funding region. The relevant intraperiod objects are:

$$\begin{aligned} i &= \omega \\ n &= z\varepsilon \left(\frac{\eta(\zeta k)^{\alpha}}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\ V^p &= z\varepsilon(\zeta k)^{\frac{\alpha}{1-\eta}} \left(\frac{\eta}{w(1+\omega)} \right)^{\frac{\eta}{1-\eta}} (1-\eta) - b - \nu + (1-\delta)\zeta k + V_1(s) \\ \xi &= 0 \\ W_0 &= b \end{aligned}$$

2. When $\varepsilon \in [\underline{\varepsilon}_x, \bar{\varepsilon}]$, the firm is in the restructuring region:

$$\begin{aligned} i &= \omega \\ n &= z\varepsilon \left(\frac{\eta(\zeta k)^{\alpha}}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\ V^p &= 0 \\ \xi &= \frac{b + \nu - (1-\delta)\zeta k - V_1(s) - \varepsilon z \pi(k, \zeta; w, \omega)}{b} \\ W_0 &= \varepsilon z \pi(k, \zeta; w, \omega) + (1-\delta)\zeta k - \nu + V_1(s) \end{aligned}$$

3. When $\varepsilon < \underline{\varepsilon}_x$, the firm is liquidated, and so (i, ξ) are not defined:

$$\begin{aligned} n &= 0 \\ V^p &= 0 \\ W_0 &= (1-\lambda)\zeta k \end{aligned}$$

A.2.4 Guarantee

1. When $\varepsilon \geq \bar{\varepsilon}$, the firm finds itself in the normal funding region. The relevant intraperiod objects are:

$$i = \omega$$

$$
\begin{aligned}
n &= z\varepsilon \left(\frac{\eta(\zeta k)^{\alpha}}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\
V^p &= z\varepsilon(\zeta k)^{\frac{\alpha}{1-\eta}} \left(\frac{\eta}{w(1+\omega)} \right)^{\frac{\eta}{1-\eta}} (1-\eta) - b - \nu + (1-\delta)\zeta k + V_1(s) \\
\tau &= 0 \\
W_0 &= b
\end{aligned}
$$

2. When $\varepsilon \in [\underline{\varepsilon}_\tau, \bar{\varepsilon}]$, the firm benefits from the fiscal guarantee:

$$
\begin{aligned}
i &= \omega \\
n &= z\varepsilon \left(\frac{\eta(\zeta k)^{\alpha}}{w(1+\omega)} \right)^{\frac{1}{1-\eta}} \\
V^p &= 0 \\
\tau &= b + \nu - (1-\delta)\zeta k - V_1(s) - \varepsilon z \pi(k, \zeta; w, \omega) \\
W_0 &= b
\end{aligned}
$$

3. When $\varepsilon < \underline{\varepsilon}_\tau$, the firm is liquidated, and so i is not defined:

$$
\begin{aligned}
n &= 0 \\
V^p &= 0 \\
\tau &= 0 \\
W_0 &= (1-\lambda)\zeta k
\end{aligned}
$$

For reference, the total fiscal cost for this program can be computed as

$$
\text{cost}_\tau(s) = \int_{\underline{\varepsilon}_\tau(s)}^{\bar{\varepsilon}(s)} \tau(s, \varepsilon) \mathrm{d}F(\varepsilon) = z\pi(k, \zeta; w, \omega) \int_{\underline{\varepsilon}_\tau(s)}^{\bar{\varepsilon}(s)} [\bar{\varepsilon}(s) - \varepsilon] \mathrm{d}F(\varepsilon)
$$

A.3 Dynamic Decisions

Given the solution to the intraperiod equilibrium, we can characterize the dynamic decisions and payoffs of lenders and firms.

Firms. Recall that the firm's dynamic problem is given by 5. Given the intraperiod equilibrium, and denoting the Lagrange multiplier on the borrowing constraint by ς, we can derive the FOC for each of the firm's decisions as:

$$[k']: \quad \mathbb{E}_{\zeta'|\zeta}\left\{M\cdot\int_{\bar{\varepsilon}(s')}^{\infty}\left[z'\varepsilon'\left[\frac{\eta}{w'(1+\omega)}\right]^{\frac{\eta}{1-\eta}}\alpha(\zeta'k')^{\frac{\alpha+\eta-1}{1-\eta}}\zeta'+(1-\delta)\zeta'\right]\mathrm{d}F(\varepsilon')\right\}$$
$$+\varsigma\theta-1=0 \tag{21}$$
$$[b']: \quad q-\mathbb{E}_{\zeta'|\zeta}\left\{M\cdot\int_{\bar{\varepsilon}(s')}^{\infty}\mathrm{d}F(\varepsilon')\right\}-\varsigma=0 \tag{22}$$
$$[z']: \quad -\phi\left[\frac{z'}{z(\varepsilon^*)^{\rho}}\right]^{\kappa}\frac{\kappa}{z'}+\mathbb{E}_{\zeta'|\zeta}\left\{M\cdot\int_{\bar{\varepsilon}(s')}^{\infty}\varepsilon'\left[\frac{\eta}{w'(1+\omega)}\right]^{\frac{\eta}{1-\eta}}(1-\eta)(\zeta'k')^{\frac{\alpha}{1-\eta}}\mathrm{d}F(\varepsilon')\right\}$$
$$+\mathbb{E}_{\zeta'|\zeta}\left\{M\cdot\int_{\bar{\varepsilon}(s')}^{\infty}(1-\rho)\kappa\phi'\left(\frac{z''}{z'(\varepsilon^{*\prime})^{\rho}}\right)^{\kappa}\frac{1}{z'}\mathrm{d}F(\varepsilon')\right\}=0 \tag{23}$$

Notice that when choosing investment, innovation, and debt, the firm does not internalize any future states where $\varepsilon' < \bar{\varepsilon}(s')$, even if it survives through evergreening. Thus an increase in this threshold tends to be associated with underinvestment in both capital and R&D in partial equilibrium.

Lenders. For brevity, we report the lender's dynamic decisions for the evergreening economy. The equivalent conditions for the other economies are easy to derive given the expressions for the intraperiod equilibrium in A.2. Given the intraperiod equilibrium for the evergreening economy, we can write the value of the lender at the beginning of the period as:

$$\begin{aligned}W_0(s,\varepsilon) = {} & \mathbf{1}[\varepsilon\geq\bar{\varepsilon}(s)]\cdot b\\ & +\mathbf{1}[\underline{\varepsilon}(s)\leq\varepsilon<\bar{\varepsilon}(s)]\cdot\left\{b+\frac{\eta[b+\nu-(1-\delta)\zeta k-V_1(s)]}{1-\eta}\right\}\\ & -\mathbf{1}[\underline{\varepsilon}(s)\leq\varepsilon<\bar{\varepsilon}(s)]\cdot\left\{w(1+\omega)\left[\frac{b+\nu-(1-\delta)\zeta k-V_1(s)}{(1-\eta)(z\varepsilon)^{1-\eta}(\zeta k)^{\alpha}}\right]^{\frac{1}{\eta}}\right\}\\ & +\mathbf{1}[\varepsilon<\underline{\varepsilon}(s)]\min\{(1-\lambda)\zeta k,b\}\end{aligned}$$

This can be combined with 7 to write an expression for the equilibrium price of intertemporal debt:

$$q=\mathbb{E}_{\zeta'|\zeta}M\cdot\left\{\int_{\bar{\varepsilon}(s')}^{\infty}\mathrm{d}F(\varepsilon')+\int_{\underline{\varepsilon}(s')}^{\bar{\varepsilon}(s')}\frac{b'+\eta[\nu-(1-\delta)(\zeta'k')-V']}{b'(1-\eta)}\mathrm{d}F(\varepsilon')\right\}$$

$$-\mathbb{E}_{\zeta'|\zeta} M \cdot \left\{ \int_{\underline{\varepsilon}(s')}^{\bar{\varepsilon}(s')} \frac{w'(1+\omega)}{b'} \left(\frac{b' + \nu - (1-\delta)(\zeta' k') - V'}{(1-\eta)(z'\varepsilon')^{1-\eta}(\zeta' k')^{\alpha}} \right)^{\frac{1}{\eta}} \mathrm{d}F(\varepsilon') \right\}$$

$$+\mathbb{E}_{\zeta'|\zeta} M \cdot \left\{ \int_{0}^{\underline{\varepsilon}(s')} \min\left[1, \frac{(1-\lambda)\zeta' k'}{b'}\right] \mathrm{d}F(\varepsilon') \right\} \tag{24}$$

A.4 Equilibrium Definition

A competitive equilibrium is a sequence of allocations $(C_t, N_t, D_{t+1}, z_{t+1}, k_{t+1}, b_{t+1}, n_t, \ell_t)$, prices (w_t, q_t, i_t), and thresholds for liquidation and distress $(\underline{\varepsilon}_t, \bar{\varepsilon}_t)$, such that for all t:

1. **Household optimization.** The representative household chooses $\{C_t, N_t, D_{t+1}\}$ to maximize lifetime utility subject to its budget constraint, taking prices and firm distributions as given.

2. **Firm optimization.** Firms choose intraperiod allocations (n_t, ℓ_t) and interperiod decisions $(z_{t+1}, k_{t+1}, b_{t+1})$ to maximize firm value, taking prices, lending policies, and thresholds as given.

3. **Lender optimization.** Lenders choose intraperiod contract terms and the interperiod price of debt $\{i_t, \xi_t, q_t\}$ to maximize profits subject to regulatory constraints, zero-profit/free-entry conditions, and funding constraints. The thresholds $(\underline{\varepsilon}_t, \bar{\varepsilon}_t)$ satisfy the firm's indifference conditions implied by optimal lending contracts.

4. **Market clearing.** The labor, goods, deposit, intraperiod debt, and interperiod debt markets clear.

5. **Consistency of laws of motion.** Aggregate states evolve according to the transition rules implied by firm decisions and the stochastic processes for shocks. In equilibrium, all firms make identical dynamic decisions, and so $s_t = S_t$.

A.5 Full List of Equilibrium Conditions

Evergreening Economy.

$$\tilde{\Theta} = (\zeta \tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)} \right]^{\frac{\eta}{1-\eta}} (1-\eta) \int_{\bar{\varepsilon}}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) \tag{E.1}$$

$$1 - \theta q = \mathbb{E} M' \left\{ \frac{\alpha}{1-\eta} \frac{\tilde{\Theta}'}{\tilde{k}'} + \int_{\bar{\varepsilon}'}^{\infty} \left[(1-\delta)\zeta' - \theta \right] \mathrm{d}F(\varepsilon') \right\} \tag{E.2}$$

$$\tilde{b}' = \theta \tilde{k}' \tag{E.3}$$

$$\tilde{V} = -\tilde{\phi}\left(\frac{G_z}{(\varepsilon^*)^\rho}\right)^\kappa + (G_z)^{\frac{1-\eta}{1-\alpha}}\left[-\tilde{k}' + q\tilde{b}' + \mathbb{E}M'\left\{\tilde{\Theta}' + \int_{\bar{\varepsilon}'}^{\infty}[-\tilde{b}' + (1-\delta)\zeta'\tilde{k}' - \nu + \tilde{V}']\mathrm{d}F(\varepsilon')\right\}\right] \tag{E.4}$$

$$\sigma\tilde{C}N^\varphi = \tilde{w}\left[1 + (\sigma-1)\frac{N^{1+\varphi}}{1+\varphi}\right] \tag{E.5}$$

$$M' = \beta\frac{\left[1 + (\sigma-1) = \frac{(N')^{1+\varphi}}{1+\varphi}\right]^\sigma(\tilde{C}')^{-\sigma}}{\left[1 + (\sigma-1)\frac{N^{1+\varphi}}{1+\varphi}\right]^\sigma\tilde{C}^{-\sigma}}(G_z)^{-\sigma\frac{1-\eta}{1-\alpha}} \tag{E.6}$$

$$Q^d = \mathbb{E}M' \tag{E.7}$$

$$N = \left[\frac{\eta(\zeta\tilde{k})^\alpha}{\tilde{w}(1+\omega)}\right]^{\frac{1}{1-\eta}}\int_{\bar{\varepsilon}}^{\infty}\varepsilon\mathrm{d}F(\varepsilon) + \left[\frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V}}{(1-\eta)(\zeta\tilde{k})^\alpha}\right]^{1/\eta}\int_{\underline{\varepsilon}}^{\bar{\varepsilon}}\varepsilon^{-\frac{1-\eta}{\eta}}\mathrm{d}F(\varepsilon) \tag{E.8}$$

$$\begin{aligned} q =& \mathbb{E}M'\left\{\int_{\bar{\varepsilon}'}^{\infty}\mathrm{d}F + \int_{\underline{\varepsilon}'}^{\bar{\varepsilon}'}\frac{\tilde{b}' + \eta[\nu - (1-\delta)(\zeta'\tilde{k}') - \tilde{V}']}{\tilde{b}'(1-\eta)}\mathrm{d}F\right\} \\ &-\mathbb{E}M'\left\{\int_{\underline{\varepsilon}'}^{\bar{\varepsilon}'}\frac{\tilde{w}'(1+\omega)}{\tilde{b}'}\left(\frac{\tilde{b}' + \nu - (1-\delta)(\zeta'\tilde{k}') - \tilde{V}'}{(1-\eta)(\varepsilon')^{1-\eta}(\zeta'\tilde{k}')^\alpha}\right)^{\frac{1}{\eta}}\mathrm{d}F\right\} \\ &+\mathbb{E}M'\left\{\int_0^{\underline{\varepsilon}'}\min\left[1, \frac{(1-\lambda)(\zeta'\tilde{k}')}{\tilde{b}'}\right]\mathrm{d}F\right\} \end{aligned} \tag{E.9}$$

$$\bar{\varepsilon} = \frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V}}{1-\eta}\left[\frac{\tilde{w}(1+\omega)}{\eta}\right]^{\frac{\eta}{1-\eta}}\frac{1}{(\zeta\tilde{k})^{\frac{\alpha}{1-\eta}}} \tag{E.10}$$

$$\underline{\varepsilon}_{unc} = \left[\frac{\tilde{w}(1+\omega)}{\max\{0, \tilde{b} - (1-\lambda)\zeta\tilde{k}\} + \frac{\eta}{1-\eta}(\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V})}\right]^{\frac{\eta}{1-\eta}}\left[\frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V}}{(1-\eta)(\zeta\tilde{k})^\alpha}\right]^{\frac{1}{1-\eta}} \tag{E.11}$$

$$\underline{\varepsilon}_{con} = \frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V}}{1-\eta}\left[\frac{\tilde{w}(1+i^{reg})}{\eta}\right]^{\frac{\eta}{1-\eta}}\frac{1}{(\zeta\tilde{k})^{\frac{\alpha}{1-\eta}}} \tag{E.12}$$

$$\underline{\varepsilon} = \max\{\underline{\varepsilon}_{unc}, \underline{\varepsilon}_{con}\} \tag{E.13}$$

$$\tilde{C} = \tilde{\Lambda} - (G_z)^{\frac{1-\eta}{1-\alpha}}\tilde{k}' - \tilde{\phi}\left(\frac{G_z}{(\varepsilon^*)^\rho}\right)^\kappa \tag{E.14}$$

$$\tilde{\Lambda} = \frac{\tilde{\Theta}}{1-\eta} + [F(\bar{\varepsilon}) - F(\underline{\varepsilon})]\frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V}}{1-\eta} + [1 - F(\underline{\varepsilon})][(1-\delta)\zeta\tilde{k} - \nu] + F(\underline{\varepsilon})(1-\lambda)(\zeta\tilde{k}) \tag{E.15}$$

$$G_z = (\varepsilon^*)^{\rho\frac{\kappa(1-\alpha)}{\kappa(1-\alpha)-(1-\eta)}}\left\{\mathbb{E}M'\left[\frac{\tilde{\Theta}'}{\kappa\tilde{\phi}} + (1-\rho)\left(\frac{G_z'}{(\varepsilon^{*\prime})^\rho}\right)^\kappa[1 - F(\bar{\varepsilon}')]\right]\right\}^{\frac{(1-\alpha)}{\kappa(1-\alpha)-(1-\eta)}} \tag{E.16}$$

$$\varepsilon^* = \frac{\int_{\underline{\varepsilon}}^{\infty}\varepsilon\mathrm{d}F(\varepsilon)}{1 - F(\underline{\varepsilon})} \tag{E.17}$$

Restructuring Economy. The equilibrium conditions for the restructuring economy are identical with the following exceptions. The equation numbering corresponds to the equations above.

$$N = \left[\frac{\eta(\zeta\tilde{k})^\alpha}{\tilde{w}(1+\omega)}\right]^{\frac{1}{1-\eta}}\int_{\underline{\varepsilon}_x}^{\infty}\varepsilon\mathrm{d}F(\varepsilon) \tag{R.8}$$

$$q = \mathbb{E}M' \left\{ \int_{\bar{\varepsilon}'}^{\infty} \mathrm{d}F + \int_{\underline{\varepsilon}'_x}^{\bar{\varepsilon}'} \frac{(\zeta'\tilde{k}')^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}'(1+\omega)}\right]^{\frac{\eta}{1-\eta}} (1-\eta)\varepsilon' - \nu + (1-\delta)(\zeta'\tilde{k}') + \tilde{V}'}{\tilde{b}'} \mathrm{d}F \right\} \tag{R.9}$$

$$+\mathbb{E}M' \left\{ \int_0^{\underline{\varepsilon}'_x} \min\left[1, \frac{(1-\lambda)(\zeta'\tilde{k}')}{\tilde{b}'}\right] \mathrm{d}F \right\}$$

$$\underline{\varepsilon}_x = \frac{\nu - (1-\delta)\zeta\tilde{k} - \tilde{V} + \max\{(1-\xi^{reg})\tilde{b}, (1-\lambda)\zeta\tilde{k}\}}{(\zeta\tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)}\right]^{\frac{\eta}{1-\eta}} (1-\eta)} \tag{R.13}$$

$$\tilde{\Lambda} = (\zeta\tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)}\right]^{\frac{\eta}{1-\eta}} \int_{\underline{\varepsilon}_x}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) + [1 - F(\underline{\varepsilon}_x)][(1-\delta)\zeta\tilde{k} - \nu] + F(\underline{\varepsilon}_x)(1-\lambda)(\zeta\tilde{k}) \tag{R.15}$$

Guarantee Economy. The equilibrium conditions for the guarantee economy are identical with the following exceptions. The equation numbering corresponds to the equations above.

$$N = \left[\frac{\eta(\zeta\tilde{k})^{\alpha}}{\tilde{w}(1+\omega)}\right]^{\frac{1}{1-\eta}} \int_{\underline{\varepsilon}_\tau}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) \tag{G.8}$$

$$q = \mathbb{E}M' \left\{ \int_{\underline{\varepsilon}'_\tau}^{\infty} \mathrm{d}F + \int_0^{\underline{\varepsilon}'_\tau} \min\left[1, \frac{(1-\lambda)(\zeta'\tilde{k}')}{\tilde{b}'}\right] \mathrm{d}F \right\} \tag{G.9}$$

$$\underline{\varepsilon}_\tau = \frac{\tilde{b} + \nu - (1-\delta)\zeta\tilde{k} - \tilde{V} - \tau^{reg}}{(\zeta\tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)}\right]^{\frac{\eta}{1-\eta}} (1-\eta)} \tag{G.13}$$

$$\tilde{\Lambda} = (\zeta\tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)}\right]^{\frac{\eta}{1-\eta}} \int_{\underline{\varepsilon}_\tau}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) + [1 - F(\underline{\varepsilon}_\tau)][(1-\delta)\zeta\tilde{k} - \nu] + F(\underline{\varepsilon}_\tau)(1-\lambda)(\zeta\tilde{k}) \tag{G.15}$$

Hard Credit Economy. The equilibrium conditions for the hard credit economy are identical with the following exceptions. The equation numbering corresponds to the equations above.

$$N = \left[\frac{\eta(\zeta\tilde{k})^{\alpha}}{\tilde{w}(1+\omega)}\right]^{\frac{1}{1-\eta}} \int_{\bar{\varepsilon}}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) \tag{HC.8}$$

$$q = \mathbb{E}M' \left\{ \int_{\bar{\varepsilon}'}^{\infty} \mathrm{d}F + \int_0^{\bar{\varepsilon}'} \min\left[1, \frac{(1-\lambda)(\zeta'\tilde{k}')}{\tilde{b}'}\right] \mathrm{d}F \right\} \tag{HC.9}$$

$$\underline{\varepsilon} = \bar{\varepsilon} \tag{HC.13}$$

$$\tilde{\Lambda} = (\zeta\tilde{k})^{\frac{\alpha}{1-\eta}} \left[\frac{\eta}{\tilde{w}(1+\omega)}\right]^{\frac{\eta}{1-\eta}} \int_{\bar{\varepsilon}}^{\infty} \varepsilon \mathrm{d}F(\varepsilon) + [1 - F(\bar{\varepsilon})][(1-\delta)\zeta\tilde{k} - \nu] + F(\bar{\varepsilon})(1-\lambda)(\zeta\tilde{k}) \tag{HC.15}$$

B Further Evidence on Direct Estimation

In this appendix, we compare the results of our baseline regression approach in Section 3.1 to alternative ones used in the prior literature and provide a range of further evidence.

Comparison to Literature. How do our estimates compare to related findings in the literature? While previous studies have estimated spillover effects of R&D investment across various dimensions (see, e.g., Bloom, Schankerman and Van Reenen, 2013, Arqué-Castells and Spulber, 2022), we are not aware of any prior studies that have analyzed how firms learn from each other's productivity. In contrast, a large body of literature estimates the effects of R&D investment on firm productivity. However, prior studies have either used a firm's "R&D knowledge stock" accumulated through past R&D expenditures or a measure of R&D intensity, typically defined as R&D expenditures over firm output, to evaluate this relation. To assess the plausibility of our estimate for β_1, we therefore employ these alternative regressors, and separately report results based on the outlined instrumental variable approach as well as simple OLS regressions in Table 7.

To begin, columns (i) and (ii) compare our baseline IV results to an OLS approach of the same regression setup. This comparison shows that our IV approach yields a substantially larger coefficient for β_1 of 0.35 as opposed to 0.04 based on an OLS regression, underscoring the importance of the IV approach. Columns (iii) and (iv) instead use log-values of firms' R&D knowledge stocks as regressors, and again conduct IV and OLS estimations separately.[31] We obtain values for β_1 of 0.19 based on the IV approach, and 0.06 based on the OLS approach. The IV estimate lies at the upper end—but within the range—of prior estimates (see, e.g., Table 2 in Hall, Mairesse and Mohnen, 2010). Columns (v) and (vi) analogously report estimates for R&D intensity, giving us estimates of 0.52 for the IV approach and a coefficient that is close to zero for the OLS approach.[32] The IV estimate is again at the upper end of previous estimates in the literature (see, e.g., Table 3 in Hall, Mairesse and Mohnen, 2010). Thus, we view our identification approach as yielding similar effects of R&D investment on firm productivity growth and highlighting the importance of addressing the endogeneity of R&D expenditures.

[31] We define the R&D knowledge stock as $K^{R\&D}_{i,t} = (1-\delta) \cdot K^{R\&D}_{i,t-1} + R\&D_{i,t}$ and set $\delta = 0.15$ as in Bloom, Schankerman and Van Reenen (2013).

[32] We define R&D intensity as firm R&D expenditures relative to value added, but obtain similar results when dividing by sales instead. Such a regression specification could alternatively be derived from a R&D cost function that takes the form $R\&D_{i,s,t} = ValueAdded_{i,s,t} \cdot \log(\phi_t \cdot (z_{i,s,t+1}/(z^{1-\rho}_{i,s,t}(a^*_{i,s,t})^{\rho}))^{\kappa})$, and is therefore different than our original functional form (13).

Table 7: Further Evidence (1) - Estimates R&D Cost Function.

	(i) Baseline (IV)	(ii) Baseline (OLS)	(iii) Knowledge Stock (IV)	(iv) Knowledge Stock (OLS)	(v) R&D Intensity (IV)	(vi) R&D Intensity (OLS)
β_1 $(= 1/\kappa)$	0.35***	0.04***	0.19***	0.06***	0.52***	-0.01
	(0.09)	(0.00)	(0.05)	(0.01)	(0.11)	(0.02)
β_2 $(= \rho)$	0.29***	0.23***	0.30***	0.27***	0.16***	0.18***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Time FE	✓	✓	✓	✓	✓	✓
First-Stage F-Stat	19		51		169	
R-squared	0.12	0.12	0.15	0.15	0.1	0.09
Observations	34,556	34,556	21,406	21,409	69,888	70,008
Number of Firms	4,847	4,847	3,471	3,472	9,025	9,037
Number of Industries	46	46	46	46	50	50

Notes: Estimation results for regression (15). R&D intensity is defined as firm R&D expenditures relative to value added and we exclude outlier by dropping observations larger than 10 and smaller than zero. Standard errors in parentheses are clustered by firm. See text for descriptions on each regression. Sample: 1982-2023. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Further Evidence. Tables 8 and 9 provide further evidence. Columns (ii) and (iii) in Table 8 show the results from regressions that test for the dynamic response of firm productivity by changing the timing of the dependent variable to $(\log z_{i,s,t+2} - \log z_{i,s,t-1})$ and $(\log z_{i,s,t+3} - \log z_{i,s,t-1})$, respectively. The estimated coefficients β_1 and β_2 are slightly larger but close to our original estimates, illustrating that most of the productivity dynamics occur within the one-year horizon of our baseline specification, but also some thereafter. Column (iv) employs labor productivity—defined as value added/employees—instead of TFP, which has the advantage that it does not require a separate estimation step. While the estimate for β_2 remains close to our baseline, the estimate for β_1 differs quantitatively due to the alternative variable definitions. Column (v) addresses the concern that the regressor $\log(a^*_{i,s,t-1}/z_{i,s,t-1})$ is generated from a separate estimation step, yielding possibly standard errors that are too low. To this end, we employ a bootstrap estimation by constructing new estimation samples through resampling with replacement. The estimation results are again similar as the bootstrap-estimated standard errors are only slightly larger. Column (vi) also tests the robustness of inference, considering a more conservative approach to clustering the standard errors by state and industry code. While our regressors of interest remain statistically different from zero at the 1 percent level, the first-stage F-statistic falls below typical levels for weak instruments.

Table 8: Further Evidence (2) - Estimates R&D Cost Function.

	(i) Baseline	(ii) h=2	(iii) h=3	(iv) LP	(v) Bootstrap	(vi) Cluster
β_1 $(= 1/\kappa)$	0.35***	0.41***	0.51***	0.17***	0.36***	0.35***
	(0.09)	(0.12)	(0.18)	(0.04)	(0.14)	(0.10)
β_2 $(= \rho)$	0.29***	0.34***	0.40***	0.33***	0.29***	0.29***
	(0.02)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
Time FE	✓	✓	✓	✓	✓	✓
First-Stage F-Stat	19	15	11	19	19	4.3
R-squared	0.12	0.14	0.13	0.1	0.12	0.12
Observations	34,556	29,033	24,641	39,238	34,556	34,556
Number of Firms	4,847	4,518	3,824	5,789	4,847	4,847
Number of Industries	46	46	46	47	46	46

Notes: Estimation results for regression (15). Standard errors in parentheses are clustered by firm, apart from column (vi) which uses a two-way clustering by state and 2-digit SIC code. See text for descriptions on each regression. Sample: 1982-2023. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Columns (ii)-(iv) in Table 9 test the empirical estimates of ρ when firms are assumed to learn from other parts in the firm productivity distribution than the average. To this end, we posit that firms learn from the median, the 75th percentile, or the 90th percentile of the TFP distribution of firms within the same industry, yielding alternative definitions for $a^*_{i,s,t}$. For the various specifications, we obtain estimates of ρ in the range [0.34,0.37] and thus close to our baseline. And finally, column (v) in Table 9 weights the state-level tax credit rates by the R&D expenditure activity of firms across the states in which they are active. To this end, we use data on firms' patents from the NBER patent data project as a proxy for R&D activity.[33] We weight the tax credit rates by the patents firms filed in various states over the estimation sample for which the patent data is available. Again, we find that our results are robust to this alternative specification.

[33]These data are available at: https://sites.google.com/site/patentdataproject/Home.

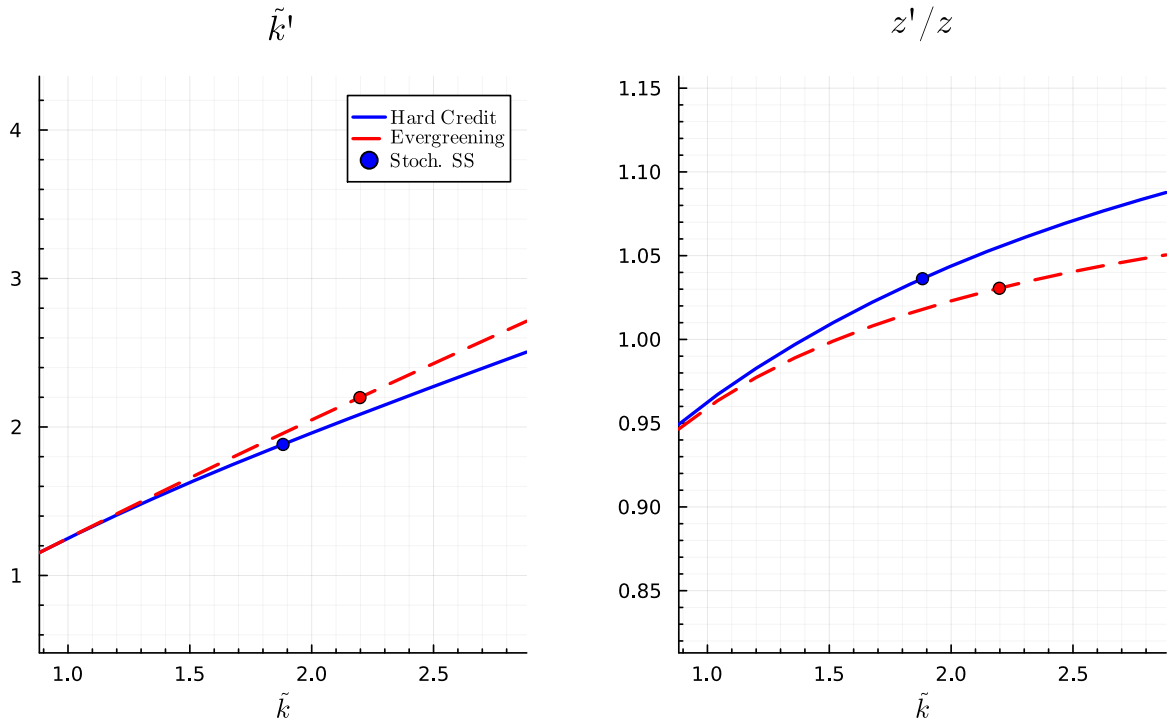
Table 9: Further Evidence (3) - Estimates R&D Cost Function.

	(i) Baseline	(ii) P50	(iii) P75	(iv) P90	(v) Patents
β_1 $(= 1/\kappa)$	0.35***	0.48***	0.43***	0.41***	0.43***
	(0.09)	(0.13)	(0.11)	(0.11)	(0.12)
β_2 $(= \rho)$	0.29***	0.37***	0.36***	0.34***	0.30***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Time FE	✓	✓	✓	✓	✓
First-Stage F-Stat	19	16	17	18	15
R-squared	0.12	0.14	0.14	0.13	0.13
Observations	34,556	34,556	34,556	34,556	24,136
Number of Firms	4,847	4,847	4,847	4,847	2,857
Number of Industries	46	46	46	46	42

Notes: Estimation results for regression (15). Standard errors in parentheses are clustered by firm. See text for descriptions on each regression. Sample: 1982-2023. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

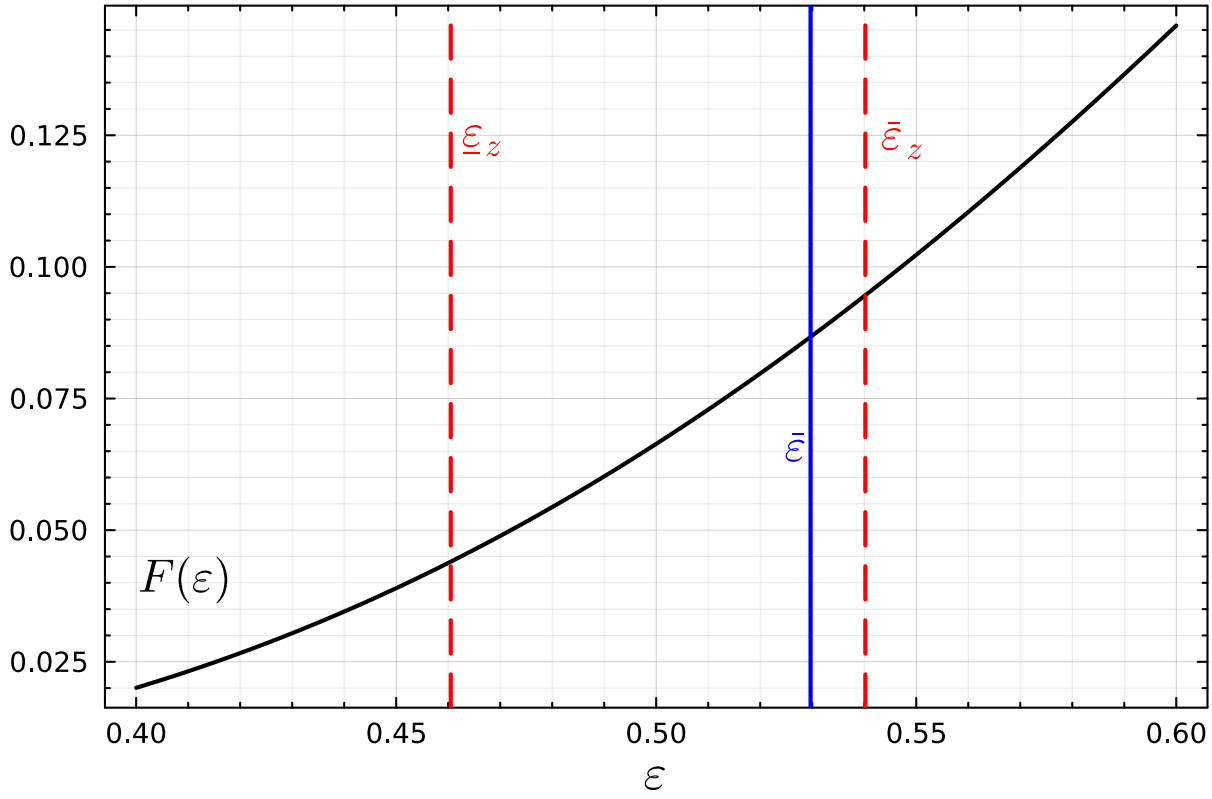
C Additional Figures

Figure 12: Firm policy functions.



Notes: Firm policy functions for detrended physical capital $\tilde{k}'$ and R&D z' for evergreening and hard credit economies. The dots indicate the stochastic steady state of each respective economy.

Figure 13: Probability distribution functions.

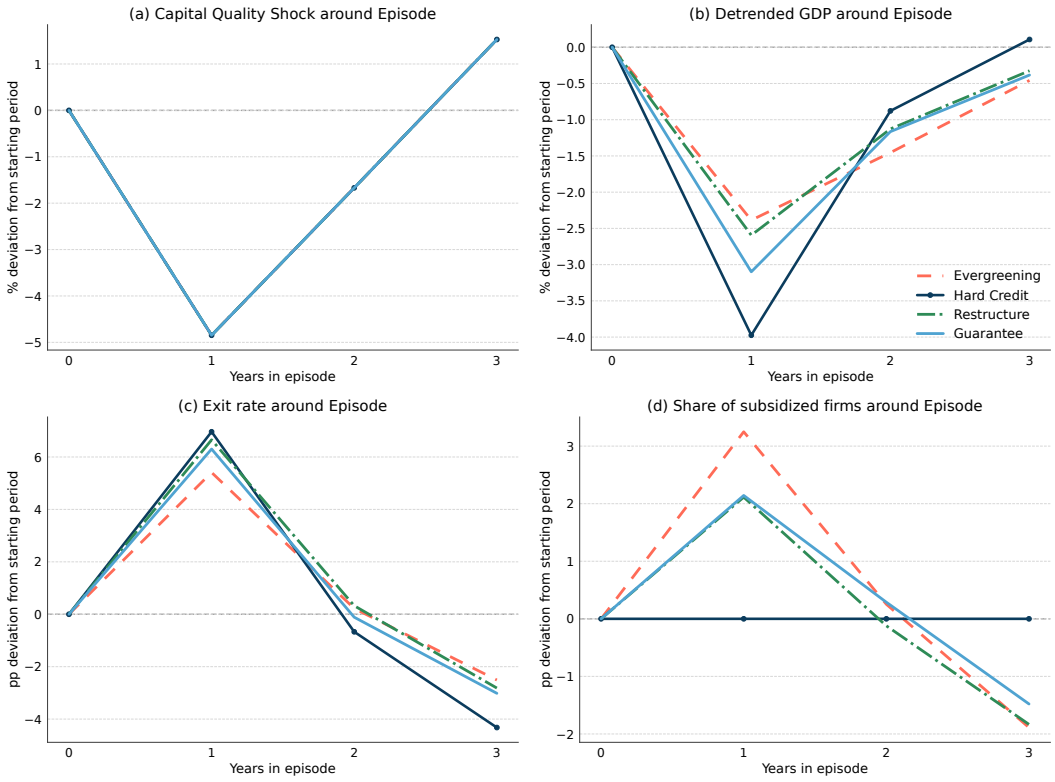


Notes: Probability distribution function of idiosyncratic productivity, liquidation and distress thresholds in the evergreening economy (red), and liquidation threshold in the hard credit economy (blue).

D Recession Analysis

In this appendix, we study a typical recession across simulated paths. We select recession episodes in which a one-period negative shock is large enough to generate a decline in GDP. Specifically, we define a recession episode as a one-period decline in ζ, followed immediately by a one-period recovery, and retain only those episodes in which GDP declines for one period at the onset of the shock in all four economies. Figure 14 plots the average shock as well as selected endogenous variables during these episodes. On impact, (detrended) GDP is lower in the HC economy relative to the SC economies as seen in panel (b). However, and consistent with the IRF evidence, the HC economy eventually catches up and surpasses the SC economies. Again, this figure prominently displays the stabilization vs. growth trade-off between hard and soft credit economies. Panels (c) and (d) again rationalize the differences in the behavior of output and employment on impact, as SC economies experience significant increases in the share of firms that receive some form of subsidy and would otherwise have had to exit.

Figure 14: Recession analysis.



E Model Robustness: Preferences

Tables 10 and 11 compare moments and welfare across the four economies for different preference parameters, $\beta = 0.99$ and $\sigma = 3$, respectively. For each case, we recalibrate the respective parameters so as to match the same targets as in the baseline. The tables show that the key qualitative results remain: hard credit is associated with faster GDP growth and higher GDP and consumption growth volatilities. Exit rates and the degree of selection are rather robust to preferences, with most of the differences emerging in both the level of real interest rates and the lending spread. As expected, CEV calculations are sensitive to preference parameters: an increase in patience magnifies the welfare losses relative to hard credit, as the benefits of this counterfactual economy are backloaded. More risk-aversion, on the other hand, compresses the welfare advantage of hard credit. This is explained not just by lower volatility but also by the level effect on the utility composite, and the fact that higher risk-aversion also corresponds to a lower elasticity of substitution.

Table 10: Model moments, higher discount factor ($\beta = 0.99$).

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	8.82	4.97	4.98	5.01
ε^*	1.05	1.03	1.03	1.03
GDP growth	2.37	2.00	2.05	2.06
$\sigma(g_Y)$	2.84	2.03	2.30	2.26
$\sigma(g_C)$	2.61	2.44	2.55	2.52
Real interest rate, $1/Q^d - 1$	5.50	4.87	4.90	4.92
Lending spread, $(1/q - 1/Q^d)$	3.49	2.01	2.05	2.00
Detrended wage, $\tilde{w}$	0.75	0.80	0.80	0.80
K/Y	1.49	1.73	1.74	1.73
$corr(R\&D, Y)$	0.70	0.89	0.83	0.90
CEV of moving from HC		-5.55	-4.51	-4.39

Table 11: Model moments, higher risk-aversion ($\sigma = 3$).

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	8.78	4.86	4.87	4.89
ε^*	1.05	1.03	1.03	1.03
GDP growth	2.36	2.00	2.04	2.06
$\sigma(g_Y)$	2.79	2.03	2.27	2.25
$\sigma(g_C)$	3.03	2.77	2.90	2.87
Real interest rate, $1/Q^d - 1$	8.36	7.52	7.55	7.58
Lending spread, $(1/q - 1/Q^d)$	3.70	2.12	2.16	2.10
Detrended wage, $\tilde{w}$	0.72	0.76	0.76	0.76
K/Y	1.28	1.47	1.47	1.47
$corr(R\&D, Y)$	0.68	0.90	0.85	0.90
CEV of moving from HC		-0.69	-0.29	-0.20

F Model Robustness: ε^*

Tables 12 and 13 compare moments and welfare across the four economies for different specifications of ε^*. Instead of the mean idiosyncratic productivity, we consider the cases where ε^* is equal to the 75th and 90th percentiles of the distribution of incumbent firms, respectively. It is plausible to assume that, instead of learning from mean productivity, firms learn through a more directed search process where they try to emulate more productive firms. In Appendix Table 9, we re-estimate our directly estimated parameters for the R&D cost function (κ, ρ) assuming that firms learn from the 75th or 90th percentiles of TFP in the same industry. For each economy, we use those direct estimates, and recalibrate all other internal parameters so as to match the targeted moments. Our main qualitative results are robust to changing the exact definition of ε^*: the hard credit economy registers higher growth rates and higher measures of volatility. The normative conclusions are different, however, with soft credit now dominating in terms of welfare (except for the case of evergreening and ε^* equal to the 75th percentile). Of relevance to this result is the fact that the differences in GDP growth across economies are now more compressed (0.32 and 0.28 pp vs 0.39 pp in the baseline), while the differences in volatility remain quantitatively similar. Additionally, the cyclicality of R&D is now much higher in the hard credit economy, which could result in welfare losses.

Table 12: Model moments, ε^* as the 75th percentile of the incumbent distr.

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	9.09	4.93	4.94	4.97
ε^*	1.21	1.20	1.20	1.20
GDP growth	2.32	2.00	2.04	2.05
$\sigma(g_Y)$	2.86	2.03	2.23	2.21
$\sigma(g_C)$	2.70	2.47	2.59	2.55
Real interest rate, $1/Q^d - 1$	6.43	5.90	5.93	5.96
Lending spread, $(1/q - 1/Q^d)$	3.60	2.00	2.02	1.98
Detrended wage, $\tilde{w}$	0.75	0.81	0.80	0.80
K/Y	1.38	1.58	1.58	1.58
$corr(R\&D, Y)$	0.74	0.91	0.88	0.92
CEV of moving from HC		-0.35	0.28	0.45

Table 13: Model moments, ε^* as the 90th percentile of the incumbent distr.

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	9.21	5.00	5.02	5.06
ε^*	1.41	1.40	1.40	1.40
GDP growth	2.28	2.00	2.03	2.04
$\sigma(g_Y)$	2.83	2.03	2.22	2.19
$\sigma(g_C)$	2.59	2.35	2.46	2.42
Real interest rate, $1/Q^d - 1$	6.36	5.91	5.93	5.95
Lending spread, $(1/q - 1/Q^d)$	3.63	2.00	2.03	2.00
Detrended wage, $\tilde{w}$	0.84	0.90	0.90	0.90
K/Y	1.45	1.65	1.65	1.65
$corr(R\&D, Y)$	0.86	0.89	0.88	0.91
CEV of moving from HC		1.02	1.50	1.61

G Model Robustness: ρ—Recalibrating the Model

In this section, we extend the analysis in Section 6 by fully recalibrating the model for $\rho \in \{0, 0.15\}$. Tables 14 and 15 summarize aggregate moments and welfare across the different credit regimes. Qualitatively, the moment rankings are similar compared with our baseline, but noticeably, the growth differences between HC and SC are smaller, and the volatility differences are larger relative to the baseline. Additionally, the HC economy features more exit (10.2% and 9.5% vs. 8.9%), which contributes to reducing detrended levels and explaining differences in the welfare results.

Table 14: Model moments and welfare across credit regimes, $\rho = 0$

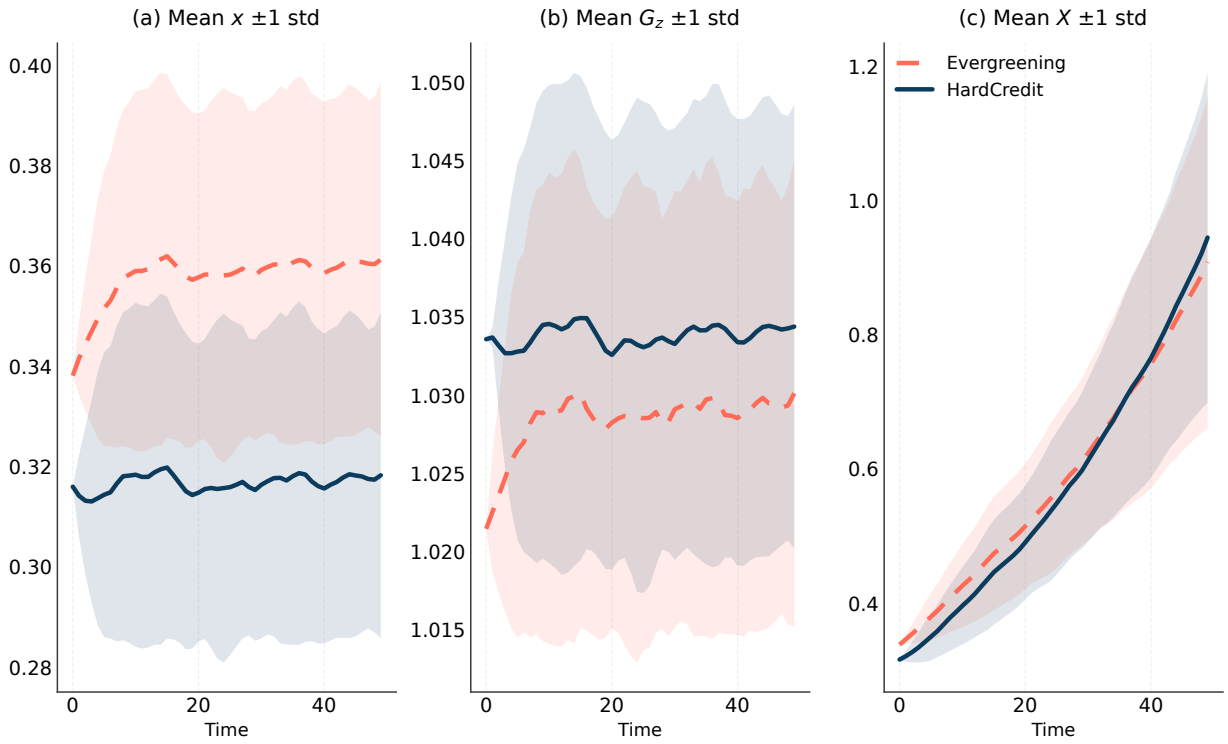
	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	10.19	5.00	5.03	5.05
ε^*	1.06	1.03	1.03	1.03
GDP growth	2.28	2.00	2.04	2.03
$\sigma(g_Y)$	3.36	2.03	2.26	2.27
$\sigma(g_C)$	3.44	2.92	3.31	2.93
Real interest rate, $1/Q^d - 1$	6.27	5.95	5.93	5.97
Lending spread, $(1/q - 1/Q^d)$	4.05	2.03	2.10	2.00
Detrended wage, $\tilde{w}$	0.61	0.66	0.66	0.66
K/Y	0.86	0.98	0.99	0.98
Intraperiod rate, i	2.00	1.66	2.00	2.00
Avg. debt restructured, ξ (%)	0.00	0.00	0.05	0.00
Guarantees over GDP (%)	0.00	0.00	0.00	0.05
corr$(R\&D, Y)$	0.40	0.83	0.70	0.86
CEV, exact		17.14	16.58	17.53

Table 15: Model moments and welfare across credit regimes, $\rho = 0.15$

	Hard Credit	Evergreening	Restructuring	Guarantee
Share of subsidized firms (%)	0.00	4.99	4.99	4.99
Exit rate (%)	9.49	4.96	4.98	5.01
ε^*	1.06	1.03	1.03	1.03
GDP growth	2.34	2.01	2.04	2.05
$\sigma(g_Y)$	2.97	2.03	2.27	2.25
$\sigma(g_C)$	2.81	2.51	2.68	2.58
Real interest rate, $1/Q^d - 1$	6.48	5.96	5.97	5.99
Lending spread, $(1/q - 1/Q^d)$	3.77	2.02	2.06	2.00
Detrended wage, $\tilde{w}$	0.68	0.73	0.73	0.73
K/Y	1.19	1.38	1.38	1.38
Intraperiod rate, i	2.00	1.68	2.00	2.00
Avg. debt restructured, ξ (%)	0.00	0.00	0.10	0.00
Guarantees over GDP (%)	0.00	0.00	0.00	0.18
$corr(R\&D, Y)$	0.74	0.91	0.85	0.92
CEV, exact		2.26	2.62	2.81

Figure 15 replicates Figure 5 for the case with $\rho = 0.15$, with panel (c) graphically illustrating the point about growth vs. levels: it now takes roughly twice as long for the HC economy to overtake the evergreening economy in terms of composite consumption levels. This is explained both by a larger difference in detrended levels (panel (a)) as well as a smaller difference in growth rates (panel (b)).

Figure 15: Simulations of composite consumption.



Notes: Simulations of composite consumption across HC and Evergreening economies for $\rho = 0.15$, see text for details.

H Decomposing the role of each friction

This section attempts to provide some insights into the role played by each friction in the quantitative model. Table 16 reports selected model moments across credit regimes for three economies: baseline, an economy without innovation externalities ($\rho = 0$), and an economy where we try to eliminate congestion in input markets by fixing the real wage at its level in the baseline HC economy.[34]

The results indicate that both mechanisms are quantitatively important for the welfare ranking between hard and soft credit. Panel (b) confirms the role of innovation externalities, discussed in Section 6: when $\rho = 0$, the growth cost of keeping less productive firms

[34]We acknowledge several issues with this exercise. First and foremost, this entails not just changing the level of wages but also their cyclicality, which could have heterogeneous implications for welfare across credit regimes. Second, this is a partial equilibrium exercise, as the labor market does not necessarily clear. The quantity of labor matters directly for welfare. We assume that the equilibrium quantity of labor is the minimum between labor supplied and demanded at the fixed wage. When labor demanded exceeds labor supplied, we assume that all firms are rationed in proportion to their unconstrained individual labor demands.

alive is substantially weaker, and the soft-credit regimes deliver higher welfare than hard credit. Although hard credit still features more selection and faster GDP growth, the welfare gains from reducing exit and stabilizing the economy dominate once the learning externality is removed.

Panel (c) highlights the importance of input-market congestion. In the baseline economy, soft-credit regimes keep more firms operating, which raises labor demand and puts upward pressure on wages. Higher wages reduce expected profits and weaken incentives to invest in both physical capital and innovation. When wages are instead fixed at the hard-credit level, this congestion channel is muted. Firms in the soft-credit regimes become more profitable, invest more, and attain higher growth rates than in the baseline. As a result, the welfare ranking is reversed: all three soft-credit regimes now dominate hard credit.

Taken together, these exercises show that the welfare losses from soft credit are not driven by a single force. Innovation externalities make the selection margin valuable for long-run growth, while input-market congestion amplifies the cost of keeping distressed firms alive by depressing future profitability and investment. The fact that removing either mechanism is enough to overturn the baseline welfare ranking highlights that our main results rely on the interaction between selection, innovation, and general-equilibrium wage effects.

Table 16: Model moments and welfare across credit regimes

	Hard Credit	Evergreening	Restructuring	Guarantee
(a): Baseline				
Share of subsidized firms (%)	0.00	5.00	5.00	5.00
Exit rate (%)	8.86	4.91	4.92	4.96
ε^*	1.05	1.03	1.03	1.03
GDP growth	2.39	2.00	2.05	2.06
$\sigma(g_Y)$	2.81	2.03	2.27	2.25
Lending spread, $(1/q - 1/Q^d)$	3.55	2.02	2.05	2.00
Detrended wage, $\tilde{w}$	0.73	0.78	0.78	0.78
CEV of moving from HC		-3.22	-2.51	-2.39
(b): No innovation externalities ($\rho = 0$)				
Share of subsidized firms (%)	0.00	11.03	5.63	9.50
Exit rate (%)	26.12	15.33	20.56	16.84
ε^*	1.15	1.09	1.12	1.10
GDP growth	3.91	3.10	3.50	3.29
$\sigma(g_Y)$	2.38	2.04	2.30	2.21
Lending spread, $(1/q - 1/Q^d)$	10.89	6.36	8.47	6.76
Detrended wage, $\tilde{w}$	0.55	0.63	0.59	0.62
CEV of moving from HC		10.94	6.30	10.96
(c): No congestion (wages fixed at HC level)				
Share of subsidized firms (%)	0.00	5.27	5.02	5.20
Exit rate (%)	8.71	5.06	5.18	5.11
ε^*	1.05	1.03	1.03	1.03
GDP growth	2.30	2.51	2.50	2.52
$\sigma(g_Y)$	3.58	2.23	2.47	2.35
Lending spread, $(1/q - 1/Q^d)$	3.44	2.06	2.12	2.03
Detrended wage, $\tilde{w}$	0.73	0.73	0.73	0.73
CEV of moving from HC		7.89	7.38	8.02

I Computational Appendix

I.1 Global solution method

We solve the detrended model globally using policy-function iteration and interpolation over the aggregate state space. The method consists of solving the system of equilibrium conditions described in Appendix A.5 on a grid for the aggregate state variables. Because the equilibrium conditions are nonlinear and contain expectations of future endogenous variables, their evaluation requires approximating the equilibrium policy functions outside the grid points.

Let the aggregate state be

$$S \equiv (\tilde{k}, \zeta),$$

where $\tilde{k}$ denotes detrended physical capital and ζ is the aggregate capital-quality shock. As explained in the main text, the collateral constraint on interperiod debt is always binding. Hence, interperiod debt can be recovered from the corresponding capital choice using

$$\tilde{b}' = \theta \tilde{k}'.$$

For a given credit regime $r \in \{h, e, x, \tau\}$, corresponding respectively to hard credit, evergreening, restructuring, and guarantees, the equilibrium can be represented by a collection of policy functions

$$X_r(S) = \left(\tilde{k}'_r(S), G_{z,r}(S), \tilde{V}_r(S), \tilde{w}_r(S), q_r(S), Q^d_r(S)\right),$$

together with the regime-specific liquidation, distress, and intervention thresholds. Once $X_r(S)$ and the relevant threshold functions are known, all remaining equilibrium objects can be recovered from the static equilibrium conditions in Appendix A.5.

The dynamic equilibrium conditions can be written compactly as

$$\mathcal{R}_r\left(X_r(S), \mathbb{E}\left[\mathcal{H}_r\big(X_r(S'), S'\big) \mid S\right], S\right) = 0,$$

where $\mathcal{H}_r(\cdot)$ collects the future endogenous objects entering the firms' first-order conditions and continuation values, the lenders' zero-profit condition, the household stochastic discount factor, and the deposit-pricing condition.

We construct a tensor-product grid

$$\mathcal{G} = \mathcal{G}_{\tilde{k}} \times \mathcal{G}_{\zeta} = \{S_j\}_{j=1}^{N_G}.$$

The bounds for detrended capital are chosen to contain the ergodic set generated by long stochastic simulations, with an additional buffer to limit extrapolation near the boundaries. The grid for the aggregate shock is constructed from its discretized stochastic process. We approximate the policy functions between grid points using piecewise multilinear interpolation.

For each credit regime, the algorithm stores the policy values at every point of $\mathcal{G}$. Denote the values at iteration m and grid point j by $X^{(m)}_{r,j}$. The corresponding interpolants are denoted by $\widehat{X}^{(m)}_r(S)$.

The solution algorithm proceeds as follows.

1. *Initialization.* Compute the deterministic balanced-growth equilibrium for regime r. Use this solution to initialize the policy functions over the entire grid, yielding the initial interpolants $\widehat{X}_r^{(0)}(S)$.

2. *Solve current policies.* Given the current policy interpolants $\widehat{X}_r^{(m)}(S)$, solve, at each grid point S_j,
$$\mathcal{R}_r\left(X_{r,j}^{\text{new}}, \mathbb{E}\left[\mathcal{H}_r\left(\widehat{X}_r^{(m)}(S'), S'\right) \mid S_j\right], S_j\right) = 0.$$
Thus, we use the current approximations to the future policy functions, together with numerical quadrature over the aggregate shocks, to evaluate the expectation terms. We then solve the resulting nonlinear system for the updated current policies $X_{r,j}^{\text{new}}$. The solution from the previous iteration at the same grid point is used as the initial guess. When necessary, solutions at nearby grid points are used as alternative initial guesses.

3. *Update policies.* Update the policy values using damping:
$$X_{r,j}^{(m+1)} = \lambda_m X_{r,j}^{\text{new}} + (1-\lambda_m) X_{r,j}^{(m)}, \qquad \lambda_m \in (0,1].$$
New interpolants $\widehat{X}_r^{(m+1)}(S)$ are then constructed from the updated values.

4. *Convergence.* Iterate over steps 2–3 until
$$d_X^{(m+1)} \equiv \max_j \left\| X_{r,j}^{(m+1)} - X_{r,j}^{(m)} \right\|_\infty < \text{tol}_X.$$

The four credit regimes share the same state space and broad solution procedure. They differ in the characterization of the intraperiod equilibrium and, consequently, in the expressions used to compute the thresholds, intervention schedules, lender payoffs, and debt prices. We solve the hard-credit economy first and use its solution as an initial guess for the soft-credit economies.

I.2 Optimal policy

As explained in Section 7.2, optimal policy under discretion solves

$$\begin{aligned}\tilde{\mathcal{U}}(\tilde{k},\zeta) = \max_{\varpi^{reg}} &\left\{ u(\tilde{C},N) + \beta G_z^{(1-\sigma)\frac{1-\eta}{1-\alpha}} \mathbb{E}\left[\tilde{\mathcal{U}}(\tilde{k}',\zeta') \mid \tilde{k},\zeta\right] \right\} \\ \text{s.t.} \quad &(\tilde{C},N,\tilde{k}',G_z) \in \mathcal{Y}(\tilde{k},\zeta;\varpi^{reg}).\end{aligned}$$

Here, $\mathcal{Y}(\tilde{k}, \zeta; \varpi^{reg})$ denotes the set of competitive-equilibrium allocations that can be implemented from state $(\tilde{k}, \zeta)$ when the current policy instrument is ϖ^{reg}.

We solve the policymaker's problem jointly with the competitive equilibrium. We first construct a finite grid $\mathcal{G}_\varpi$ for the policy instrument. At each aggregate state S_j and for every candidate $\varpi_\ell^{reg} \in \mathcal{G}_\varpi$, we solve the private-sector equilibrium conditional on that policy and compute its choice-specific value,

$$\mathcal{V}_{j\ell} = u(\tilde{C}_{j\ell}, N_{j\ell}) + \beta G_{z,j\ell}^{(1-\sigma)\frac{1-\eta}{1-\alpha}} \mathbb{E}\left[\tilde{\mathcal{U}}^{(m)}(\tilde{k}'_{j\ell}, \zeta') \mid S_j\right].$$

In the absence of smoothing, the policymaker would choose the policy associated with the largest choice-specific value:

$$\varpi^{reg,*}(S_j) \in \arg\max_{\varpi_\ell^{reg} \in \mathcal{G}_\varpi} \mathcal{V}_{j\ell}.$$

In practice, the policymaker's value function can be nearly flat with respect to the policy instrument in some regions of the state space. Small numerical differences can therefore produce discrete changes in the selected policy across neighboring states or iterations. To smooth this discrete-choice problem, we introduce independent type-I extreme-value perturbations for each candidate value of ϖ^{reg}, following Dvorkin et al. (2021). Let $\sigma^{xv} > 0$ denote the scale of these perturbations. The probability assigned to candidate policy ϖ_ℓ^{reg} is then

$$p_{j\ell} = \frac{\exp\left(\mathcal{V}_{j\ell}/\sigma^{xv}\right)}{\sum_s \exp\left(\mathcal{V}_{js}/\sigma^{xv}\right)}.$$

For numerical stability, this expression is evaluated after subtracting $\max_s \mathcal{V}_{js}$ from every choice-specific value. We set σ^{xv} to a small value, so the resulting policy rule closely approximates the solution to the original, unperturbed maximization problem while varying smoothly across states and iterations. The extreme-value shocks are used only to solve the model: when simulating, we pick the policy that yields the highest value for the policymaker.

It is worth noting that the extreme-value shocks mechanically increase welfare. We use them only to construct the smoothed policy rule. After convergence, we recompute the policymaker's welfare using the resulting policy functions but excluding the extreme-value shocks. Welfare in the optimal-policy economy is therefore directly comparable with welfare in the other versions of the model.