Innovate to Borrow:
How Intagibles Shape Finance and Growth

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Preliminary Draft
May 2026

Abstract

We study a dynamic economy in which heterogeneous entrepreneurs invest in either generic or innovative technologies, the latter relying on intangible, firm-specific assets whose payoffs are realized through learning or experimentation (e.g., know-how, R&D). A key friction is that, to finance investment, entrepreneurs can pledge assets but not cash flows. We show that innovative technologies can *relax* financing constraints by increasing the value of continuation relative to default, thereby enabling borrowing against future cash flows. Technology choice is non-monotonic in productivity: low-productivity entrepreneurs innovate-to-experiment and delay investment, intermediate types adopt generic technologies, and high-productivity entrepreneurs innovate-to-scale and relax financial constraints. In equilibrium, financial frictions distort both the allocation of capital and the choice of technology, leading to insufficient experimentation. The model helps us understand how innovation is adopted across firms and economies and has novel policy implications.

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JEL Codes: D24, E22, G32, O31, O40.
Keywords: intangible capital, borrowing capacity, technology choice, financial frictions, misallocation, innovation, experimentation.

1 Introduction

Entrepreneurs must secure external funding to undertake investment, and their ability to do so depends critically on the nature of their assets. In standard frameworks, borrowing capacity is tied to asset prices: firms pledge collateral whose value fluctuates over the cycle, amplifying downturns when prices fall. Over the past decades, however, firms' investment has shifted away from tangible assets such as machinery and structures toward intangible assets such as know-how, R&D, and organizational capital (Corrado et al., 2005, 2009; Chiavari and Goraya, 2024). This transformation has been accompanied by a change in corporate financing: firms increasingly rely on borrowing backed by cash flows rather than by the liquidation value of assets (Lian and Ma, 2018; Kermani et al., 2022; Lian et al., 2021). Together, these developments challenge the conventional view that borrowing capacity is primarily determined by asset prices and raise the question of what determines borrowing capacity when assets are increasingly firm-specific and intangible.

This paper proposes a framework to study the joint determination of technology choice, asset characteristics, and borrowing capacity. We argue that the nature of firm assets—particularly their specificity and generated cash flows—is a central determinant of financing constraints. Unlike tangible assets, which are easily redeployable and thus valuable in liquidation, most intangible assets derive much of their value by remaining within the firm. As a result, they affect borrowing capacity not through their resale value but through their impact on entrepreneurs' continuation value and, therefore, incentives to repay.

Our starting point is the canonical macro-finance framework inspired by Hart and Moore (1994) and Kiyotaki and Moore (1997), in which entrepreneurs with heterogeneous productivity seek funds from lenders to invest, but they cannot pledge their project's cash flows (e.g., due to inalienability of human capital). We extend this setting by allowing entrepreneurs to choose between generic and innovative technologies. Generic technologies rely on physical capital that can be seized and resold by lenders. In contrast, innovative technologies require intangible assets that are accumulated in-house through learning (e.g., organizational know-how) or experimentation (e.g., R&D). Crucially, when lenders seize assets upon default, the entrepreneur loses control over all assets, including those that are firm-specific and cannot be redeployed outside the firm.

In this environment, borrowing capacity is determined endogenously by the need to provide the entrepreneur with incentives to repay. Crucially, these incentives depend not only on the liquidation value of assets, but also on their value to the entrepreneur in continuation. When assets are specific and difficult to replace, default entails a significant loss for the entrepreneur, strengthening repayment incentives. As a result, innovative technologies can increase borrowing capacity even when they have low liquidation value, as repayment is sustained by the entrepreneur's desire to retain valuable intangible assets. These incentives are shaped by the allocation of bargaining power in renegotiation, which determines the entrepreneur's payoff in default relative to continuation.

Our analysis delivers three main results. First, *borrowing capacity is tightly linked to the entrepreneur's choice of technology*, as entrepreneurs can borrow not only against the liquidation value of assets but also against the value of continuation. Innovative technologies generate high continuation values because they rely on intangible assets accumulated over time or through successful experimentation. Since these assets are difficult to replace if lost, default is particularly costly for the entrepreneur. As a result, with innovative technologies, repayments become contingent on success: the entrepreneur repays in states where she has accumulated sufficient knowledge or achieved experimental success. This provides a micro-founded rationale for the rise of cash flow-based lending documented in the data (Lian and Ma, 2018; Lian et al., 2021; Kermani et al., 2022), as well as for the growing reliance of innovative firms on alternative financing such as venture capital (Hall and Lerner, 2010; Falato et al., 2022).

Second, *technology choice is non-monotonic in entrepreneurial productivity*. Low-productivity entrepreneurs adopt innovative technologies in order to experiment, hoarding cash and delaying investment until outcomes are realized.[1] Intermediate-productivity entrepreneurs choose generic technologies and invest at full capacity subject to standard collateral constraints, they do so to relax financial constraints by re-investing intermediate cash flow. High-productivity entrepreneurs also adopt innovative technologies, but to relax financing constraints evne further and scale up production. Thus, innova-

[1] This is consistent with the evidence in Falato et al. (2022) that corporate cash hoarding in the US is intimately tied to the rise of intangibles.

tion serves two distinct roles—experimentation and financing—depending on the level of productivity. This pattern is consistent with evidence that both small and large firms play important roles in innovation, albeit for different purposes, with smaller firms engaging more in exploratory activities and larger firms specializing in incremental innovation (Acemoglu et al., 2018), and with evidence that intangible investment is widespread and highly heterogeneous across firms (Crouzet and Eberly, 2018).

Third, *in general equilibrium, financial frictions distort both the allocation of capital across entrepreneurs and their technology choices.* Absent financial frictions, only the most productive entrepreneurs are active: they adopt innovative technologies and experiment, so that capital is allocated only to successful innovative projects. By hindering the reallocation of capital, these frictions reduce the value of experimentation and shift firms toward generic technologies and toward innovation aimed at relaxing financial constraints (innovate-to-scale), leading to insufficient experimentation in equilibrium. Importantly, while financial frictions constrain innovation, this is not because intangible assets are harder to pledge, but because experimentation relies on the ability to reallocate capital across projects and states, which becomes costly when financing is limited.

Our framework also provides a natural interpretation for cross-country differences in the adoption and organization of innovatiFon driven by differences in financial development. The model predicts that more financially developed economies (e.g., with higher entrepreneurial wealth) feature greater experimentation by productive firms and faster scaling of successful projects. In contrast, economies with tighter financial constraints feature innovation concentrated among large firms, which adopt innovative technologies to relax constraints and expand production, rather than to experiment. These predictions are consistent with evidence that in more financially developed economies innovation is driven by entry and rapid scaling of young firms (Acemoglu et al., 2018; Calvino et al., 2015), while in emerging economies formal R&D investment is disproportionately undertaken by large, exporting, and foreign-linked firms (Cirera and Maloney, 2017).

On the policy side, much of the literature emphasizes that the key friction in financing innovation arises from the limited pledgeability of intangible assets, suggesting policies aimed at expanding their financing. By contrast, our framework highlights a different margin: the allocation of capital across technologies. In equilibrium, generic technologies or early-stage innovative ones can absorb excessive amounts of capital, raising asset prices and crowding out experimentation by productive entrepreneurs. Policies that target innovation directly—such as forcing experimentation or subsidizing innovation—can backfire: they may foster the wrong type of innovation or investment by the wrong entrepreneurs, reducing aggregate welfare. A simple Pigouvian tax on investment in generic technologies can instead improve welfare by lowering asset prices and promoting a more efficient allocation of capital and technology choices.

Related literature. This paper contributes to the literature on financial frictions, misallocation, and technology adoption. A large body of work studies how borrowing constraints distort the allocation of capital across firms (Buera et al., 2011; Midrigan and Xu, 2014; Moll, 2014; Asriyan et al., 2025). More closely related, Cole et al. (2016) show how differences in financial development shape the adoption of technologies across countries. Our contribution is to highlight that financial frictions interact not only with how much capital entrepreneurs invest in, but also with which technologies they choose. In our framework, technology choice endogenously shapes borrowing capacity by affecting repayment incentives, so misallocation operates through the distribution of both capital and technologies across entrepreneurs.

Second, the paper contributes to the literature on intangible capital and finance. Existing work documents the growing importance of intangible assets in production and growth (Corrado et al., 2005, 2009; Crouzet and Eberly, 2022), as well as their implications for corporate financing, debt capacity, and monetary transmission (Peters and Taylor, 2017; Falato et al., 2022; Döttling and Ratnovski, 2023; Caggese and Pérez-Orive, 2022). Much of this literature emphasizes the limited pledgeability of intangible assets and the resulting tightening of financing constraints. Our contribution is to show that this need not be the case. When intangible assets are accumulated through learning or successful experimentation, they can strengthen repayment incentives and relax borrowing constraints even when their liquidation value is low.

Finally, the paper relates to the literature on the drivers of innovation and its distribution across firms. Existing work shows that innovation differs systematically across entrants and incumbents, with smaller firms engaging more in exploratory innovation and larger firms specializing more in incremental innovation (Acemoglu et al., 2018; Akcigit and Kerr, 2018). A related literature studies how financial conditions affect innovative investment and firm growth (Hall and Lerner, 2010; Brown et al., 2009). Our contribution is to provide a framework in which financial capacity is endogenous and jointly determined with technology choice, shedding new light on how innovation is adopted in the cross section of firms and how these patterns vary across economies.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 characterizes the entrepreneur's problem and the main partial equilibrium results. Section 4 presents the general equilibrium implications. Section 5 discusses the normative properties of equilibrium. Section 6 presents the model's empirical predictions. Section 7 discusses the role of key assumptions. Section 8 concludes.

2 Model

Time is discrete and infinite, indexed by $t = 0, 1, 2, \ldots$. The economy is populated by overlapping generations of entrepreneurs (Es) who live for three periods. Each generation has measure one. Entrepreneurs within a generation are heterogeneous in productivity, indexed by A. Productivity is drawn independently at birth from a distribution G with full support on $[0, \bar{A}]$.

The Es born at time t have a preference for old-age consumption:

$$U_t = E[c_{t+2}], \tag{1}$$

where c_t denotes consumption at time t. Each E is endowed with w units of consumption goods when born and with a productive project described next. Since the economy is stationary, we suppress time subscripts unless otherwise noted, and use subscripts $\tau \in \{0, 1, 2\}$ to denote a young, adult, and old entrepreneur, respectively.

2.1 Technology

Es have access to an investment project with productivity A. At each period, Es can choose their production technology, indexed by $\tau \in [0, 1]$, and their investment in physical capital k and intangible capital h. Output is given by

$$y_{t+1} = A \cdot h_t^{\tau_t} \cdot k_t, \tag{2}$$

where generic technologies ($\tau = 0$) rely only on physical capital, while innovative (specific) technologies ($\tau = 1$) rely on both physical and intangible capital.

2.2 Investment

Physical capital. Physical capital is traded in a competitive market with inelastic supply $\bar{K}$ and price q. Each project has a capacity constraint $k_t \leq k^{\max}$. In much of the analysis, we assume $k^{\max}$ is sufficiently large that it does not bind in equilibrium.[2]

Intangible capital. Intangible capital is built in-house and is firm-specific. Es are born intangible-capital poor, $\underline{h} < 1$. If an E invests $\chi \geq 0$ units of consumption goods at time t, intangible capital evolves as follows:

$$h_{t+1} = \begin{cases} \bar{h} \equiv (1+g) \cdot \underline{h} > 1 & \text{w.p. } \pi, \\ \underline{h} & \text{w.p. } 1-\pi, \end{cases} \tag{3}$$

where $\pi \in [0, 1]$ denotes the probability of innovation or success.

The assumptions on intangible capital are minimal and aim to capture two distinguishing features relative to physical capital: first, intangible capital is built in-house and is therefore firm-specific with no resale value; second, its accumulation involves non-pecuniary costs, either because certain intangibles can only be built gradually over time—such as organizational capital or firm-specific know-how—or because they rely on uncertain outcomes—such as R&D or marketing investment. These two features (firm-specific and experientially costly to obtain) are central to our results.

We restrict attention to cases where both technologies can coexist in equilibrium, which requires $\chi < w$ and the following assumption.

Assumption 1. *The innovative technology can be more productive than the generic one ex post, $\bar{h} > 1$, but not ex ante:*

$$\left(\pi \cdot \bar{h} + 1 - \pi\right) \cdot \underline{h} < 1. \tag{4}$$

Assumption 1 ensures that investment in innovative technologies is not trivially dominant: the expected value of intangible capital is below one, so generic technologies

[2] See the proof of Proposition 1 in the Appendix for the formal condition.

retain a comparative advantage in generating higher cash flows sooner.

2.3 Financial Markets

Es operate in a small open economy where they can borrow and lend at the world interest rate $R = 1$. At time t, Es borrow by issuing debt claims that can be ex-post renegotiated, effectively issuing state-contingent renegotiation-proof repayments $b_t(h_{t+1})$ per unit of physical capital k_t.

Financial friction. The only friction in the model is that Es can pledge their project's physical and intangible capital, (h, k), but not their cash flows. This captures the classical inalienability of human capital (Hart and Moore, 1994). Crucially, many intangible assets—such as organizational capital, brand value, customer relationships, or proprietary know-how—are not tangible yet are fully pledgeable in the following sense: when control is transferred to creditors, these assets are lost for the entrepreneur. It is precisely this feature that allows innovative technologies to relax borrowing constraints, as we show below.

We begin by supposing that creditors have all the bargaining power at the renegotiation stage; we relax this assumption and discuss its importance in Section 7.

2.4 First-Best Benchmark

We begin by characterizing the first-best allocation of technologies and capital across entrepreneurs, which obtains in equilibrium absent financial constraints (i.e., when cash flows are fully pledgeable).

Proposition 1 (First-Best)**.** *In the first-best, there exists a threshold productivity level, $A^\star = G^{-1}\big(1 - \bar{K}/(\pi \cdot k^{\max})\big)$, such that entrepreneurs with $A \leq A^\star$ save, while those with $A > A^\star$ adopt the innovative technology and experiment. Their investment is given by*

$$k_0 = 0, \quad k_1(\underline{h}) = 0, \quad k_1(\bar{h}) = k^{\max}, \tag{5}$$

with aggregate output

$$Y = \int_{A^\star}^{\bar{A}} A \cdot \bar{h} \cdot k^{\max} \, dG(A). \tag{6}$$

These allocations are implemented in equilibrium, absent financial frictions, at the capital price

$$q^\star = \frac{\pi \cdot k^{\max} \cdot \bar{h} \cdot A^\star - \chi \cdot R^2}{\pi \cdot k^{\max} \cdot (R-1)}. \tag{7}$$

In the first-best, all active entrepreneurs adopt the innovative technology. They incur the fixed cost χ to experiment, and only those with successful outcomes operate at scale. Investment is therefore state-contingent: projects are shut down following failure and expanded to $k^{\max}$ following success.

Although innovation may have negative expected value ex ante—by Assumption 1—its option value combined with the ability to condition investment on realized productivity makes it optimal in equilibrium. Prices play a key role: the equilibrium price of capital must be high enough to ensure that only productive, successful entrepreneurs enter and operate at scale, while others optimally choose to save.

This benchmark highlights that, absent financial frictions, the economy efficiently selects into innovative technologies, experiments, and reallocates capital toward successful projects. Any deviations from this allocation in what follows arise from financing constraints.

3 Entrepreneur's Problem and Borrowing Limits

3.1 Preliminaries

We impose some preliminary findings that greatly simplify the analysis.

First, as the expected return of adopting a technology does not increase over an entrepreneur's lifetime—it is constant for generic and decreasing for innovative—the following results follow: (i) an E that chooses not to adopt a technology at $t = 0$ will not adopt it at $t = 1$; and (ii) an E that chooses to invest in generic technologies at $t = 0$ will do so at $t = 1$. Second, an E that chooses to invest in physical capital, $k_t > 0$, will not save simultaneously, $b_t \geq 0$.

3.2 Generic Technologies

With generic technologies there is no uncertainty, so repayments are non-contingent.

Value function. The value of adopting the generic technology for an entrepreneur with productivity A is

$$
\begin{aligned}
V_0^g(A) = \max_{k_0,k_1,b_0,b_1} \ & (A + q - b_1) \cdot k_1 \\
\text{s.t.} \quad & q \cdot k_0 = w + \tfrac{b_0}{R} \cdot k_0, \\
& q \cdot k_1 = (A + q - b_0) \cdot k_0 + \tfrac{b_1}{R} \cdot k_1, \\
& b_0 \leq \bar{b}_0, \quad b_1 \leq \bar{b}_1.
\end{aligned} \tag{8}
$$

The solution is: only sufficiently productive entrepreneurs invest in generic technologies, and when they do, they invest at full capacity—their financing constraint binds.

Borrowing capacity. As entrepreneurs can renege on their obligations and instead use their cash flows y_t to consume, save, or reinvest, repayment must be incentive-compatible. If the entrepreneur repays, her continuation value is $v_t \cdot (A - b_t + q) \cdot k_t$, while if she defaults she retains output but loses capital, yielding $v_t \cdot A \cdot k_t$. Repayment is incentive-compatible if and only if

$$
b_t \leq q \equiv \bar{b}_t, \quad \forall\, t. \tag{9}
$$

This result follows from the fact that the marginal value of cash flows is unaffected by the repayment decision: after either repayment or default, the entrepreneur can freely consume, save, or reinvest in the generic technology. As a result, default only entails losing access to capital, so repayments cannot exceed the value of the capital lost upon default.

Combining these results, we define the value function of a generic entrepreneur as

$$
V_0^g(A) = v(A)^2 \cdot w, \tag{10}
$$

where

$$
v(A) \equiv \max\left\{ R,\ \frac{A \cdot R}{q \cdot (R-1)} \right\} \tag{11}
$$

is the per-period marginal value of cash flows for an entrepreneur not investing in innovative technologies.

3.3 Innovative Technologies

Investment in the innovative technology is only feasible for an E if $w > \chi$. Moreover, there is uncertainty about h_1, realized at $t = 1$. We denote the success (failure) state by $\bar{h}$ ($\underline{h}$). The problem of an E that adopts the innovative technology is

$$\begin{aligned} V^i(A) = \max_{k_0,k_1,b_0,b_1} \; & E[v(A,h_1) \cdot \max\{(A \cdot h + q - b_0(h_1)) \cdot k_0,\ (w-\chi) \cdot R\}] \\ \text{s.t.} \quad & q \cdot k_0 \leq w - \chi + \tfrac{E[b_0(h_1)]}{R} \cdot k_0, \\ & q \cdot k_1 \leq (A \cdot h + q - b_0(h_1)) \cdot k_0 + \tfrac{b_1}{R} \cdot k_1, \quad \forall\, h_1, \\ & b_0(h_1) \leq \bar{b}_0(h_1), \quad b_1 \leq \bar{b}_1, \end{aligned} \tag{12}$$

where $v(A, h_1)$ denotes the marginal value of funds in state h_1 and is given by

$$v(A,h_1) \equiv \max\left\{ v(A),\ \frac{A \cdot h_1}{q - \frac{b_1}{R}} \right\}. \tag{13}$$

There are two cases: (i) *experimentation*, where the E pays χ but waits to invest, so $k_0 = 0$ and $k_1(h_1) \geq 0$; (ii) *innovation-to-scale*, where the E pays χ and invests at $t = 0$, i.e. $k_0 > 0$.

Borrowing capacity. We compare the continuation value of the E with the value of reneging on repayments. At $t = 2$ there is no continuation value, so the E repays if and only if

$$b_1 \leq \bar{b}_1 = q. \tag{14}$$

At $t = 1$, the E repays if the value of continuation exceeds that of default. As intangible capital takes time to accumulate, it is never optimal to adopt innovative technologies in $t = 1$ following default. Thus, the E can either save or invest in generic technology following default, as captured by $v(A)$. Repayment is incentive compatible if and only if

$$v(A) \cdot y_1 \leq [y_1 + (q - b_0(h_1)) \cdot k_0] \cdot v(A,h_1), \tag{15}$$

where

$$v(A,h_1) \equiv \max\left\{ v(A),\ \frac{R}{R-1} \cdot \frac{A \cdot h_1}{q} \right\}. \tag{16}$$

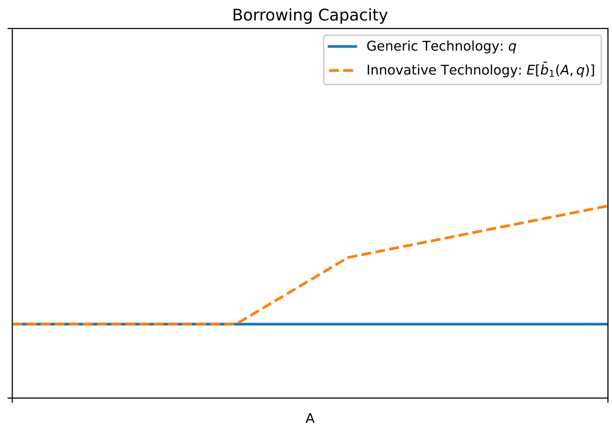


Figure 1: Borrowing capacity of E with productivity A. The solid line shows borrowing capacity under generic technologies (equal to q for all A). The dashed line shows expected borrowing capacity under innovative technologies, which is increasing in A above the threshold. Parameters: $h = 0.8$, $g = 0.4$, $\pi = 0.6$, $q = 2$.

The following lemma summarizes these findings.

Lemma 1 (Borrowing Limits)**.** *The borrowing limit at $t = 0$ is determined by state-contingent repayments*

$$\bar{b}_0(h_1) = \begin{cases} q & \text{if } \tau_1 = 0, \\ q + A \cdot h \cdot \left(1 - \dfrac{v(A)}{v(A, h_1)}\right) & \text{if } \tau_1 = 1, \end{cases} \tag{17}$$

and at $t = 1$ by $\bar{b}_1 = q$.

Lemma 1 establishes the central mechanism of the paper. Innovative technologies *relax* financial constraints by raising borrowing limits. In states where innovation succeeds, the continuation value exceeds the outside option, $v(A, \bar{h}) > v(A)$, allowing entrepreneurs to credibly pledge part of their cash flows. Although intangible assets have no liquidation value, the *threat of losing them* sustains repayment. As a result, higher continuation values translate into greater borrowing capacity, given by the expectation of state-contingent borrowing limits (Figure 1).

3.4 Optimal Technology Choice

We now characterize the solution to the entrepreneur's problem.

Proposition 2 (Technology Choice)**.** *There exist three thresholds A_E, A_G, and A_I such that:*

(i) $A \in [0, A_E]$*: entrepreneurs* ***save*** *their endowment and obtain* $V(A) = R^2 \cdot w$*.*

(ii) $A \in (A_E, A_G)$*: entrepreneurs* ***innovate-to-experiment*** *by paying* χ *and delaying investment until the state is revealed, obtaining*

$$V(A) = E[v(A, h_1)] \cdot R \cdot \left(1 - \frac{\chi}{w}\right) \cdot w. \tag{18}$$

(iii) $A \in [A_G, A_I]$*: entrepreneurs adopt* ***generic technologies*** *and invest at full capacity, obtaining*

$$V(A) = v(A) \cdot \frac{A \cdot R}{q \cdot (R-1)} \cdot w. \tag{19}$$

(iv) $A \in (A_I, \bar{A}]$*: entrepreneurs* ***innovate-to-scale*** *and invest at full capacity, obtaining*

$$V(A) = v(A) \cdot \frac{A \cdot h \cdot R}{q(R-1) - \beta \cdot A} \cdot \left(1 - \frac{\chi}{w}\right) \cdot w, \tag{20}$$

where $\beta \equiv \pi \cdot h \cdot (\bar{h} - 1)/\bar{h} > 0$*.*

Discussion. The key insight from Proposition 2 is that technology choice is *non-monotonic* in entrepreneurial productivity A, reflecting two distinct roles of innovation: experimentation and financing.

Low-productivity entrepreneurs ($A \in (A_E, A_G)$) adopt innovative technologies to experiment. Despite the cost $(1 - \chi/w)$, they value the option to improve productivity, captured by the expected continuation value $E[v(A, h_1)]$. As a result, these entrepreneurs delay investment: they save when young and choose capital only after uncertainty is realized, leading to state-contingent investment:

$$k_0(A) = 0, \quad k_1(A, h_1) = \begin{cases} 0 & v(A, h_1) < R, \\ \dfrac{(w - \chi) \cdot R}{q \cdot (R-1)} & v(A, h_1) \geq R. \end{cases} \tag{21}$$

Intermediate types ($A \in [A_G, A_I]$) instead choose generic technologies. In this region, the gains from re-investing early cash flows offset the cost from investing in a less productive technology, and thus Es with sufficiently high A choose generic technologies to increase scale. As a result, their borrowing is constrained by the value of capital. These entrepreneurs borrow and invest at full capacity:

$$k_0(A) = \frac{w \cdot R}{q \cdot (R-1)}, \quad k_1(A) = \frac{A \cdot k_0(A) \cdot R}{q \cdot (R-1)}. \tag{22}$$

High-productivity entrepreneurs ($A > A_I$) return to innovative technologies, not to experiment but to relax financing capacity not only through re-investment of intermediate cashflows but through the ability to borrow against them. Borrowing capacity increases with A in this region, allowing them to scale investment beyond what is feasible under generic technologies:

$$k_0(A) = \frac{w \cdot R}{q \cdot (R-1) - \beta \cdot A}, \quad k_1(A, h_1) = \begin{cases} \dfrac{A(1-\beta/\pi) \cdot k_0(A) \cdot R}{q \cdot (R-1)} & h_1 = \bar{h}, \\ \dfrac{A \cdot k_0(A) \cdot R}{q \cdot (R-1)} & h_1 = \underline{h}. \end{cases} \tag{23}$$

Corollary 1 (Thresholds)**.** *The thresholds A_E, A_G, and A_I are given by*

$$A_E = q \cdot (R-1) \cdot \min\left(\frac{w/(w-\chi) - (1-\pi)}{\pi \cdot \bar{h}}, 1 \right), \tag{24}$$

$$A_G = q \cdot (R-1) \cdot \max\left(\frac{w-\chi}{w} \cdot \left(\pi \cdot \bar{h} + 1 - \pi\right), 1 \right), \tag{25}$$

$$A_I = q \cdot (R-1) \cdot \frac{1}{\beta} \cdot \left(1 - \underline{h} \cdot \frac{w-\chi}{w}\right). \tag{26}$$

All three thresholds are increasing in $q \cdot (R-1)$. An increase in the innovation cost χ, or a decrease in returns $\underline{h}$ and $\bar{h}$, raises A_E and A_I but lowers A_G.

Corollary 1 highlights that financing conditions and innovation characteristics jointly determine technology choice. Higher q and R raise all thresholds, tightening financial constraints and lowering the present value of production. In contrast, higher innovation cost χ or lower returns make innovative technologies less attractive, shrinking both the experimentation and innovation-to-scale regions. Accordingly, increases in q and R primarily shift entrepreneurs from production into saving, whereas increases in χ or reductions in $\bar{h}$ and $\underline{h}$ reallocate entrepreneurs from innovation toward generic technologies.

Figure 2 illustrates the value functions and resulting technology choices.

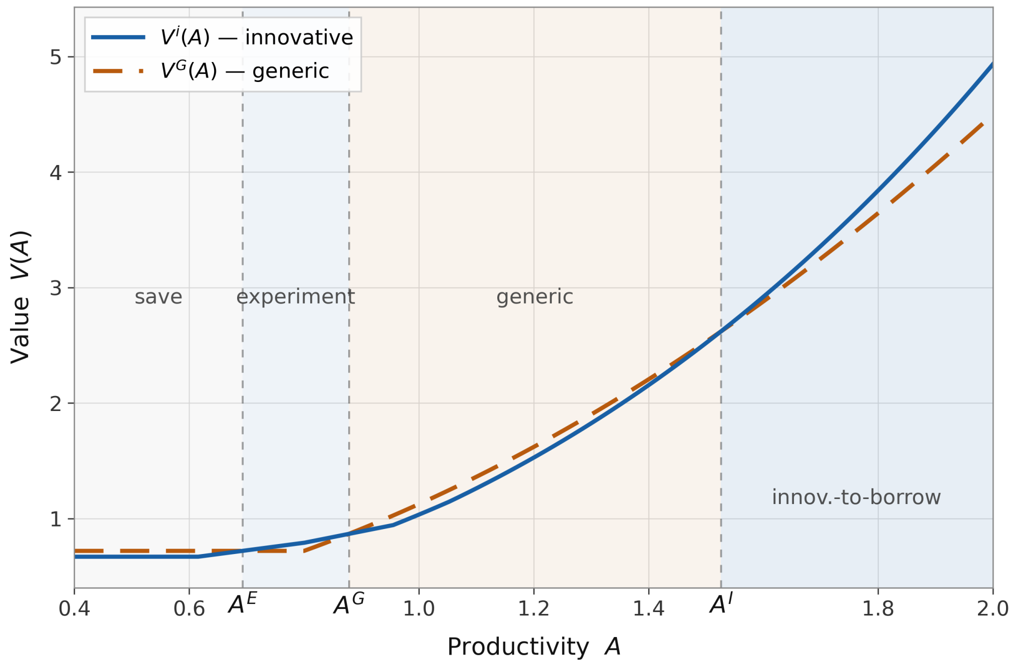


Figure 2: Value functions $V^g(A)$ and $V^i(A)$ as a function of productivity A. The innovative technology dominates for low A (experimentation region) and high A (innovate-to-scale region), while the generic technology dominates for intermediate A.

4 Aggregate Implications

We now characterize the stationary equilibrium of the economy. In addition to optimal contracting and investment, general equilibrium requires that the capital demands $\{k_t(A,q)\}_{A,t}$ clear the market for capital at every date:

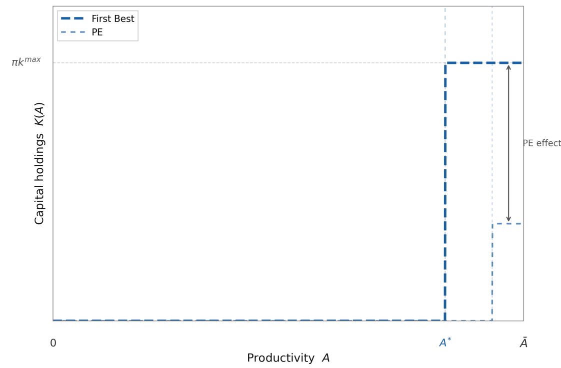
$$\bar{K} = \int [k_0(A,q) + k_1(A,q)] \, dG(A). \tag{27}$$

Proposition 3 (Existence)**.** *A stationary equilibrium exists.*

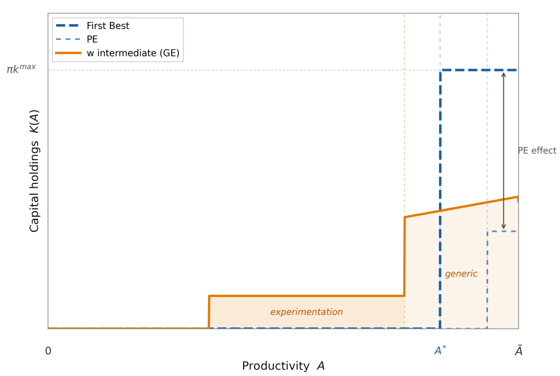
The proof rests on two observations. First, aggregate capital demand on the right-hand side of (27) converges to zero as $q \to \infty$ and becomes arbitrarily large as $q \to 0$. Second, both individual capital demands— conditional on technology choice—and the thresholds governing technology choices are continuous in q.

We next show that the adoption of innovative technologies depends critically on the fixed cost of innovation χ relative to entrepreneurial wealth w. Beyond its direct effect on entrepreneurs' ability to cover fixed costs, w also affects the equilibrium

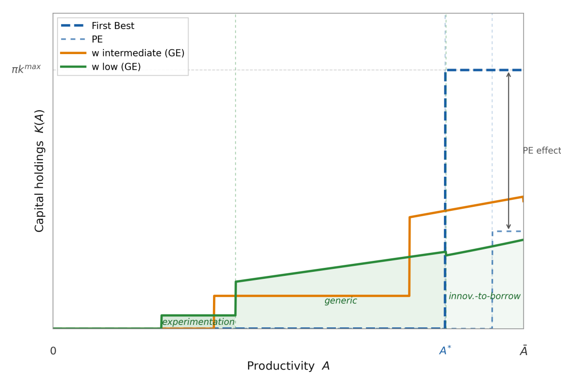
(a) First-best benchmark



(b) Partial equilibrium



(c) GE intermediate wealth



(d) GE lower wealth

Figure 3: **Financial Frictions and Misallocation in General Equilibrium**.

price of capital through the market-clearing condition (27). Higher wealth raises the equilibrium price q, lowers the return on investment, and thereby relaxes financial constraints. Richer economies therefore face looser financial constraints and adopt innovative technologies differently from poor economies.

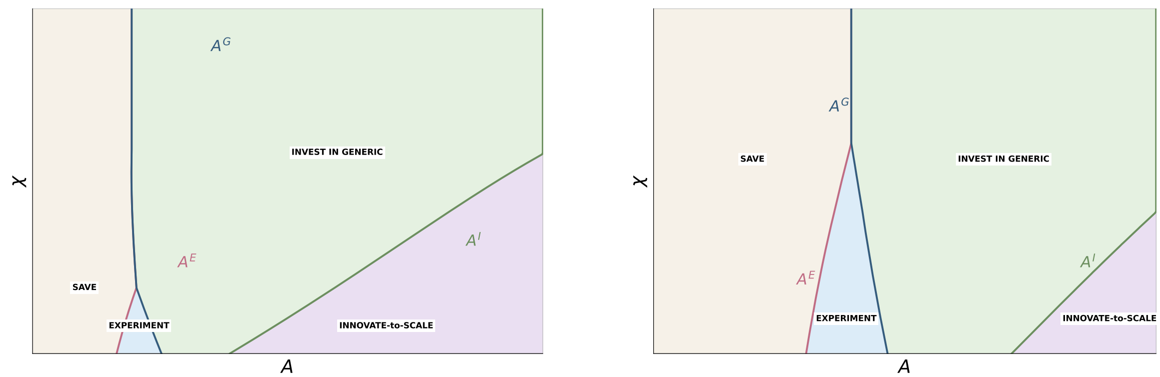
Proposition 4 (Innovation Regimes)**.** *In a stationary equilibrium:*

(i) Some entrepreneurs experiment if and only if

$$\chi < \chi^E \equiv \frac{\pi \cdot (\bar{h} - 1)}{\pi \cdot \bar{h} + 1 - \pi} \cdot w. \tag{28}$$

(ii) Some entrepreneurs innovate-to-scale if and only if

$$\chi < \chi^I \equiv \max\left\{ \frac{\pi \cdot \frac{\bar{h}-1}{\bar{h}}}{q \cdot (R-1)} - \frac{1-h}{h},\ 0 \right\} \cdot w. \tag{29}$$



(a) Poor economy ($w < w^\star$).

(b) Rich economy ($w > w^\star$).

Figure 4: Equilibrium technologies versus innovation cost χ. In poor economies, innovation-to-scale is the prevalent form of innovation. In rich economies, experimentation predominates.

(iii) There exists a threshold $w^\star > 0$ such that $\chi^E > \chi^I$ if and only if $w > w^\star$.

Proposition 4 characterizes how the nature of innovation depends on financial development. In poor economies ($w < w^\star$), the condition for innovation-to-scale is looser than the condition for experimentation ($\chi^I > \chi^E$): innovate-to-scale is the prevalent form of innovation. In rich economies ($w > w^\star$), experimentation is the prevalent form. Intuitively, in rich economies asset prices are high, making it less attractive to invest early at scale with innovative technologies, and more attractive to wait and condition investment on experimental success. Figure 4 illustrates these two cases.

4.1 The Rise of Intangibles

A central application of our framework is understanding the macroeconomic consequences of the secular decline in the cost of intangible investment—a fall in χ—that has been documented across advanced economies over recent decades (Corrado et al., 2005, 2009; Chiavari and Goraya, 2024).

As χ falls, the model predicts:

(i) **Increasing investment in intangibles**, albeit non-monotonically across the firm-size distribution. The experimentation region (A_E, A_G) expands while the generic region $[A_G, A_I]$ contracts.

(ii) **Rise of cash-flow-based borrowing**. As more entrepreneurs adopt innovative technologies, the share of borrowing backed by continuation values (rather than liquidation values) increases.

(iii) **Increasing innovation and accelerated firm-level productivity growth**. The expansion of the experimentation region increases the option value of investment, leading to faster scaling of successful projects.

These predictions are broadly consistent with the empirical record for advanced economies over the past four decades, where the shift toward intangible-intensive production has been accompanied by a rise in cash-flow-based debt and increased dispersion in firm-level productivity growth (Falato et al., 2022; Crouzet and Eberly, 2022).

4.2 Convergence to First-Best

Proposition 5 (Convergence)**.** *The equilibrium allocations—entrepreneurial technology choices and capital holdings—converge to their first-best counterparts as entrepreneurial wealth w grows large.*

Proposition 5 establishes that financial frictions are the sole source of deviation from the first-best. As $w \to \infty$, financial constraints become slack for all entrepreneurs, and the economy converges to an allocation in which only productive entrepreneurs are active and all use the innovative technology with full experimentation. This implies that the equilibrium distortions documented below are driven entirely by the interaction between financial frictions and technology choice.

5 Normative Analysis

5.1 Equilibrium Distortions

We now characterize the distortions introduced by financial frictions relative to the first-best. The competitive equilibrium is generically inefficient for three distinct reasons.

Misallocation across entrepreneurs. Financial constraints prevent the full reallocation of capital toward productive entrepreneurs. In the competitive equilibrium, entrepreneurs with intermediate productivity ($A \in [A_G, A_I]$) invest using generic technologies even though, in the first-best, they would either save or experiment. This absorbs capital that could be deployed more productively elsewhere.

Misallocation across technologies. Financial frictions distort technology choice. In the competitive equilibrium, high-productivity entrepreneurs who would optimally experiment in the first-best instead innovate-to-scale: they invest early with the innovative technology to relax borrowing constraints, rather than waiting to condition investment on experimental success: they trade-off productivity for scale. This are the right entrepreneurs, using the wrong technology.

Misallocation within technologies. Among low-productivity entrepreneurs who experiment, the scale of investment following success may be constrained by accumulated savings, leading to under-investment in the success state. These entrepreneurs expand gradually through retained resources following successful experimentation, whereas the first-best would call for immediate scaling to $k^{\max}$.

Together, these distortions imply that *financial frictions lead to insufficient experimentation in equilibrium.* The depressed price of capital in the competitive equilibrium (relative to the first-best) fosters investment in less productive technologies and by less productive entrepreneurs, crowding out the experimentation that would generate the most value.

5.2 Policy Analysis

The normative analysis suggests that policies aimed at correcting the distortions from financial frictions may not achieve their intended goals if they fail to target the right margin.

5.2.1 Forcing Experimentation

A natural policy response to insufficient experimentation is to mandate or subsidize experimental investment across all entrepreneurs. However, our model reveals a subtle trap: forcing experimentation by all entrepreneurs causes too many low-productivity entrepreneurs to incur the fixed cost χ, leading to excessive capital demand, a sharp decline in asset prices, and lower aggregate surplus.

Quantitatively, a calibrated version of the model shows that forcing all entrepreneurs to experiment leads to an asset price decline of approximately 58% and a fall in aggregate surplus of approximately 18%. The intuition is straightforward: the first-best allocates experimentation only to the most productive entrepreneurs, who can scale efficiently following success. Broad-based experimentation misallocates resources toward unproductive projects.

5.2.2 Subsidizing Innovation

An innovation subsidy that reduces the effective cost of χ has an ambiguous effect on equilibrium. While it expands both the experimentation and innovate-to-scale regions, it also attracts less productive entrepreneurs into the innovative technology. The net effect depends on whether the policy fosters the right type of innovation (experimentation) by the right entrepreneurs (high productivity) or the wrong type (innovate-to-scale) by the wrong entrepreneurs (low to intermediate productivity). Numerical analysis confirms that the effect on aggregate surplus can be either positive or negative, depending on parameters.

5.2.3 A Pigouvian Tax on Generic Technologies

Our framework suggests a more targeted policy: a tax on investment in generic technologies. By raising the relative cost of generic investment, such a tax induces some entrepreneurs who would otherwise invest generically to either experiment or save, reducing excess capital demand, lowering asset prices, and reallocating capital toward productive innovative projects.

Proposition 6 (Generic Technology Tax)**.** *A Pigouvian tax τ on investment in generic technologies weakly expands the set of entrepreneurs who adopt innovative technologies. Under appropriate conditions, such a tax increases equilibrium welfare by lowering the price of capital and promoting a more efficient distribution of both capital and technology choices across entrepreneurs.*

The key insight is that the fundamental distortion is not the underprovision of innovative technology per se, but rather the overuse of generic technology that absorbs scarce capital and crowds out experimentation. A tax that directly targets this margin can improve the equilibrium allocation without the perverse general equilibrium effects of direct innovation subsidies. The policy implication is consequential for current debates in advanced economies: the challenge may not be funding early-stage innovation, but enabling its scaling and reallocation through improved capital market efficiency.

6 Empirical Predictions

Our model delivers a set of empirical predictions that we discuss in relation to existing evidence.

Prediction 1: Intangible assets need not reduce borrowing capacity. Contrary to the conventional view that intangible assets tighten financing constraints due to their low liquidation value, our model predicts that intangible-intensive firms can borrow as much as—or more than—tangible-intensive firms, but against cash flows rather than collateral values.

This prediction is supported by a growing body of empirical work. He (2025) finds that intangible assets are strongly associated with cash-flow-based debt but only weakly associated with asset-based debt: each dollar of acquired intangibles is associated with a \$0.25 increase in cash-flow-based debt—statistically indistinguishable from the effect of tangible assets—while the corresponding increase in asset-based debt is only \$0.05. Lian and Ma (2018) show that firms with more intangibles have a higher share of cash-flow-based debt. Larkin (2013) shows that favorable brand perception increases debt capacity by stabilizing future cash flows. Zhang and Zhou (2026) provide further direct evidence using U.S. firm-level data matched with Dealscan loan covenant data, showing that cash-flow-based borrowers have significantly higher intangible ratios than asset-based borrowers.

Prediction 2: Innovation is non-monotonic in firm size and productivity. Our model predicts that low-productivity (small) firms innovate through experimentation, while high-productivity (large) firms innovate by scaling up innovations that have already been proven. Intermediate-productivity firms rely on generic technologies.

This is consistent with the evidence in Akcigit and Kerr (2018), who show that large firms tend to innovate through internal and incremental improvements, while small firms are relatively more important for external and radical innovations. Similarly, Acemoglu et al. (2018) document that both small and large firms contribute to innovation, but through distinct mechanisms, with smaller firms engaging in more exploratory R&D.

Prediction 3: Financial development shapes the nature of innovation. Our model predicts that in more financially developed economies, experimentation by young and small firms predominates, with successful innovators scaling up rapidly. In less financially developed economies, innovation is concentrated among large incumbent firms that adopt innovative technologies primarily to relax borrowing constraints.

This is consistent with the cross-country evidence in Sui (2026), who uses ORBIS Historical balance sheet data linked to patent data for 24 OECD countries. She shows that in high-income countries, firms' propensity to undertake radical innovation is largely determined at birth, while in middle-income countries radical innovation is less common among young firms but increases over the firm life cycle. These cross-country differences are concentrated in industries with high external financial dependence, suggesting that financial frictions delay or distort radical innovation by young high-potential firms. Similarly, Cirera and Maloney (2017) document that in emerging economies formal R&D investment is disproportionately undertaken by large, exporting, and foreign-linked firms, whereas in advanced economies innovative activity is more broadly distributed across the firm-size distribution.

7 Discussion

7.1 Misallocation of Capital and Technology Choice

A large literature studies how financial frictions distort the allocation of capital across firms and reduce aggregate productivity (Buera et al., 2011; Midrigan and Xu, 2014; Moll, 2014). Our model highlights a distinct and complementary channel: financial frictions distort not only *how much* capital firms invest in, but also *which technologies* they choose. These two margins interact in general equilibrium, with the equilibrium price of capital jointly determined with the distribution of technologies across entrepreneurs.

An important implication is that standard measures of capital misallocation may underestimate the total welfare cost of financial frictions, since they do not capture the distortions in technology choice. In our framework, even if we were to equalize the distribution of capital across entrepreneurs, the economy would still be distorted because high-productivity entrepreneurs are using the wrong technology (innovate-to-scale rather than experimentation).

7.2 Financial Contracts and Bargaining Power

Throughout the analysis, we assumed that creditors have all the bargaining power in renegotiation. This is a natural benchmark but may not always capture the relevant empirical environment, particularly in venture capital financing where entrepreneurs often retain substantial bargaining power.

When entrepreneurs have positive bargaining power in renegotiation, the analysis is qualitatively similar but quantitatively different. The key insight is that the *direction* of the mechanism—that innovative technologies relax borrowing constraints by increasing continuation values—is robust to the allocation of bargaining power. What changes is the *magnitude*: lower creditor bargaining power implies that a smaller share of the continuation surplus can be extracted by creditors in renegotiation, reducing borrowing capacity. However, as long as there is a positive probability of losing intangible assets upon default, the mechanism operates and innovative technologies retain their financing advantage.

7.3 Lender Bargaining Power

The case of lender bargaining power in renegotiation is of particular interest because it connects to the literature on relationship lending and bank-firm relationships (Hart and Moore, 1994). When lenders have all the bargaining power— as in our baseline— the entrepreneur's repayment is driven entirely by the *threat* of losing her intangible assets. When lenders have less bargaining power, entrepreneurs may be able to renegotiate more favorable terms in default, weakening repayment incentives and reducing borrowing capacity. The model therefore predicts that industries with higher intangible intensity and greater lender concentration (proxying for lender bargaining power) should feature higher cash-flow-based borrowing, which is consistent with the evidence in Lian et al. (2021) and Kermani et al. (2022).

8 Conclusion

This paper has developed a dynamic general equilibrium framework to study the joint determination of technology choice, asset characteristics, and borrowing capacity. Our central finding is that intangible assets need not limit borrowing capacity: by generating high continuation values, they can support borrowing against future cash flows and thereby relax financial constraints for productive entrepreneurs.

Three main results emerge. First, borrowing capacity depends on the *entrepreneur's choice of technology*, not just the liquidation value of her assets. Innovative technologies increase repayment incentives by making default costly, enabling cash-flow-based lending. Second, technology choice is *non-monotonic in productivity*: low-productivity entrepreneurs experiment, intermediate types use generic technologies, and high-productivity entrepreneurs innovate-to-scale. Third, technology adoption and financing capacity are *jointly determined in general equilibrium*, with asset prices serving as the key feedback mechanism.

The normative analysis reveals that financial frictions lead to insufficient experimentation in equilibrium, distorting both the allocation of capital and the distribution of technologies across entrepreneurs. Policies that target innovation directly—such as forcing experimentation or subsidizing innovation— can backfire by inducing the wrong type of innovation or investment by the wrong entrepreneurs. A Pigouvian tax on generic technologies, by contrast, can improve welfare by lowering asset prices and promoting a more efficient allocation of resources.

Our framework speaks directly to current policy debates in advanced economies. The challenge facing Europe and other economies seeking to foster innovation and growth may not be funding early-stage innovation, but rather enabling the *scaling* of successful innovations through more efficient capital reallocation. Removing barriers to capital reallocation—through deeper financial markets, stronger creditor rights for intangible-intensive firms, or well-designed capital allocation policies—may therefore be more effective at fostering growth than direct innovation subsidies.

Several directions for future research are worth pursuing. First, quantifying the model to assess the relative importance of the two margins of distortion— capital misallocation and technology misallocation—is an important step toward policy calibration. Second, extending the framework to allow for dynamic financial development—whereby the accumulation of entrepreneurial wealth or the deepening of financial markets endogenously shifts the economy between innovation regimes— would provide a theory of long-run innovation transitions. Third, incorporating heterogeneous lender bargaining power and relationship lending into the framework could shed light on the role of financial market structure in shaping innovation outcomes.

References

Acemoglu, D., U. Akcigit, H. Alp, N. Bloom, and W. Kerr (2018): "Innovation, Reallocation, and Growth," *American Economic Review*, 108, 3450–3491.

Akcigit, U. and W. R. Kerr (2018): "Growth through Heterogeneous Innovations," *Journal of Political Economy*, 126, 1374–1443.

Asriyan, V., L. Laeven, A. Martin, A. Van der Ghote, and V. Vanasco (2025): "Falling Interest Rates and Credit Reallocation: Lessons from General Equilibrium," *Review of Economic Studies*, 92, 2197–2227.

Brown, J. R., S. M. Fazzari, and B. C. Petersen (2009): "Financing Innovation and Growth: Cash Flow, External Equity, and the 1990s R&D Boom," *Journal of Finance*, 64, 151–185.

Buera, F. J., J. P. Kaboski, and Y. Shin (2011): "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 101, 1964–2002.

Caggese, A. and A. Pérez-Orive (2022): "Financing Constraints, R&D Investment, and Innovative Activities," *Journal of Financial Economics*.

Calvino, F., C. Criscuolo, and C. Menon (2015): "Cross-Country Evidence on Start-up Dynamics," OECD Science, Technology and Industry Working Papers.

Chiavari, A. and S. S. Goraya (2024): "The Rise of Intangible Capital and the Macroeconomic Implications," Working Paper.

Ciaramella, L., D. Heller, and L. Leitzinger (2024): "Securing Debt in the Knowledge Economy: Evidence from Intellectual Property Registers," Working Paper.

Cirera, X. and W. F. Maloney (2017): "The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up," World Bank Report.

Cole, H. L., J. Greenwood, and J. M. Sanchez (2016): "Why Doesn't Technology Flow from Rich to Poor Countries?" *Econometrica*, 84, 1477–1521.

Corrado, C., C. Hulten, and D. Sichel (2005): "Measuring Capital and Technology: An Expanded Framework," in *Measuring Capital in the New Economy*, University of Chicago Press.

Corrado, C., C. Hulten, and D. Sichel (2009): "Intangible Capital and U.S. Economic Growth," *Review of Income and Wealth*, 55, 661–685.

Crouzet, N. and J. Eberly (2018): "Intangibles, Investment, and Efficiency," *AEA Papers and Proceedings*, 108, 426–431.

Crouzet, N. and J. Eberly (2022): "The Economics of Intangible Capital," *Journal of*

Economic Perspectives, 36, 29–52.

Döttling, R. and L. Ratnovski (2023): "Monetary Policy and Corporate Debt Structure," *Review of Financial Studies*.

Falato, A., D. Kadyrzhanova, J. W. Sim, and R. Steri (2022): "Rising Intangible Capital, Shrinking Debt Capacity, and the U.S. Corporate Savings Glut," *Journal of Finance*, 77, 2797–2838.

Gill, A. and D. Heller (2024): "Leveraging Intellectual Property: The Value of Harmonized Enforcement Regimes," *Journal of Banking & Finance*, 163, 107169.

Hall, B. H. and J. Lerner (2010): "The Financing of R&D and Innovation," in *Handbook of the Economics of Innovation*, Elsevier, vol. 1, 609–639.

Hart, O. and J. Moore (1994): "A Theory of Debt Based on the Inalienability of Human Capital," *Quarterly Journal of Economics*, 109, 841–879.

He, B. (2025): "Financing Intangible Capital," Job Market Paper.

Hochberg, Y. V., C. J. Serrano, and R. H. Ziedonis (2018): "Patent Collateral, Investor Commitment, and the Market for Venture Lending," *Journal of Financial Economics*, 130, 74–94.

Kermani, A., E. Benmelech, and C. Frydman (2022): "Asset Specificity and the Propagation of Macroeconomic Shocks," *American Economic Review*, 112, 189–227.

Kiyotaki, N. and J. Moore (1997): "Credit Cycles," *Journal of Political Economy*, 105, 211–248.

Larkin, Y. (2013): "Brand Perception, Cash Flow Stability, and Financial Policy," *Journal of Financial Economics*, 110, 232–253.

Lian, C. and Y. Ma (2018): "Anatomy of Corporate Borrowing Constraints," *Quarterly Journal of Economics*, forthcoming.

Lian, C., Y. Ma, and C. Wang (2021): "Asset Collateralization and Financial Intermediation," *Journal of Financial Economics*, 139, 838–865.

Lim, S. C., A. J. Macias, and T. Moeller (2020): "Intangible Assets and Capital Structure," *Journal of Banking & Finance*, 118, 105873.

Loumioti, M. (2012): "The Use of Intangible Assets as Loan Collateral," Doctoral dissertation, Harvard Business School.

Midrigan, V. and D. Y. Xu (2014): "Finance and Misallocation: Evidence from Plant-Level Data," *American Economic Review*, 104, 422–458.

Moll, B. (2014): "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?" *American Economic Review*, 104, 3186–3221.

OECD (2023): "OECD Science, Technology and Innovation Outlook 2023: Enabling Transitions in Times of Disruption."

Peters, R. H. and L. A. Taylor (2017): "Intangible Capital and the Investment-q Relation," *Journal of Financial Economics*, 123, 251–272.

Sui, X. (2026): "Innovation Potential, Firm Life Cycle, and Cross-Country Productivity Differences," Working Paper.

Zhang, R. and W. Zhou (2026): "Monetary Policy, Intangible Capital, and Debt Contracts," *Journal of Corporate Finance*, 98, 102943.

A Proofs

A.1 Proof of Proposition 1

In the first-best, cash flows are fully pledgeable, so there are no financial constraints. The social planner maximizes aggregate output subject to the resource constraint $\bar{K} = \int k_t(A)\, dG(A)$ and the capacity constraint $k_t \leq k^{\max}$.

Since innovation has negative expected value ex ante by Assumption 1, the planner will not have all entrepreneurs innovate. However, the option value of the innovative technology—the ability to condition investment on the realization of h_1—makes it optimal for sufficiently productive entrepreneurs. Specifically, an entrepreneur with productivity A generates expected output $A \cdot \pi \cdot \bar{h} \cdot k^{\max}$ by experimenting and investing in the success state, net of the innovation cost χ. This exceeds the value of saving if and only if $A > A^{\star}$, where $A^{\star}$ is defined implicitly by the market-clearing condition $\bar{K} = \pi \cdot k^{\max} \cdot (1 - G(A^{\star}))$.

The equilibrium price $q^{\star}$ is then determined by the zero-profit condition for the marginal entrepreneur, $A^{\star}$: she must be indifferent between experimenting and saving, which yields the expression in the proposition after accounting for the two-period investment horizon.

A.2 Proof of Lemma 1

At $t = 2$. The entrepreneur has no continuation value. She repays the amount $b_1 \cdot k_1$ if and only if the output she keeps exceeds what she would obtain by defaulting. Upon default, she retains output y_2 and loses capital $q \cdot k_1$. Repayment is therefore incentive-compatible if and only if $(q - b_1) \cdot k_1 \geq 0$, which gives $b_1 \leq q$.

At $t = 1$. The entrepreneur must compare the value of continuation— keeping her physical and intangible capital and operating in the following period— with the value of default—keeping only her cash flows. Following default at $t = 1$, the entrepreneur cannot reinvest in innovative technologies (as intangible capital takes time to accumulate), so her continuation value is $v(A) \cdot y_1$. Following repayment, her continuation value is $v(A, h_1) \cdot [y_1 + (q - b_0(h_1)) \cdot k_0]$.

Repayment is incentive-compatible if and only if

$$v(A, h_1) \cdot [y_1 + (q - b_0(h_1)) \cdot k_0] \geq v(A) \cdot y_1. \tag{30}$$

Rearranging gives the borrowing limit in equation (17).

A.3 Proof of Proposition 2

The proof proceeds by computing the value function under each technology choice and comparing them across regions of A. We define the thresholds A_E, A_G, and A_I as the productivity levels at which entrepreneurs are indifferent between adjacent technology choices, as given in Corollary 1.

Experimentation versus saving (A_E). An entrepreneur is indifferent between experimenting and saving when $E[v(A, h_1)] \cdot R \cdot (1 - \chi/w) = R^2$. Solving for A gives A_E as in equation (24).

Generic versus experimentation (A_G). An entrepreneur prefers generic investment to experimentation when the gain from scaling immediately (via generic technologies) exceeds the option value of experimentation. Setting $v(A) \cdot A \cdot R/(q(R-1)) = E[v(A, h_1)] \cdot R \cdot (1 - \chi/w)$ and solving for A gives A_G as in equation (25).

Innovate-to-scale versus generic (A_I). An entrepreneur prefers innovate-to-scale when the relaxed borrowing capacity outweighs the cost of innovation χ. Setting the two value functions equal and solving for A gives A_I as in equation (26).

A.4 Proof of Proposition 4

Part (i). Experimentation exists in equilibrium (i.e., $A_E < A_G$) if and only if the threshold condition $A_E < A_G$ holds. Substituting the expressions from Corollary 1 and simplifying gives the condition $\chi < \chi^E$ as defined in equation (28).

Part (ii). Innovation-to-scale exists in equilibrium (i.e., $A_I < \bar{A}$) if and only if $\chi < \chi^I$. The expression for χ^I in equation (29) follows by substituting the market-clearing price q and rearranging.

Part (iii). The comparison χ^E versus χ^I depends on the equilibrium price q, which itself depends on w through the market-clearing condition. Through this channel, higher w raises q, which raises χ^E relative to χ^I, eventually reversing the inequality at $w = w^\star$.