Intangible Capital, Heterogeneous Borrowing Types, and Firm Dynamics*

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Abstract

We study how non-rival intangible capital interacts with borrowing structure and financial frictions to shape firm dynamics over business cycles. We show: (i) the positive and significant association between intangible-capital growth and labor productivity growth becomes smaller in recessions; (ii) the non-rivalry of intangible capital is evident such that intangible growth predicts faster sales growth and broader firm scope, yet this relationship declines in recessions; (iii) intangible-intensive firms carry less total and secured debt, and substitute toward earnings-based covenant (EBC) borrowing over asset-based covenant (ABC) borrowing; and (iv) intangible-intensive firms with EBC have tightening financially constraints in recessions, which mitigates the productivity payoff of non-rival intangibles. We rationalize these patterns in a general-equilibrium model in which firms draw EBC/ABC constraints at entry and intangibles are non-rival in the firm production technology. The model yields a credit-amplification mechanism with heterogeneous borrowing types, reconciling the productivity slowdown despite rising intangibles.

Keywords: Intangible Capital, Financial Frictions, Earnings-Based and Asset-Based Borrowing, Firm Dynamics

JEL Codes: E22, E23 E24, E32, G01, G32, O31

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1 Introduction

The rising importance of intangible assets in firm investment decisions presents a paradox: despite their well-documented role in driving innovation and firm-level productivity, aggregate productivity growth in the U.S. has slowed markedly. A key factor in this divergence is the role of financial frictions, which differentially affect firms, particularly during periods of financial distress. The extent to which these constraints shape firms' investment decisions, borrowing behavior, and long-run productivity remains a central question in the literature. While existing research has explored these trends, the underlying mechanisms linking intangible capital accumulation, borrowing constraints, and productivity remain insufficiently understood.

This paper develops a firm-dynamics framework in which firms operate under heterogeneous borrowing constraints that depend on their reliance on intangible versus tangible capital. Our approach is motivated by two key characteristics of intangible capital. First, financing constraints for intangible investment differ fundamentally from those for tangible investment. While tangible assets can be pledged as collateral, intangible assets provide limited borrowing capacity, forcing firms to rely more heavily on internal funds or earnings-based borrowing. Second, intangible capital plays a crucial role in shaping firm scope and productivity growth, with firms investing heavily in intangibles often experiencing significant expansion in both dimensions. However, these gains depend on access to financing, and financial frictions can substantially dampen the benefits of intangible investment.

This interplay creates a trade-off: firms with greater intangible investment have higher productivity potential but face more severe financial constraints, particularly during economic downturns. Building on this insight, we propose a mechanism through which financial conditions influence the extent to which intangible capital contributes to firm and aggregate productivity. Under favorable financial conditions, firms investing in intangible capital can expand and enhance productivity growth through earnings-based bor-

rowing. However, tightening financial constraints—particularly after the global financial crisis—have disproportionately affected intangible-intensive firms, limiting their ability to expand and sustain growth. We argue that the resulting decline in intangible capital investment, driven by tighter earnings-based borrowing constraints, has been a key factor in the post-crisis slowdown in aggregate productivity growth in the U.S. economy.

Our paper's novelty lies in three key contributions. First, we examine the role of the non-rivalry property of intangible capital in shaping firm-level productivity dynamics, offering an alternative explanation for observed productivity patterns. Second, to the best of our knowledge, this study is among the first to systematically investigate the relationship between intangible capital and heterogeneous borrowing types, distinguishing between earnings-based and asset-based financing. Third, we analyze the interaction between non-rivalry in intangible capital and borrowing constraints to provide insights into broader macroeconomic trends over the business cycles, including the observed productivity slowdown.

We empirically and theoretically examine how intangible capital interacts with borrowing types and financial frictions to shape firm dynamics and productivity. Using firm-level data from Compustat, intangible capital measures from Peters and Taylor (2017), and loan-level covenants from DealScan, we establish a set of empirical facts that discipline a general-equilibrium model with heterogeneous firms and heterogeneous borrowing constraints.

First, we find that the growth of sales, intangible capital, and labor productivity co-move over time; however, intangible growth slows after 2000 and labor-productivity growth weakens after 2008. In the micro data, baseline panel regressions show that a 1 percentage-point (pp) increase in intangible-capital growth is associated with a 0.07–0.11 pp increase in labor-productivity growth. Interacting intangible growth with recession intensity (the number of recession days in a year) yields a negative and statistically significant coefficient, indicating that downturns attenuate the productivity payoff of intan-

gibles.

Second, we document the non-rivalry of intangible capital and its role in productivity over the business cycle. Intangible-capital growth is strongly associated with sales growth (0.14–0.24 pp per 1 pp of intangible growth) and with expansion in the number of reported business segments. Taken together, these patterns are consistent with the non-rivalry of intangible capital: a given stock of intangibles can be deployed concurrently across products and markets, enabling firms to scale sales and expand scope without proportional increases in tangible inputs. We also construct a firm-level non-rivalry index from the Compustat Historical Segments File and show that this non-rivalry measure is positively and significantly associated with productivity growth. Yet the sales, scope, and non-rivalry–productivity links weaken during recessions, consistent with macro-financial conditions curtailing the scalability of intangibles.

Third, we investigate how intangible intensity relates to borrowing composition and financial frictions. Intangible-intensive firms carry less total debt and a lower secured-debt share. Merging DealScan and Compustat, we show that these firms substitute toward earnings-based covenant (EBC) borrowing and away from asset-based covenant (ABC) borrowing on both the extensive margin (number of deals) and the intensive margin (deal volumes), consistent with the limited collateralizability of intangible capital.

Fourth, we link productivity to the interaction of intangibles and financial frictions. Intangible-intensive firms that rely on earnings-based borrowing experience heightened financial constraints in recessions: constraints tighten most sharply for intangible-intensive firms borrowing via EBCs when earnings deteriorate, reflecting the procyclicality of earnings-based covenants. We then show that, correspondingly, the productivity gains from intangible investment for financially constrained firms are sharply attenuated—or even reversed—during recessions.

Finally, we synthesize these findings into an amplification mechanism. Firms with higher intangible intensity tend to rely more on earnings-based borrowing. During reces-

sions, earnings weaken, EBCs bind more tightly, and credit is curtailed, tightening financial constraints precisely for intangible-intensive firms. This tightening reduces firms' ability to scale or redeploy their intangible assets, thereby eroding the effective non-rivalry of intangibles. As a result, the productivity payoff from intangible investment diminishes. This mechanism reconciles rising intangible investment at the micro level with sluggish aggregate productivity growth in the 2000s and post-2008 period: the benefits of intangibles are highly sensitive to financial conditions over the business cycle.

Based on the evidence and insights from our empirical framework, we develop a general equilibrium model with heterogeneous firms that differ in their borrowing constraints and production capabilities. The model economy features three key elements that drive firm dynamics and aggregate outcomes. First, firms can produce multiple varieties using a combination of tangible and intangible capital, where intangible capital exhibits non-rivalry in production - it can be deployed across different varieties without diminishing returns. Second, firms face two distinct types of borrowing constraints that are assigned at entry: earnings-based constraints, where borrowing capacity is tied to current profits, and asset-based constraints, where borrowing is limited by the collateral value of physical capital. Third, firms experience both aggregate and idiosyncratic productivity shocks that interact with these financial frictions to generate rich patterns in investment and production decisions.

Our theoretical framework yields several important implications for firm behavior and market structure. When firms face positive productivity shocks, their response depends crucially on their borrowing regime and capital composition. Firms with earnings-based constraints can leverage their improved productivity into greater borrowing capacity, allowing them to scale up both tangible and intangible investments. The model features an endogenous entry mechanism where potential entrants receive a signal about their productivity and face an ex-ante probability of being assigned either an earnings-based or asset-based borrowing constraint. Entry occurs only when the expected value of

operation exceeds the fixed entry cost, with the entry decision incorporating the forward-looking value of the firm under its assigned borrowing regime. This endogenous entry condition, combined with the non-rivalry of intangible capital and heterogeneous financial constraints, generates rich firm dynamics that influence both the extensive and intensive margins of production. Through this structure, the model provides a unified framework for analyzing how financial frictions and intangible capital jointly shape firm dynamics, entry decisions, and aggregate outcomes.

Related Literature Our paper is related to several strands of the literature. The first strand of the literature focuses on the productivity slowdown in the U.S. economy. Some potential explanations behind the decline in the related literature are the decline in knowledge diffusion (Akcigit and Ates, 2023), market dominance by superstar firms (Autor et al., 2020), growing productivity dispersion between global frontiers and laggards (Andrews et al., 2016), implementation lags of technology (Brynjolfsson et al., 2018), changing cost structure through intangible capital (De Ridder, 2024), higher market power with rising intangible capital (Crouzet and Eberly, 2019), and many others. Moreover, some studies investigate underlying sources of endogenous productivity (see Howitt et al., 2004; Doraszelski and Jaumandreu, 2013; Anzoategui et al., 2019). Our empirical findings are at the firm level and forthcoming Jordà (2005) local projections in our model framework highlight the relevance of financial frictions.

The second branch of related literature focuses on the steady increase in intangible assets within firms over recent decades (see Corrado et al., 2009; Corrado and Hulten, 2010; McGrattan and Prescott, 2010; Eisfeldt and Papanikolaou, 2014; Corrado et al., 2016; Peters and Taylor, 2017; Ewens et al., 2019; McGrattan, 2020). This body of work demonstrates that the accumulation of intangible assets impacts various aspects of firm behavior, including productivity growth (Corrado et al., 2017; McGrattan, 2020), competition (Ayyagari et al., 2019), market dominance (Crouzet and Eberly, 2019; De Ridder, 2024),

markups (Altomonte et al., 2021), profits (Crouzet and Eberly, 2020), and input factors (Chiavari and Goraya, 2020). In our context, Haskel and Westlake (2018) and Crouzet et al. (2022a) discuss the non-rivalrous properties of intangible capital. In our paper non-rivalry of intangible capital generates non-linearity in production factor demand amplifying short-run dynamics to financial shocks.

Lastly, our paper is related to the macro-finance literature concerned with the role of financial shocks and their transmission on the macro-level and micro-level. Canonical papers such as Kiyotaki and Moore (1997) and Bernanke and Gertler (1986) among others rely on a financial accelerator where a sudden decline in collateral value creates an intertemporal feedback loop that amplifies a financial shock throughout the economy. Our forthcoming calibration/estimation approaches resemble Jermann and Quadrini (2012) in estimating the series of financial shocks. Our firm-level estimations and forthcoming implications, when a financial shock occurs, resemble the micro-level analysis conducted by Greenwald (2019); Lian and Ma (2021). The aggregate considerations when the covenants for borrowers can vary as in Drechsel (2023) is a central feature adopted in our framework. The inability of firms to collateralize their intangible capital due to the limited commitment problem of the lenders' inability to seize such assets has been examined by Perez-Orive (2016); Lopez and Olivella (2018); Sun and Xiaolan (2019); Bianchi et al. (2019); Queralto (2020) among others. Our model overcomes this problem by the inclusion of earnings-based borrowing constraints which allow firms to finance their investment and innovation decisions tied to their earnings which endogenously depend on intangible capital (for a summary on financing innovation see Hall and Lerner, 2010; Kerr and Nanda, 2015). Our paper's insights are more closely aligned with Ottonello and Winberry (2024), which examines the importance of financial frictions in the allocation of investment and innovation. In contrast, our focus is on the impact of the non-rivalry channel of intangible capital on productivity and the incorporation of heterogeneous borrowing constraints, including earnings-based and asset-based borrowing. Overall, our

contribution to the literature is a rigorous examination of how aggregate shocks are transmitted both at the firm level, considering flexible borrowing constraints.

Layout Our paper is organized as follows: Section 2 describes the databases and discusses the measurement of main variables such as intangible capital, earnings-based, and asset-based borrowing. Section 3 provides stylized facts, and Section 4 documents reduced-form empirical analysis. Section 5 presents the model setup and framework. Finally, Section 6 concludes by discussing key takeaways and suggesting future extensions.

2 Data

This section provides details on the data sources used in the paper.

Compustat We collect data on the income statement and balance sheet for U.S. publicly held firms from S&P's Compustat database at both yearly and quartely frequency. Our Compustat yearly sample data covers the period from 1980 to 2020. Following the typical sampling procedures found in related literature, we exclude financial firms (SIC codes 4900 - 4999), utilities (SIC codes 6000 - 6999), and firms categorized as public service, international affairs, or nonoperating establishments (SIC code 9000 and above). Additionally, we remove observations with missing or negative assets or sales, as well as small firms with total assets under $5 million. We also trim the selected variables based on industry (NAICS) and year. We measure firm-level labor productivity as the ratio of sales revenue per employee, as commonly used in the standard macroeconomics literature (for some examples see Comin and Philippon, 2005; Gutiérrez and Philippon, 2016; Autor et al., 2020). Table A.1 presents the firm-level constructed data variables and their descriptions in the Compustat sample. Table A.2 reports the summary statistics for selected variables in the Compustat yearly data.

Compustat Segment We use the Compustat Historical Segments File and follow the approach outlined by De Ridder (2024) to proxy the number of business lines operated by firms. Specifically, we count the number of products for each firm by examining the 6-digit NAICS codes associated with their business segments as reported by the firm. Consistent with the methodology described in De Ridder (2024), we assign a count of 1 for firms that are not present in the segments file. We utilize the number of business lines as a measure to quantify the non-rivalry channel of intangible capital. We also use this database to measure the net sales of different business segments (6-digit NAICS codes) for firms. Table A.3 provides the summary statistics for the number of business lines. Figure B.1 depicts the histogram of the number of business lines, revealing that over 90% of firm observations consist of only one business line per year.

Measuring Intangible Capital We do not directly use the $intan$ variable from the firm balance sheet (via Compustat) to measure intangible capital. We follow Peters and Taylor (2017) to measure firm-level intangible capital. The advantage of their method is the consideration of intangible capital's origin: internal and external as the accounting guidelines describe. External intangible capital can be observed in the balance sheet as intangible asset when a firm purchases an intangible asset externally. For example, after acquisitions, the assets of the acquired firm are recorded as part of Intangible Assets in the acquirer firm's balance sheet. On the other hand, they argue that the internally created intangible capital usually appears on the income statement as expenses and not in the balance sheet as intangible asset. For example, a firm's R&D spending to develop knowledge, patents, or software cannot be observed in the balance sheet as intangible asset. Or similarly, marketing expenses to strengthen a firm's brand is included in selling, general, and administrative (SG&A) expenditures. To capture these off-balance-sheet internal intangible expenses, Peters and Taylor (2017) implement the perpetual inventory method to capitalize them, and they call the capitalized R&D expenditures as *Knowledge Capital*

and some capitalized portion of SG&A expenditures as *Organizational Capital*. We adopt their approach to measure intangible capital. Given our focus on the non-rivalry channel of intangible capital, we exclusively consider the organizational capital and exclude the knowledge capital. This is because the knowledge capital includes patents, which represent monopoly power and market influence, aspects that fall outside the scope of our study. We compute the intangible capital ratio as the ratio of organizational capital stock to the sum of organizational capital stock and net property, plant, and equipment (*ppent* variable). Table A.4 provides the summary statistics for the components of intangible capital and the intangible capital ratio, while Table A.5 documents the summary statistics for selected Compustat variables by intangible capital ratio. Figure B.2 displays the histogram of the intangible capital ratio in the entire sample, indicating significant heterogeneity across firms.

DealScan We complement our benchmark analysis with detailed loan-level data from the LPC DealScan database provided by Thomson Reuters. Our DealScan sample data covers the period from 1994 to 2017. The database covers approximately 75% of the overall volume of the U.S. commercial loan market. LPC DealScan database includes rich information on loan deals, which is the unit of observation, and depending on the deal, it can consist of several loan facilities. Following Lian and Ma (2021) and Drechsel (2023), we focus on loan covenants to extract information on earning-based borrowing. Loan covenants are contractual obligations that a borrowing firm must adhere to throughout the duration of a loan. Typically, covenants are associated with specific indicators and a numerical maximum or minimum value for this indicator is set for the loan deal. Since our focus is on earnings-based borrowing, we look for covenants related to earnings of a firm. For example, Drechsel (2023) shows that the most frequently used covenant, present at over 60% of the covenants, stipulates that the borrower's total debt cannot surpass earnings by a multiple of 4.58 at any point in time. Additionally, the top four most com-

monly mentioned covenants are linked to earnings before interest, taxes, depreciation and amortization (EBITDA) in the loan database.

We merge Compustat and LPC DealScan databases using the identifier links following Chava and Roberts (2008).[1] Table A.6 provides the summary statistics for number of deals and total deal amounts by distinguishing the deals with and without covenants. Figure B.3 illustrates the histogram of the number of loan deals, indicating that more than 80% of firm observations involve only one loan deal per year.

3 Stylized Facts

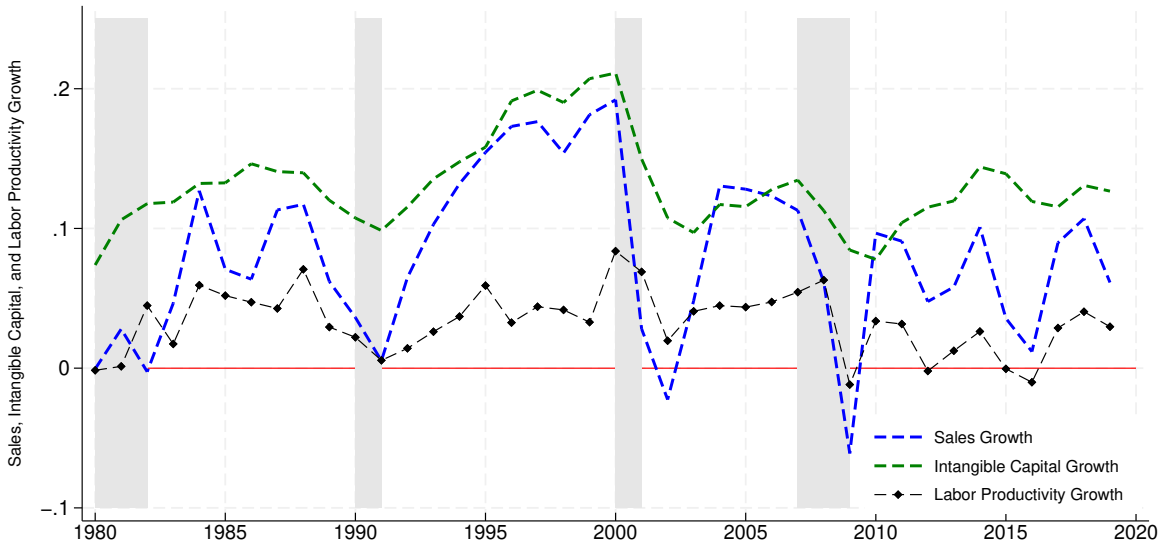
Before turning to the regression analysis, we present two sets of descriptive patterns that motivate our empirical framework. The first documents the aggregate relationship between sales, intangible investment, and labor productivity over time. The second explores how financing outcomes vary systematically with firms' intangible intensity.

Figure 1 plots aggregate growth in sales, intangible capital, and labor productivity for publicly listed U.S. firms since 1980. Three patterns stand out. First, there is strong co-movement across the three series, with expansions and downturns occurring at broadly similar times. This synchronicity provides motivation for our analysis, as it suggests a common underlying mechanism linking sales, productivity, and intangible investment. In particular, sales growth is central because it provides a natural margin for testing the non-rivalry of intangibles: firms can scale revenues across markets without proportional increases in tangible inputs. Second, the pace of intangible capital growth, while rapid in the 1980s and 1990s, slows noticeably after 2000. Third, labor productivity growth experiences a marked slowdown after the 2008 financial crisis, with weaker recoveries than in earlier periods. Taken together, these facts highlight both the potential and the fragility of intangibles such that their general co-movement with productivity emphasizes their

[1] January 2024 version of the link file is obtained from Michael Roberts' website.

importance, while the post-2000 and post-2008 slowdowns show that their productivity payoff may depend critically on macro-financial conditions.

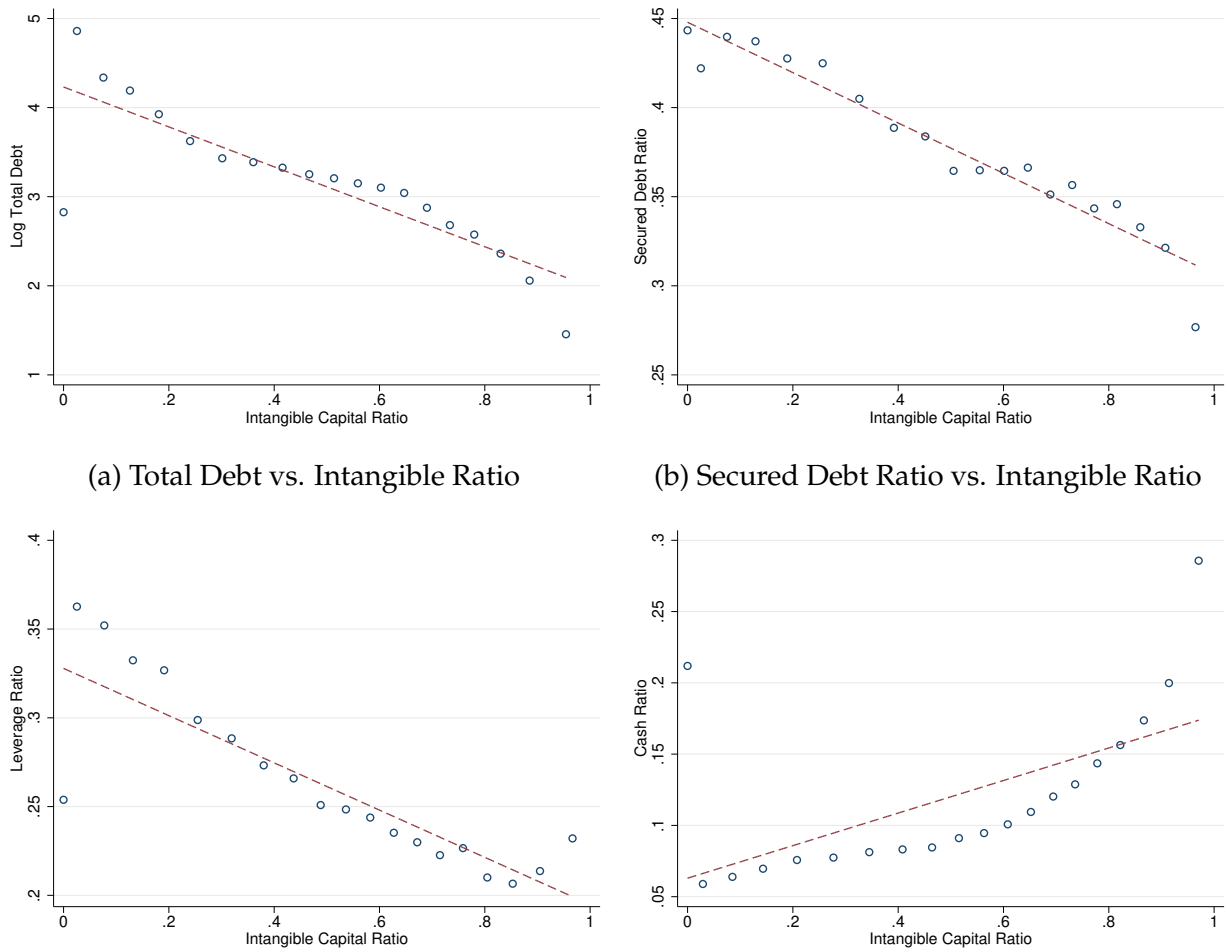
Figure 1: Trends in Sales, Intangible Capital, and Labor Productivity Growth



Note: This figure plots the time trends in the annual averages of firm-level growth in sales, intangible capital, and labor productivity for the Compustat sample.

Figure 2 documents how financing covaries with a firm's intangible capital ratio. Panel (a) shows that total debt tends to be lower for more intangible-intensive firms, while Panel (b) indicates that the composition of debt shifts away from secured borrowing as intangibles rise, consistent with the lower collateralizability of intangible assets. Panel (c) suggests that overall leverage is not negatively associated with the intangible capital ratio, and Panel (d) shows that firms with higher intangible intensity hold more cash, consistent with precautionary liquidity when pledgeable assets are scarce. Taken together, the figure provides motivating evidence for our regression framework: intangible-intensive firms rely less on secured debt, maintain lower total borrowing, and hold more liquidity.

Figure 2: Financial Characteristics vs. Intangible Capital Ratio



(a) Total Debt vs. Intangible Ratio

(b) Secured Debt Ratio vs. Intangible Ratio

(c) Leverage Ratio vs. Intangible Ratio

(d) Cash Ratio vs. Intangible Ratio

Note: This figure shows bin scatter plots between selected firm-level financial variables and the intangible capital ratio for the entire sample. The financial variables are (a) the logarithm of total debt, (b) the secured debt ratio, (c) the leverage ratio (total debt per total assets), and (d) the cash ratio (total cash per total assets).

4 Empirical Analysis

This section examines the relationship between intangible capital, firm productivity, borrowing types, and financial constraints. We proceed in four steps. First, we assess the link between intangible capital and labor productivity. Second, we explore the non-

rivalry property of intangible capital through its association with sales growth and firm scope expansion. Third, we analyze how borrowing types—earnings-based versus asset-based—interact with intangible capital, and how these interactions relate to firms' financial constraints over the business cycle. Finally, we study how financial constraints shape the productivity effects of intangible capital, with a particular focus on cyclical fluctuations.

Our baseline regression specification is as follows:

$$y_{ist} = \beta_0 + \beta_1 x_{ist-1} + \Gamma W_{ist-1} + \eta_i + \phi_s + \varepsilon_t + \epsilon_{ist}, \tag{1}$$

where firm i in industry s at year t has outcome y_{ist}, which varies across three dependent variables: labor productivity growth, sales growth, and segment growth. The main regressor of interest, x_{ist-1}, is either intangible capital growth or the intangible capital ratio, lagged one period to mitigate simultaneity concerns. The vector W_{ist-1} includes standard firm-level controls—log assets (size), Tobin's Q, and markups —which capture observable heterogeneity in firm characteristics. We include firm fixed effects (η_i) to control for time-invariant differences across firms. Industry fixed effects (ϕ_s) account for sector-specific technological and demand shocks, while year fixed effects (ε_t) absorb aggregate business cycle conditions and policy changes. Standard errors are clustered at the firm level.

4.1 Productivity and Intangibles

We begin by examining the link between intangible capital and firm labor productivity. Table 1 reports the baseline estimates. Across specifications, intangible growth is positively and significantly associated with labor productivity growth: a one percentage point increase in intangible capital growth raises productivity growth by roughly 0.07–0.11 percentage points. The magnitude is economically meaningful, consistent with the idea that intangible capital enhances efficiency firm-level productivity.

To assess whether this effect is state-dependent, we interact intangible growth with a measure of recession intensity, defined as the number of recession days in a year. Column (5) of Table 1 shows that the interaction term is negative and statistically significant, indicating that downturns attenuate the productivity benefits of intangible investment. As we document later, tighter credit conditions may disproportionately constrain intangible-intensive firms, which rely more heavily on financing modes sensitive to earnings fluctuations. Taken together, these results suggest that intangibles boost labor productivity in expansions, but their benefits are fragile in recessions. This helps explain the apparent paradox of rising intangible investment coinciding with sluggish aggregate productivity growth.

Table 1: Intangible Growth and Labor Productivity Growth

	(1)	(2)	(3)	(4)	(5)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
L.Intangible Growth	0.109***	0.106***	0.0998***	0.0724***	0.0795***
	(0.00831)	(0.00833)	(0.00867)	(0.0101)	(0.0109)
L.Recession					0.000218
					(0.0106)
L.Intangible Growth × L.Recession					-0.0690*
					(0.0356)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
R^2	0.00386	0.00592	0.0122	0.0947	0.0948
N	158921	158921	153683	152124	152124

Note: This table reports panel regression estimates of the relationship between firm-level labor productivity growth and the lagged intangible capital growth. Control variables include a lagged of log assets (size), Tobin's Q, and markups. Recession variable is a continuous measure of the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

4.2 Non-Rivalry Intangibles

We next examine the non-rivalry property of intangible capital, focusing on whether intangible capital investments enable firms to scale output across products and markets without proportional increases in tangible inputs. We present evidence in three steps: first on sales growth, then on segment expansion, and finally using a direct measure of non-rivalry linked to productivity growth.

Table 2: Sales Growth and Intangible Growth

	(1)	(2)	(3)	(4)	(5)
	Sales Growth	Sales Growth	Sales Growth	Sales Growth	Sales Growth
L.Intangible Growth	0.244***	0.243***	0.224***	0.137***	0.145***
	(0.0128)	(0.0129)	(0.0131)	(0.0136)	(0.0145)
L.Recession					-0.0190*
					(0.0110)
L.Intangible Growth × L.Recession					-0.0759*
					(0.0438)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
R^2	0.0147	0.0249	0.0343	0.148	0.148
N	165913	165913	160392	158848	158848

Note: This table reports panel regression estimates of the relationship between firm-level sales growth and the lagged intangible capital growth. Control variables include a lagged of log assets (size), Tobin's Q, and markups. Recession variable is a continuous measure of the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 2 shows that intangible capital growth is strongly and positively associated with sales growth. Across all specifications, a one percentage point increase in intangible growth raises sales growth between 0.14 and 0.24 percentage points. The magnitude is large: firms expanding their intangible stock more rapidly experience substantially faster top-line growth. This result is consistent with the idea that intangibles embody scalable

knowledge, organizational capabilities, and brand equity that translate directly into revenue expansion. However, column (5) reveals that the effect is state-dependent. The negative and statistically significant interaction between intangible growth and recessions indicates that downturns erode this channel. Even when intangible capital accumulates, weaker demand conditions limit firms' ability to translate these assets into higher sales, pointing to the fragility of the non-rivalry advantage in adverse macroeconomic environments.

Table 3: Segment Growth and Intangible Growth

	(1)	(2)	(3)	(4)	(5)
	Segment Growth	Segment Growth	Segment Growth	Segment Growth	Segment Growth
L.Intangible Growth	0.0142***	0.00534*	0.00647**	0.00767**	0.0103**
	(0.00291)	(0.00277)	(0.00290)	(0.00390)	(0.00442)
L.Recession					-0.0225***
					(0.00709)
L.Intangible Growth × L.Recession					-0.0267***
					(0.0100)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
R^2	0.000603	0.0882	0.0944	0.131	0.131
N	154024	154024	153984	152431	152431

Note: This table reports panel regression estimates of the relationship between firm-level segment growth and the lagged intangible capital growth. Control variables include a lagged of log assets (size), Tobin's Q, and markups. Recession variable is a continuous measure of the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 3 provides complementary evidence by examining whether intangible capital enables firms to expand their scope across business segments. The estimates show that firms with faster intangible growth are more likely to increase the number of reported business segments. While the magnitudes are smaller than those for sales growth, the estimates remain statistically significant and economically meaningful: intangible growth predicts diversification across product lines or markets. This finding highlights a key

manifestation of non-rivalry—intangible assets can be deployed simultaneously in multiple business activities without being depleted. Yet, once again, recessions undermine this effect. The negative interaction term in column (5) shows that diversification benefits diminish in downturns, suggesting that firms face constraints in scaling intangibles across new lines of business when external financing is tight or demand is weak.

To formalize this relationship, we construct a firm-level measure of non-rivalry using the Compustat Historical Segments File, which reports net sales for different business segments (classified by 6-digit NAICS codes). Specifically, we calculate the annual sales growth of each business segment within a firm, compute the average segment-level sales growth, and normalize it by the firm's annual intangible capital growth. This approach captures the extent to which intangible capital expansion translates into growth across multiple business segments. A higher ratio indicates greater firm-level non-rivalry, as it reflects a stronger capacity to scale intangible capital across different industries.

Our non-rivalry measure is defined as follows:

$$\textit{non-rivalry}_{i,t} = \frac{\frac{1}{N_{i,t}} \sum_{s=1}^{N_{i,t}} \textit{sales growth}_{i,s,t}}{\textit{intangible growth}_{i,t}} \tag{2}$$

where i represents a firm, t denotes a year, and s indexes the firm's business segments. $N_{i,t}$ is the number of business segments firm i operates in during year t. $\textit{sales growth}_{i,s,t}$ measures the annual sales growth of segment s for firm i in year t, while $\textit{intangible growth}_{i,t}$ represents the firm's overall annual intangible capital growth. For firms operating in only a single business segment in a given year ($N_{i,t} = 1$), we use the total sales variable from the benchmark Compustat dataset. This adjustment ensures that our measure remains consistent across firms with varying degrees of diversification.

Table 4 validates whether our measure effectively captures the non-rivalry aspect of intangible capital. The results show a robust and positive association between non-rivalry and productivity growth across all specifications, with coefficients around 0.006–0.007. These estimates confirm that firms able to leverage intangibles in a non-rival fashion en-

joy higher productivity growth. Importantly, column (5) shows that this relationship is weakened during recessions: the interaction between non-rivalry and recession intensity is negative and statistically significant. This finding implies that while intangibles have the potential to generate broad-based productivity gains, the realization of these gains depends on macro-financial conditions. When recessions hit, the scalability of intangible assets is curtailed, limiting their contribution to productivity growth.

Table 4: Non-Rivalry Intangibles and Productivity Growth

	(1)	(2)	(3)	(4)	(5)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
L.Non-Rivalry	0.00624***	0.00662***	0.00696***	0.00600***	0.00711***
	(0.000874)	(0.00104)	(0.00107)	(0.00113)	(0.00128)
L.Recession					-0.121
					(0.0842)
L.Non-Rivalry × L.Recession					-0.00876**
					(0.00377)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
R^2	0.00142	0.00408	0.0168	0.165	0.165
N	82365	82365	82315	80634	80634

Note: This table reports panel regression estimates of the relationship between firm-level labor productivity growth and the lagged measure of non-rivalry. Non-rivalry measure is constructed based on the equation (2). Control variables include a lagged of log assets (size), Tobin's Q, and markups. Recession variable is a continuous measure of the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

4.3 Intangibles, Borrowing Types, and Financial Constraints

In this section, we examine the relationship between borrowing types, financial constraints, and intangible capital over the business cycle. We begin with an analysis based

on the Compustat sample and then turn to the merged DealScan–Compustat sample.

Analysis using the Compustat Data Building on the insights from the descriptive analysis, we conduct a regression analysis using our Compustat sample to investigate the systematic association between firm-level debt characteristics and the intangible capital ratio.

Table 5: Firm-level Total Debt and Intangible Capital Ratio

	(1)	(2)	(3)	(4)
	Log Total Debt	Log Total Debt	Log Total Debt	Log Total Debt
L.Intangible Ratio	-0.924***	-0.827***	-0.535***	-0.557***
	(0.0126)	(0.0329)	(0.0466)	(0.0684)
Control Variables	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	No	Yes	Yes
Year FE	No	Yes	Yes	Yes
R^2	0.721	0.726	0.752	0.858
N	149426	149426	137680	136261

Note: This table displays the results of the regression specification where the dependent variable is the firm-level logarithm of total debt, and the main explanatory variable is the one-year lag of the firm-level intangible capital ratio. Control variables include the one-year lag of the firm-level logarithm of total assets, markup, and Tobin's Q. Standard errors (in parentheses) are clustered at the firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5 presents regression results examining the relationship between total debt and the intangible capital ratio at the firm level. The dependent variable is the logarithm of firm-level total debt, regressed on the one-year lagged intangible capital ratio. Control variables (assets, markup, and Tobin's Q) and various fixed effects (firm, year, and industry) are included in all specifications to account for potential confounding effects.

The coefficients for the intangible capital ratio across different specifications (columns (1) to (4)) consistently show negative and statistically significant associations. This indicates that higher levels of intangible capital are associated with lower levels of total debt. Overall, the results suggest a robust negative relationship between intangible capital and total debt, implying that firms with higher intangible capital ratios tend to have lower total debt levels, even after accounting for other factors included in the regression models.

Table 6 presents the results of regressions analyzing the relationship between the secured debt ratio and the intangible capital ratio at the firm level. The dependent variable is the secured debt ratio, defined as the ratio of debt secured by mortgages or other assets to total debt, including current liabilities. The control variables are the same as those in Table 5. Overall, the results reveal a robust negative relationship between intangible capital intensity and the secured debt ratio, suggesting that firms with higher intangible capital are likely to rely less on asset-based borrowings.

Table 6: Firm-level Secured Debt Ratio and Intangible Capital Ratio

	(1)	(2)	(3)	(4)
	Secured Debt Ratio	Secured Debt Ratio	Secured Debt Ratio	Secured Debt Ratio
L.Intangible Ratio	-0.186***	-0.220***	-0.197***	-0.148***
	(0.00404)	(0.00971)	(0.0119)	(0.0190)
Control Variables	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	No	Yes	Yes
Year FE	No	Yes	Yes	Yes
R^2	0.0627	0.0862	0.171	0.508
N	104547	104547	103468	101986

Note: This table displays the results of the regression specification where the dependent variable is the firm-level secured debt ratio, and the main explanatory variable is the one-year lag of the firm-level intangible capital ratio. The secured debt ratio is calculated as the share of secured debt (backed by mortgages or other secured assets) in total debt ($\frac{\textit{Debt - Mortgages \& Other Secured (dm)}}{\textit{Total Debt (dlc + dltt)}}$). Control variables include the one-year lag of the firm-level logarithm of total assets, markup, and Tobin's Q. Standard errors (in parentheses) are clustered at the firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Analysis using the DealScan-Compustat Merged Data Even though using Compustat data provides crucial insights into the relationship between firm-level financial characteristics and intangible capital, we supplement this with the DealScan database, which offers rich information on loan deals and covenants to distinguish between earnings-based and asset-based borrowings. We merge this data with our Compustat sample. In this context, to provide more systematic evidence and quantify the role of intangible capital in heterogeneous borrowing constraints, such as earnings-based and asset-based borrowings, we specify the following regression model:

$$y_{it} = \beta_0 + \beta_1 \textit{intangible capital}_{it} + \beta_2' X_{it-1} + u_i + u_t + u_s + \epsilon_{it} \tag{3}$$

where the dependent variable takes the following values: i) the firm-level total number of earnings-based loan deals per year, ii) the firm-level total number of asset-based loan deals per year, iii) the firm-level total volume of earnings-based loan amounts per year, and iv) the firm-level total volume of asset-based loan amounts per year. The variable $\textit{intangible ratio}_{it}$ represents the the firm-level logarithm of intangible capital. The vector of firm-level control variables, denoted as X_{it-1}, includes earnings before interest, taxes, depreciation, and amortization (*EBITDA*), one-year lagged *EBITDA*, Tobin's Q, and net property, plant, and equipment (*ppent*), with all control variables normalized by one-year lagged book assets. To account for unobserved heterogeneity, we incorporate firm (u_i), year (u_t), and industry (u_s) fixed effects. One-year lagged explanatory variables are included to mitigate potential endogeneity issues. Standard errors are clustered at the firm level.

Following the classification of earnings-based and asset-based covenants in Lian and Ma (2021) and Drechsel (2023), Table 7 shows how borrowing structures vary with intangible intensity. The first two columns indicate that intangible-intensive firms engage in more earnings-based covenant (EBC) borrowing and fewer asset-based covenant (ABC) deals. Quantitatively, the coefficient on intangible capital in Column (1) implies that a

one percentage point increase in intangible intensity raises the number of EBC deals by roughly 0.5 percent, while Column (2) shows a significant decline in the number of ABC deals. These patterns are consistent with the notion that intangible assets lack collateral value and therefore cannot easily support asset-backed lending.

Table 7: Intangible Capital and Heterogeneous Borrowing Types

	(1)	(2)	(3)	(4)
	#EBC Deals	#ABC Deals	EBC Log Deal Amounts	ABC Log Deal Amounts
Intangible Capital	0.00540*	-0.0596**	0.00706***	-0.0578**
	(0.00263)	(0.0185)	(0.00212)	(0.0191)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	15174	8986	14058	8343

Note: This table reports panel regression estimates of the relationship between firm-level measures of earnings-based covenant (EBC) and asset-based covenant (ABC) deals, and the intangible capital. Earnings-based covenant and asset-based covenant deals are constructed through following the methodology of Lian and Ma (2021) and Drechsel (2023). The dependent variables in Columns (1)–(2) are based on the number of corresponding deals, while those in Columns (3)–(4) are based on the total volume of corresponding deals. Control variables include earnings before interest, taxes, depreciation, and amortization (*EBITDA*), one-year lagged *EBITDA*, Tobin's Q, and net property, plant, and equipment (*ppent*), with all control variables normalized by one-year lagged book assets. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

Columns (3) and (4) of Table 7 confirm that this pattern extends to loan size. Intangible-intensive firms borrow larger amounts when relying on EBCs, but significantly smaller amounts when borrowing with ABCs. This substitution toward earnings-based debt reflects the financing needs of firms whose productive assets cannot be pledged but can generate predictable cash flows. Taken together, Table 7 provides clear evidence that intangibles reshape borrowing composition: rather than reducing debt reliance overall, intangible-intensive firms shift toward covenants tied to earnings performance instead of

collateral value.

Table 8: Financial Constraints and Intangible Capital

	(1) Financially Constrained	(2) Financially Constrained	(3) Financially Constrained	(4) Financially Constrained	(5) Financially Constrained
L.Intangible Cap. Ratio	0.176*	0.275***	0.249**	0.661***	0.222
	(0.0922)	(0.0951)	(0.0989)	(0.108)	(0.320)
EBC					0.172
					(0.285)
EBC × L.Intangible Cap. Ratio × Recession					1.387*
					(0.737)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
N	178360	175409	125707	14421	3719

This table reports Poisson regression estimates of the relationship between a firm-level dummy indicator of financial constraints (=1 if financially constrained, =0 otherwise) and the lagged intangible capital ratio. The financial constraint dummy is constructed following the methodology of Hadlock and Pierce (2010). Earnings-based covenant and asset-based covenant deals are identified using the methodologies of Lian and Ma (2021) and Drechsel (2023). The variable *EBC* is a dummy equal to one if a firm has at least one earnings-based covenant deal in a given year. Control variables include lagged log assets (size), Tobin's Q, and markups. The recession variable measures the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 8 turns to the implications of this borrowing pattern for financial constraints. We construct the firm-level financial constraint dummy following the methodology of Hadlock and Pierce (2010). Columns (1)–(4) show that a higher intangible capital ratio is consistently associated with a greater likelihood of being classified as financially constrained. The coefficients are positive and statistically significant across most specifications, with magnitudes suggesting that a one standard deviation increase in intangible intensity raises the probability of financial constraint by 6–9 percentage points. This confirms that even though intangible-intensive firms substitute into EBC borrowing, they remain more constrained overall compared to firms with more tangible collateral.

Column (5) of Table 8 adds a triple interaction between intangible intensity, EBC borrowing, and recession exposure. The positive and statistically significant coefficient indicates that financial constraints tighten most sharply for intangible-intensive firms borrowing via EBCs during downturns. This reflects the procyclicality of earnings-based contracts: when earnings fall, covenants bind, and lenders restrict credit precisely when firms are most vulnerable. By contrast, firms with asset-based borrowing may still retain collateral value and therefore face relatively looser credit conditions. This result high-

lights a crucial amplification channel: the very borrowing mode that enables intangible-intensive firms to finance investment in normal times becomes a source of fragility in recessions.

4.4 Productivity, Intangibles, and Financial Constraints

Finally, we study whether financial constraints mediate the relationship between intangible capital and firm-level productivity. Table 9 reports results from regressions of productivity growth on intangible growth, interacted with a financial constraint dummy and recession intensity. Across specifications, intangible growth is positively and significantly associated with productivity, confirming the central role of intangibles in driving firm performance. However, this association is not uniform. Column (4) shows that the triple interaction between financial constraints, intangible growth, and recessions is large, negative, and statistically significant. In other words, financially constrained firms fail to translate intangible investment into productivity gains precisely during downturns, when external financing is scarce and earnings volatility is high.

The magnitudes are economically meaningful: while unconstrained firms continue to reap productivity benefits from intangible investment, constrained firms see these effects sharply attenuated—or even reversed—during recessions. This pattern highlights the cyclical fragility of intangibles. Because intangible capital is harder to collateralize and more dependent on earnings-based borrowing as we documented before, financial frictions amplify business cycle fluctuations in their productivity payoffs. Together with Tables 7–8, these results suggest an amplification mechanism whereby borrowing frictions make the intangible–productivity link highly state-dependent. This mechanism offers a potential explanation for the disconnect between rising intangible investment at the micro level and sluggish productivity growth in aggregate data.

Table 9: Productivity Growth, Intangible Growth, and Financial Constraints

	(1) Prod. Growth	(2) Prod. Growth	(3) Prod. Growth	(4) Prod. Growth
L.Intangible Growth	0.0939***	0.0915***	0.0844***	0.0620***
	(0.00845)	(0.00849)	(0.00876)	(0.0104)
Financially Constrained	-0.0151	-0.0137	-0.0232	-0.0612*
	(0.0213)	(0.0213)	(0.0219)	(0.0346)
Financially Constrained × L.Intangible Growth × Recession	-0.228	-0.224	-0.258	-0.585**
	(0.272)	(0.273)	(0.267)	(0.257)
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	No	Yes	Yes
Year FE	No	Yes	Yes	Yes
R^2	0.00426	0.00632	0.0126	0.0951
N	158921	158921	153683	152124

This table reports regression estimates of the relationship between the firm-level labor productivity growth and the interaction between intangible capital growth and financial constraints. The financial constraint dummy is constructed following the methodology of Hadlock and Pierce (2010). Control variables include lagged log assets (size), Tobin's Q, and markups. The recession variable measures the number of recession days in a year. Standard errors are clustered at the firm level. * $p < .10$, ** $p < .05$, *** $p < .01$.

Summary We arrive at three main conclusions and an underlying mechanism. First, intangible capital is positively and significantly associated with productivity, but the association is state-dependent and weakens during recessions. Second, the non-rivalry of intangibles is evident in sales growth, firm scope expansion, and productivity growth, yet its payoff proves fragile in recessions. Third, intangible-intensive firms rely disproportionately on earnings-based borrowing, which tightens financial constraints when earnings deteriorate in recessions and weakens productivity payoffs. The underlying mechanism is that, in recessions, financial constraints erode the effective non-rivalry of intangibles which rely on earnings-based borrowing and diminish the productivity gains from intangible capital. Together, the results provide micro-level evidence for why rising intangible investment can coexist with weak aggregate productivity growth, highlighting that the benefits of intangibles are highly sensitive to financial conditions over the business cycle.

5 Model

The economy is set as a discrete-time infinite horizon economy with time denoted t indexed starting from 1. Firms, capital goods producers, and representative households populate the economy. The firm sector is comprised of final goods producers and intermediate producers. Final consumption goods producers purchase intermediate goods and are perfectly competitive. Intermediate producers retain monopolistic rights and produce varieties that can produce more than one variety. They also face borrowing constraints where some firms are subject to earnings-based conditions while others are subject to asset-based conditions. These intermediate producers utilize tangible and intangible capital in their production process, with intangible capital being nonrivalrous in producing varieties.

Final Good Producers There is a continuum of final good producers where the final good priced as the numeraire is a composite given as a CES aggregator of intermediate goods

$$Y_t = \left(\int_0^{A_t} y_{i,t}^{\frac{1}{\eta}} di \right)^{\eta} \tag{4}$$

where $y_{i,t}$ is the intermediate variety i purchased from an associated producer and $\eta > 1$ is the elasticity of substitution between different varieties. The variable A_t represents the stock of intermediate varieties, which intermediate firms endogenously determine. We arrive at the standard demand function for intermediate goods

$$p_{i,t} = P_t Y_t^{\frac{\eta-1}{\eta}} y_{i,t}^{\frac{1-\eta}{\eta}}. \tag{5}$$

Intermediate prices aggregate to the economy's price level as $P_t = \left(\int_0^{A_t} p_{i,t}^{\frac{1}{1-\eta}} di \right)^{1-\eta} = 1$.

Intermediate Producers Intermediate firms incur a common and idiosyncratic productivity shock denoted by z_t and s_t, respectively, given by

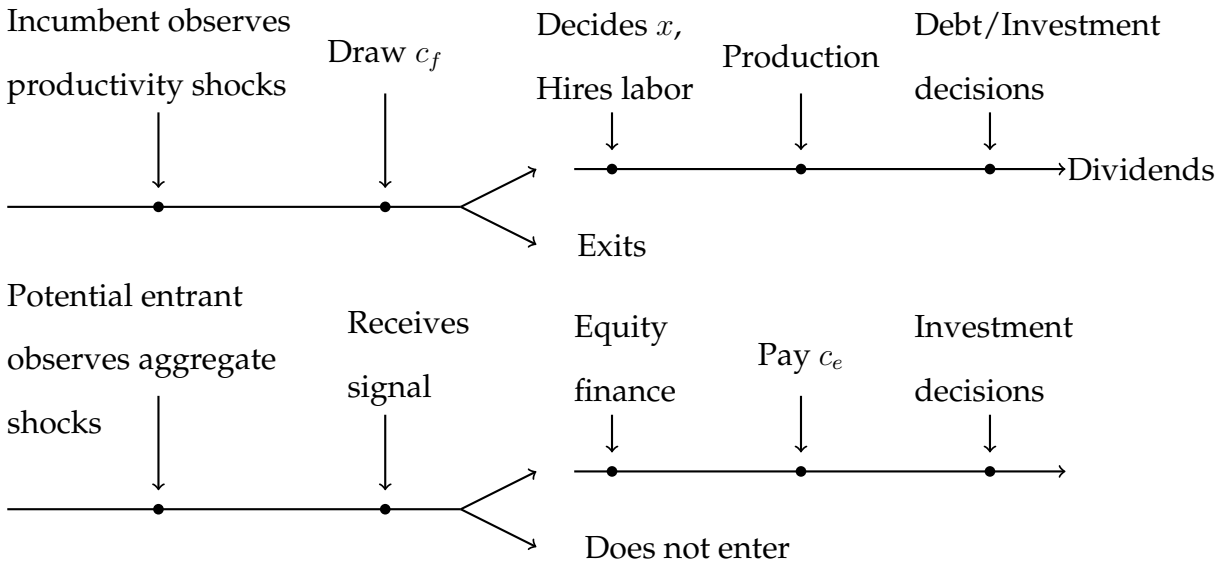
$$\log z_{t+1} = \rho_z \log z_t + \sigma_z \varepsilon_{z,t+1},$$
$$\log s_{t+1} = \rho_s \log s_t + \sigma_s \varepsilon_{s,t+1},$$

where $\varepsilon_{z,t}, \varepsilon_{s,t} \sim N(0,1)$. Let us denote the conditional distribution of s_{t+1} as $\mathcal{F}(s_{t+1}|s_t)$. At the beginning of each period before production, incumbent firms realize z_t and s_t and an operating cost c_f distributed over a time-invariant common distribution G. If an incumbent decides to exit, they recoup the market price Q_t of their current capital stock k_t, less any debts due b_t adjusted for dividend frictions. Firms that decide to produce decide how many varieties produce x_t and allocate the current stock of physical and firm-specific intangible capital k_t, n_t, respectively, and hiring labor l_t at wage w_t. In the same period, firms that choose to remain in the market also decide on investments in physical and intangible capital, i_t^k, i_t^n, constrained by current debts due b_t less new loans received b_{t+1}/R_t where R_t denotes the gross interest rate. Households own all incumbent producers that aim to maximize dividend payouts and can access equity financing subject to an adjustment cost. Each firm faces an earnings-based or asset-based borrowing constraint, which remains fixed over the firm's life cycle.

In each period, there is a constant mass $M > 0$ of prospective entrants where each receives a signal j drawn from a common time-invariant distribution J and a realization with probability χ of facing an earnings-based borrowing constraint and probability $1-\chi$ of facing an asset-based borrowing constraint. Entrants that decide to enter pay an entry cost $c_e \geq 0$. When an entrant decides to enter the market, they rely only on equity financing for their initial investments and begin operations in the following period. Let $\Gamma_t(s,k,n,b)$ denote the distribution of operating intermediate producers over the modeled heterogeneity. However, Γ_t does not capture the conditional distribution by borrowing

type. Let Γ_t^x, where $x = \text{eb}, \text{ab}$ denote the conditional distribution by earnings-based borrowers and asset-based borrows, respectively. Additionally, $\lambda_t \in \Lambda$ denotes the vector of aggregate state variables with transition operator $T(\lambda_{t+1}|\lambda_t)$. Figure 3 provides a diagram of the timing of events that abstractly holds for each time of borrowing-constraint firm.

Figure 3: Timing in Period t



Note: This figure provides a diagram of the timing of events that abstractly holds for each time of borrowing-constraint firm.

Variety Problem In the spirit of Crouzet et al. (2022b), the production of a variety $i \in A_t$ follows a three-input Cobb-Douglass function of the following:

$$y_{i,t} = z_t s_t n_t(i)^{\alpha} k_t(i)^{\beta} l_t(i)^{1-\alpha-\beta} \tag{6}$$

where $0 \leq \alpha, \beta$ and $\alpha + \beta < 1$ are the elasticities of production for intangible and physical capital, respectively. For a stock of varieties $[0, x_t] \subset A_t$, we can describe the total firms' revenue problem as allocating the appropriate factors of production for the production of each variety:

$$\Pi_t \equiv \max_{\{n_t(i),k_t(i),l_t(i)\}_{i\in[0,x_t]}} Y_t^{\frac{\eta-1}{\eta}} \int_0^{x_t} y_{i,t}^{1/\eta} di \tag{7}$$

subject to

$$\int_0^{x_t} k_t(i)di \leq k_t \tag{8}$$

$$\int_0^{x_t} l_t(i)di \leq l_t \tag{9}$$

$$\left(\int_0^{x_t} n_t(i)^{\frac{1}{1-\rho}} d_i\right)^{1-\rho} \leq n_t \tag{10}$$

The parameter $0 \leq \rho \leq 1$ captures the firm's non-rivalry aspect of intangible capital. The limits of ρ offers insight:

$$\begin{cases} \int_0^{x_t} n_t(i)di \leq n_t & \text{if } \rho = 0; \\ \max\limits_{i\in[0,x_t]} n_t(i) \leq n_t & \text{if } \rho = 1. \end{cases}$$

When $\rho = 1$, intangible capital can be used in the production stream of every variety exhibiting complete non-rivalry.

The firm demand for production factors satisfies

$$\begin{aligned} k_t(i) &= x_t^{-1} k_t, \\ l_t(i) &= x_t^{-1} l_t, \\ n_t(i) &= x_t^{-(1-\rho)} n_t, \qquad \forall\, i \in [0, x_t]. \end{aligned} \tag{11}$$

We can reduce equation (7) to express the firm's revenue as:

$$\pi_t^x = x_t^{\frac{\eta+\alpha\rho-1}{\eta}} \left[z_t s_t n_t^{\alpha} k_t^{\beta} l_t^{1-\alpha-\beta}\right]^{1/\eta} Y_t^{\frac{\eta-1}{\eta}}. \tag{12}$$

Incumbent's Optimization Problem Given the aggregate state λ_t, idiosyncratic productivity s_t, operating cost c_f, and stock of capital, k_t, n_t, incumbent firms choose the number

of varieties and labor decisions as the following static problem:

$$\pi_t = \max_{x_t, l_t} \pi_t^x - w_t l_t.$$

Incumbents can access debt markets through one-period risk-free bonds, b_t. The gross interest rate incumbents face is R_t denoted in final consumption units.

We describe the law of motion of capital and the intertemporal budget constraint of incumbents necessary for the continuation value. The law of motion of capital is given by:

$$k_{t+1} = i_t^k + (1 - \delta_k) k_t$$
$$n_{t+1} = i_t^n + (1 - \delta_n) n_t,$$

where δ_k, i_t^k, δ_n, i_t^n denote depreciation rates and investment for physical and intangible capital, respectively. We arrive at the following intertemporal budget constraint

$$\Psi(d_t) = \pi_t - w_t l_t - c_f - Q_t i_t^k - i_t^n - b_t + \frac{b_{t+1}}{r_t} \tag{13}$$

where d_t denotes the firm's free cash flow in period t distributed as a dividend to investors subject to costly change in equity payout $\Psi(\cdot)$ modeled similarly as Jermann and Quadrini (2012):

$$\Psi(d_t) = d_t + \psi(d_t - \overline{d})^2 \tag{14}$$

where $\psi \geq 0$ and $\overline{d}$ are the long-run payout target.

Motivated by the limited commitment problem, incumbents face heterogeneous borrowing constraints as documented by Lian and Ma (2021). Similar to Drechsel (2023), we characterize these borrowing constraints as asset-based or earnings-based. We assume the same borrowing constraint type applies across the entire life-cycle of a firm determined by an exogenous probability at the entry phase. Incumbents with an earnings-based bor-

rowing constraint are modeled as

$$\frac{b_{t+1}}{r_t} \leq \theta_e \pi_t.$$

The parameter $\theta_e > 1$ represents a multiple of current gross profits. Whereas incumbents with an asset-based borrowing constraint are modeled as

$$\frac{b_{t+1}}{r_t} \leq \theta_a E_t\{Q_{t+1}(1-\delta_k)k_t\}$$

where the parameter $0 < \theta_a < 1$ represents the fraction of physical capital that can be pledged as collateral. A negative value $b_t < 0$ means a firm is a saver. If the firm decides to exit, the exit occurs before production and the value is

$$V^{\text{ex}} = \Psi(Q_t k_t - b_t).$$

We arrive at two value functions dependent on the borrowing constraint a firm faces with time subscripts omitted of the following:

$$V^{\text{eb}}(s,k,n,b,c_f;\lambda) =$$
$$\max_{i^k,i^n,b'} \left\{ d + \tilde{\Lambda} \int_{\Lambda} \int_{\mathbb{R}_+} \int_{\mathbb{R}_+} \max\left\{V^{\text{eb}}(s',k',n',b',c_f';\lambda'), V^{\text{ex}}(s',k',n',b';\lambda')\right\} dG(c_f') d\mathcal{F}(s'|s) dT(\lambda'|\lambda) \right\},$$

subject to

$$\begin{aligned}
\Psi(d) &= \pi^*(x,l,s,k,n;\lambda) - c_f - Qi^k - i^n - b + \frac{b'}{r}, \\
\frac{b'}{R} &\leq \theta_e \pi^*(x,s,k,n;\lambda), \\
k' &= i^k + (1-\delta_k)k, \\
n' &= i^n + (1-\delta_n)n. \\
\pi^*(x,l,s,k,n;\lambda) &= \max_{x,l} \pi(x,l,s,k,n;\lambda) - wl,
\end{aligned}$$

and

$$V^{\text{ab}}(s,k,n,b,c_f;\lambda) =$$
$$\max_{i^k,i^n,b'}\left\{d+\tilde{\Lambda}\int_{\Lambda}\int_{\mathbb{R}_+}\int_{\mathbb{R}_+}\max\left\{V^{\text{ab}}(s',k',n',b',c_f';\lambda'),V^{\text{ex}}(s',k',n',b';\lambda')\right\}dG(c_f')d\mathcal{F}(s'|s)dT(\lambda'|\lambda)\right\},$$

subject to

$$\begin{aligned}
\Psi(d) &= \pi^*(x,l,s,k,n;\lambda) - c_f - Qi^k - i^n - b + \frac{b'}{r},\\
\frac{b'}{r} &\leq E_t\{\theta_a Q'(1-\delta_k)k\},\\
k' &= i^k + (1-\delta_k)k,\\
n' &= i^n + (1-\delta_n)n,\\
\pi^*(x,l,s,k,n;\lambda) &= \max_{x,l}\pi(x,l,s,k,n;\lambda) - wl.
\end{aligned}$$

Where V^{eb} is the cum-dividend value function of incumbents facing an earnings-based borrowing constraint, and similarly V^{ab} is for incumbents facing an asset-based borrowing constraint. $\tilde{\Lambda}$ denotes the stochastic discount factor with $\tilde{\Lambda} \equiv \beta\frac{\partial u(\cdot)/\partial c'}{\partial u(\cdot)/\partial c}$ based on the household instantaneous utility function $u(\cdot)$ evaluated at appropriate temporal consumption values and β being the subjective discount factor for households.

Entry For an aggregate state λ and signal $j \sim J(j)$ the value for a prospective entrant can take either form

$$V_e^{\text{eb}}(j;\lambda) = \max_{k',n'}\Psi(-Qk'-n') + \tilde{\Lambda}\int_{\Lambda}\int_{\mathbb{R}_+}\int_{\mathbb{R}_+}V^{eb}(s',k',n',b',c_f';\lambda')dG(c_f')d\mathcal{F}(s'|q)dT(\lambda'|\lambda),$$
$$V_e^{\text{ab}}(j;\lambda) = \max_{k',n'}\Psi(-Qk'-n') + \tilde{\Lambda}\int_{\Lambda}\int_{\mathbb{R}_+}\int_{\mathbb{R}_+}V^{ab}(s',k',n',b',c_f';\lambda')dG(c_f')d\mathcal{F}(s'|q)dT(\lambda'|\lambda),$$

depending on whether an earnings-based or asset-based borrowing constraint is anticipated. Entry will occur if and only if $V_e^{eb}(j;\lambda) \geq c_e$ or $V_e^{ab}(j;\lambda) \geq c_e$ for earnings-based

and asset-based entrants, respectively.

Physical Capital Producers Physical capital is created by a continuum of producers sold to intermediate producers at a uniform price, Q_t. Production of physical capital, I_t^k, entails transforming the final good while incurring the standard flow adjustment cost $\Phi\left(\frac{I_t}{I_{t-1}}\right)$ which is increasing and concave, with $\Phi(1) = \Phi'(1) = 0$ and $\Phi''(1) > 0$. We arrive at Tobin's Q:

$$Q_t = 1 + \Phi\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}}\Phi'\left(\frac{I_t}{I_{t-1}}\right) - \tilde{\Lambda}_{t,t+1}\int_{\Lambda}\left\{\left(\frac{I_{t+1}}{I_t}\right)^2\Phi'\left(\frac{I_{t+1}}{I_t}\right)\right\}dT(\lambda_{t+1}|\lambda_t)$$

with the law of motion of aggregate capital as

$$K_{t+1} = I_t^k + (1-\delta_k)K_t.$$

Households There is a unit continuum of representative households that provide labor and debt financing for intermediate producers and consume the final good. Households can transfer wealth intertemporally by lending to intermediate firms and trading equity shares of intermediate producers among themselves. During the beginning of the period, households pool their resources and form a financial intermediary that lends directly to intermediate firms. The financial intermediary's diversified asset portfolio guarantees households receive a risk-free bond, B_t, with future rate of return, r_t, (see Diamond, 1984). Additionally, at the beginning of the economy in time $t = 0$, all households pool their initial allocation of equity shares and form an aggregate index to which receive back equity shares on the index, ind_t, with index dividends, D_t, and price, $p_{\text{ind},t}$.

Household consumption and leisure preferences are assumed to be consistent with the following additively separable instantaneous utility function:

$$u(C_t, L_t) = \log(C_t) - \tilde{\psi}\frac{L_t^{1+\frac{1}{\rho_l}}}{1+\frac{1}{\rho_l}},$$

where L_t is labor supplied, ρ_l is the Frisch elasticity of labor. Lastly, let β denote the subjective household discount factor. The household intertemporal budget constraint can be expressed as

$$C_t + \frac{B_{t+1}}{1+r_t} + p_{\text{ind},t}\text{ind}_{t+1} = w_t L_t + B_t + \text{ind}_t(D_t + p_{\text{ind},t}).$$

The representative household value function can be expressed as

$$V^h(B, \text{ind}; \lambda) = \max_{C,L,B',\text{ind}'} u(C, L) + \beta \int_\Lambda V^h(B', \text{ind}'; \lambda') dT(\lambda'|\lambda)$$

subject to

$$C + \frac{B'}{1+r} + p_{\text{ind}}\text{ind}' = wL + B + \text{ind}(D + p_{\text{ind}}).$$

Recursive Competitive Equilibrium For an initial Γ_0, a recursive competitive equilibrium consists of (i) incumbent value functions $V^{\text{eb}}(s, k, n, b, c_f; \lambda)$ and $V^{\text{ab}}(s, k, n, b, c_f; \lambda)$; (ii) entrant value functions $V_e^{\text{eb}}(j; \lambda)$, $V_e^{\text{ab}}(j; \lambda)$; (iii) household value function $V^h(B, \text{ind}; \lambda)$; (iv) incumbent firm policy functions $n'_{\text{eb}}(s, k, n, b, c_f; \lambda)$, $n'_{\text{ab}}(s, k, n, b, c_f; \lambda)$, $k'_{\text{eb}}(s, k, n, b, c_f; \lambda)$, $k'_{\text{ab}}(s, k, n, b, c_f; \lambda)$, $b'_{\text{eb}}(s, k, n, b, c_f; \lambda)$, $b'_{\text{ab}}(s, k, n, b, c_f; \lambda)$, $l_{\text{eb}}(s, k, n; \lambda)$, $l_{\text{ab}}(s, k, n; \lambda)$, $x_{\text{eb}}(s, k, n; \lambda)$, $x_{\text{ab}}(s, k, n; \lambda)$; (v) entrant policy functions $k'_{\text{eb}}(j; \lambda)$, $k'_{\text{ab}}(j; \lambda)$, $n'_{\text{eb}}(j; \lambda)$, $n'_{\text{ab}}(j; \lambda)$; (vi) household policy functions $L(B, \text{ind}; \lambda)$, $B'(B, \text{ind}; \lambda)$, $\text{ind}'(B, \text{ind}; \lambda)$; $\{Q_t\}_{t=0}^\infty$ of prices from physical capital producers and demand schedule $\{p_{i,t}\}_{t=0}^\infty$ from final goods producers; (vii) bounded sequences of wages and interest rate $\{w_t\}_{t=0}^\infty$ and $\{r_t\}_{t=0}^\infty$; (viii) incumbents' measures $\{\Gamma_t\}_{t=0}^\infty$, $\{\Gamma_t^{\text{eb}}\}_{t=0}^\infty$ and $\{\Gamma_t^{\text{ab}}\}_{t=0}^\infty$; (viii) entrants' measures $\{\mathcal{E}_t\}_{t=0}^\infty$, $\{\mathcal{E}_t^{\text{eb}}\}_{t=0}^\infty$, and $\{\mathcal{E}_t^{\text{ab}}\}_{t=0}^\infty$ such that, for all $t \geq 0$:

(i) $V^{\text{eb}}(s, k, n, b, c_f; \lambda)$, $n'_{\text{eb}}(s, k, n, b, c_f; \lambda)$, $k'_{\text{eb}}(s, k, n, b, c_f; \lambda)$ and $b'_{\text{eb}}(s, k, n, b, c_f; \lambda)$ solve the incumbent's problem for earnings-based borrowing constraint;

   (a) $x_{\text{eb}}(s, k, n; \lambda)$, $l_{\text{eb}}(s, k, n; \lambda)$, $\{p_{it}\}_{t=0}^\infty$ solve the myopic incumbent's profit maximization for incumbents with earnings-based borrowing constraint;

(ii) $V^{\text{ab}}(s,k,n,b,c_f;\lambda)$, $n'_{\text{ab}}(s,k,n,b,c_f;\lambda)$, $k'_{\text{ab}}(s,k,n,b,c_f;\lambda)$ and $b'_{\text{ab}}(s,k,n,b,c_f;\lambda)$ solve the incumbent's profit maximization for incumbents with earnings-based borrowing constraint;

(a) $x_{\text{ab}}(s,k,n;\lambda)$ and $l_{\text{ab}}(s,k,n;\lambda)$ solve the myopic profit maximization problem for incumbents with asset-based borrowing constraint;

(iii) $V_e^{\text{eb}}(j;\lambda)$, $k'_{\text{eb}}(j;\lambda)$ and $n'_{\text{eb}}(j;\lambda)$ solve the entrant's problem with anticipated earnings-based borrowing constraint;

(iv) $V_e^{\text{ab}}(j;\lambda)$, $k'_{\text{ab}}(j;\lambda)$ and $n'_{\text{ab}}(j;\lambda)$ solve the entrant's problem with anticipated asset-based borrowing constraint;

(v) $V^h(B,\text{ind};\lambda)$, $L(B,\text{ind};\lambda)$, $B'(B,\text{ind};\lambda)$ and $\text{ind}'(B,\text{ind};\lambda)$ solve the representative households problem;

(vi) the labor market clears: for all $t \geq 0$ and wage w_t we have

$$\int l_{\text{eb}}(s,k,n;\lambda)d\Gamma_t^{\text{eb}}(s,k,n,b) + \int l_{\text{ab}}(s,k,n;\lambda)d\Gamma_t^{\text{ab}}(s,k,n,b) = L_t;$$

(vii) the debt market clears: for all $t \geq 0$ and interest rate r_t we have

$$\int b'_{\text{eb}}(s,k,n,b,c_f;\lambda)d\Gamma_t^{\text{eb}}(s,k,n,b) + \int b'_{\text{ab}}(s,k,n,b,c_f;\lambda)d\Gamma_t^{\text{ab}}(s,k,n,b) = \frac{B_{t+1}}{1+r_t};$$

(viii) the physical capital market clears: for all $t \geq 0$ and price of physical capital Q_t we have

$$\begin{aligned}&\int k'_{eb}(s,k,n,b,c_f;\lambda)d\Gamma_t^{eb}(s,k,n,b) + \int k'_{ab}(s,k,n,b,c_f;\lambda)d\Gamma_t^{ab}(s,k,n,b)\\ &+ \theta M \int_{\mathcal{C}^{\text{eb}}} k'_{eb}(j;\lambda)dJ(j) + (1-\theta)M \int_{\mathcal{C}^{\text{ab}}} k'_{ab}(j;\lambda)dJ(j) = K_{t+1},\end{aligned}$$

where

$$\mathcal{C}^{eb} = \{j \in \mathbb{R}_+ : V_e^{eb}(j;\lambda) \geq c_e\},$$
$$\mathcal{C}^{ab} = \{j \in \mathbb{R}_+ : V_e^{ab}(j;\lambda) \geq c_e\};$$

(ix) for all $t \geq 0$ and all Borel sets $\mathcal{S} \times \mathcal{P} \subset \mathbb{R}_+ \times \mathbb{R}_+^3$ we have

$$\mathcal{E}_{t+1}^{\text{eb}}(\mathcal{S} \times \mathcal{P}) = \theta M \int_{\mathcal{S}} \int_{\mathcal{B}_e^{eb}(\mathcal{P},\lambda)} dJ(j)\mathcal{F}(s'|j)$$
$$\mathcal{E}_{t+1}^{\text{ab}}(\mathcal{S} \times \mathcal{P}) = (1-\theta) M \int_{\mathcal{S}} \int_{\mathcal{B}_e^{ab}(\mathcal{P},\lambda)} dJ(j)d\mathcal{F}(s'|j)$$
$$\mathcal{E}_{t+1}(\mathcal{S} \times \mathcal{P}) = \mathcal{E}_{t+1}^{\text{eb}}(\mathcal{S} \times \mathcal{P}) + \mathcal{E}_{t+1}^{\text{ab}}(\mathcal{S} \times \mathcal{P})$$

where

$$\mathcal{B}_e^{eb}(\mathcal{P},\lambda) = \left\{j \in \mathbb{R}_+ : V_e^{eb}(j;\lambda) \geq c_e \ \wedge (k'_{eb}(j;\lambda), n'_{eb}(j;\lambda), 0) \in \mathcal{P}\right\},$$
$$\mathcal{B}_e^{ab}(\mathcal{P},\lambda) = \left\{j \in \mathbb{R}_+ : V_e^{ab}(j;\lambda) \geq c_e \ \wedge (k'_{ab}(j;\lambda), n'_{ab}(j;\lambda), 0) \in \mathcal{P}\right\};$$

(x) for all $t \geq 0$ and all Borel sets $\mathcal{S} \times \mathcal{P} \subset \mathbb{R}_+ \times \mathbb{R}_+^3$ we have

$$\Gamma_{t+1}^{\text{eb}}(\mathcal{S} \times \mathcal{P}) = \int_{\mathcal{S}} \int_{\mathcal{B}^{\text{eb}}(\mathcal{P},\lambda')} \int d\Gamma_t^{\text{eb}}(s,k,n,b)dG(c'_f)d\mathcal{F}(s'|s) + \mathcal{E}_{t+1}^{\text{eb}}(\mathcal{S} \times \mathcal{P}),$$
$$\Gamma_{t+1}^{\text{ab}}(\mathcal{S} \times \mathcal{P}) = \int_{\mathcal{S}} \int_{\mathcal{B}^{\text{ab}}(\mathcal{P},\lambda')} \int d\Gamma_t^{\text{ab}}(s,k,n,b)dG(c'_f)d\mathcal{F}(s'|s) + \mathcal{E}_{t+1}^{\text{ab}}(\mathcal{S} \times \mathcal{P}),$$
$$\Gamma_{t+1}(\mathcal{S} \times \mathcal{P}) = \Gamma_{t+1}^{\text{eb}}(\mathcal{S} \times \mathcal{P}) + \Gamma_{t+1}^{\text{ab}}(\mathcal{S} \times \mathcal{P}),$$

where

$$\mathcal{B}^{\text{eb}}(\mathcal{P},\lambda') = \left\{c'_f : V^{eb}(s',k',b',c'_f;\lambda') \geq V^{\text{ex}}(s',k',n';\lambda')\right.$$
$$\left. \wedge \ (k'_{\text{eb}}(s,k,n,b,c_f;\lambda), n'_{\text{eb}}(s,k,n,b,c_f;\lambda), b'_{\text{eb}}(s,k,n,b,c_f;\lambda)) \in \mathcal{P}\right\},$$

$$\mathcal{B}^{\text{ab}}(\mathcal{P}, \lambda') = \big\{ c'_f : V^{ab}(s', k', b', c'_f; \lambda') \geq V^{\text{ex}}(s', k', n'; \lambda') \wedge$$
$$(k'_{\text{ab}}(s, k, n, b, c_f; \lambda), n'_{\text{ab}}(s, k, n, b, c_f; \lambda), b'_{\text{ab}}(s, k, n, b, c_f; \lambda)) \in \mathcal{P} \big\} .$$

6 Conclusion

In this paper, we offer a novel exploration of the relationship between intangible capital, heterogeneous borrowing types, and firm-level productivity dynamics. By developing a firm-dynamics framework that accounts for the heterogeneous borrowing constraints faced by firms depending on their reliance on intangible versus tangible capital, we uncover important insights into the mechanisms driving key macroeconomic patterns, particularly the slowdown in aggregate productivity growth despite rising firm-level investment in intangibles.

Our empirical results show that intangible capital growth predicts higher labor productivity growth, and that the non-rivalry intangible capital is evident in higher sales growth and broader firm scope; however, these payoffs are state-dependent and weaken in recessions. Intangible-intensive firms carry less total debt and a lower secured-debt share, substitute away from asset-based covenants (ABC) and toward earnings-based covenants (EBC), and are more likely to be financially constrained especially in recessions. Consistent with a credit-amplification channel, financial constraints tighten most for intangible-intensive EBC borrowers during recessions and mitigate the productivity payoff of intangible capital. This mechanism helps reconcile a recent slowdown in aggregate productivity growth despite rising intangibles by suggesting that the benefits of intangibles are highly sensitive to macro-financial conditions.

Our theoretical framework rationalizes these empirical patterns through a general equilibrium model that highlights three key mechanisms. First, the non-rivalry property of intangible capital, combined with earnings-based borrowing constraints, creates an amplification mechanism that explains both the productivity-enhancing effects of intangi-

bles during expansions and their role in exacerbating downturns. Second, heterogeneous borrowing constraints interact with productivity shocks to generate rich firm dynamics, where firms operating under earnings-based constraints exhibit greater volatility in investment and growth rates. Third, our model demonstrates how the endogenous entry condition, influenced by ex-ante probabilities of borrowing types, shapes the distribution of firms and their subsequent growth trajectories.

This paper also suggests avenues for future research, and we intend to expand our analysis in both empirical and theoretical directions. On the empirical side, our aim is to develop a framework to investigate the cyclical properties of non-rivalrous intangible capital, various types of borrowing constraints, and their relationship with productivity. In terms of the theoretical part, our future plans involve documenting additional evidence on the cyclical properties of firms and drawing inferences on the impact of short-run financial shocks within our general equilibrium framework. Furthermore, we intend to conduct local projections (as in Jordà (2005)) to emphasize the relevance of financial frictions.

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Appendix A Tables

Table A.1: Firm-Level Constructed Data Variables and Descriptions - Compustat

Variable	Description
Labor Productivity	$\frac{\text{Sales } (sale)}{\text{Employee } (emp)}$
Intangible Capital Ratio	$\frac{\text{Organizational Capital}}{\text{Organizational Capital + Net Property, Plant and Equipment } (ppent)}$
Tobin's Q	$\frac{\text{Debt in Curr. Liab.}(dlc) + \text{Long-term Debts } (dltt) + (\text{Common Shares } (csho) \text{ x Price Close } (prcc_f)) - \text{Curr. Assets } (act)}{\text{Total Assets } (at)}$
Markup	$0.85\frac{\text{Sales } (sale)}{\text{Cost of Goods Sold } (cogs)}$ (De Loecker et al. (2020))
Cash Ratio	$\frac{\text{Cash } (ch)}{\text{Total Assets } (at)}$
Total Debt	Debt in Curr. Liab. (dlc) + Long-term Debts ($dltt$)
Leverage Ratio	$\frac{\text{Debt in Curr. Liab.}(dlc) + \text{Long-term Debts } (dltt)}{\text{Total Assets } (at)}$
Secured Debt Ratio	$\frac{\text{Debt - Mortgages \& Other Secured } (dm)}{\text{Total Debt } (dlc + dltt)}$

Note: This table presents the firm-level constructed data variables and their descriptions in the Compustat sample.

Table A.2: Summary Statistiscs - Compustat Yearly Data

	Mean	SD	P50	Observation
Assets - Total (Real, million $)	2616.11	13138.85	240.36	96145
Sales (Real, million $)	2347.96	11783.55	232.85	96145
Employees	8.35	38.4	.97	149149
Property, Plant and Equipment - Total (Net) (Real, million $)	837.03	4994.77	40.83	96010
Research and Development Expense (Real, million $)	92.66	547.8	6.68	58766
Selling, General and Administrative Expense (Real, million $)	433.09	2036.95	56.51	87725
Tobin's Q	1.11	2.07	.67	87282

Note: This table presents the summary statistics for selected variables in the Compustat sample.

Table A.3: Summary Statistiscs - Number of Business Lines (Compustat Segment)

	Mean	SD	P50	Min	Max	Observation
Number of Business Lines	1.17	0.69	1	1	13	231851

Note: This table presents the summary statistics for the number of business lines in the Compustat Segment sample.

Table A.4: Summary Statistiscs - Intangible Capital

	Mean	SD	P50	Min	Max	Observation
Total Intangible Capital	788.3	5695.17	39.52	0	368905	210459
Knowledge Capital	156.83	1741.73	0.24	0	175725.2	210459
Organizational Capital	276.71	1811.11	20.85	0	166803.9	210459
External Intangible Capital	354.75	3529.27	0.45	0	310197	210459
Intangible Capital Ratio	0.48	0.29	0.5	0	1	209836

Note: This table presents the summary statistics for the components of intangible capital and the intangible capital ratio in the Compustat sample.

Table A.5: Summary Statistics - By Intangible Capital Ratio

	Total Assets	Sales	Number of Employees	Cash Ratio	Leverage Ratio	Log Labor Productivity	Log Labor Productivity Growth
Q1							
Mean	3148.94	2781.78	10.64	0.11	0.26	5.37	0.03
P50	352.86	314.06	1.34	0.06	0.21	5.40	0.02
SD	14877.28	12888.11	49.74	0.15	0.28	1.04	0.45
Q2							
Mean	1375.74	1378.42	4.71	0.14	0.24	5.47	0.04
P50	105.81	112.08	0.42	0.08	0.15	5.47	0.02
SD	8210.17	8970.20	20.18	0.17	0.37	1.02	0.48
All							
Mean	2367.98	2163.26	8.02	0.13	0.25	5.41	0.03
P50	212.58	203.45	0.84	0.07	0.19	5.43	0.02
SD	12422.31	11350.90	39.61	0.16	0.32	1.03	0.46

Note: This table presents the summary statistics for selected variables in the Compustat sample for firms with low (Q1) and high (Q2) intangible capital ratios using the Compustat sample. The division for high and low intangible ratios is determined by whether they are above or below the median of the intangible capital ratio within each industry and year.

Table A.6: Summary Statistiscs - Compustat-DealScan Merge

	Mean	SD	P50	Min	Max	Observation
Number of Loan Deals	1.17	0.46	1	1	7	13638
Number of Loan Deals with No Covenants	0.49	0.62	0	0	7	13638
Number of Loan Deals with Covenants	0.68	0.57	1	0	6	13638
Loan Deal Amounts	4.77×10^8	1.04×10^9	1.67×10^8	302593.8	2.66×10^{10}	13638
Loan Deal Amounts - with No Covenants	2.18×10^8	7.88×10^8	0	0	2.66×10^{10}	13638
Loan Deal Amounts - with Covenants	2.59×10^8	6.78×10^8	3.28×10^7	0	1.55×10^{10}	13638

Note: This table presents the summary statistics for selected variables in the Compustat-DealScan merged sample.

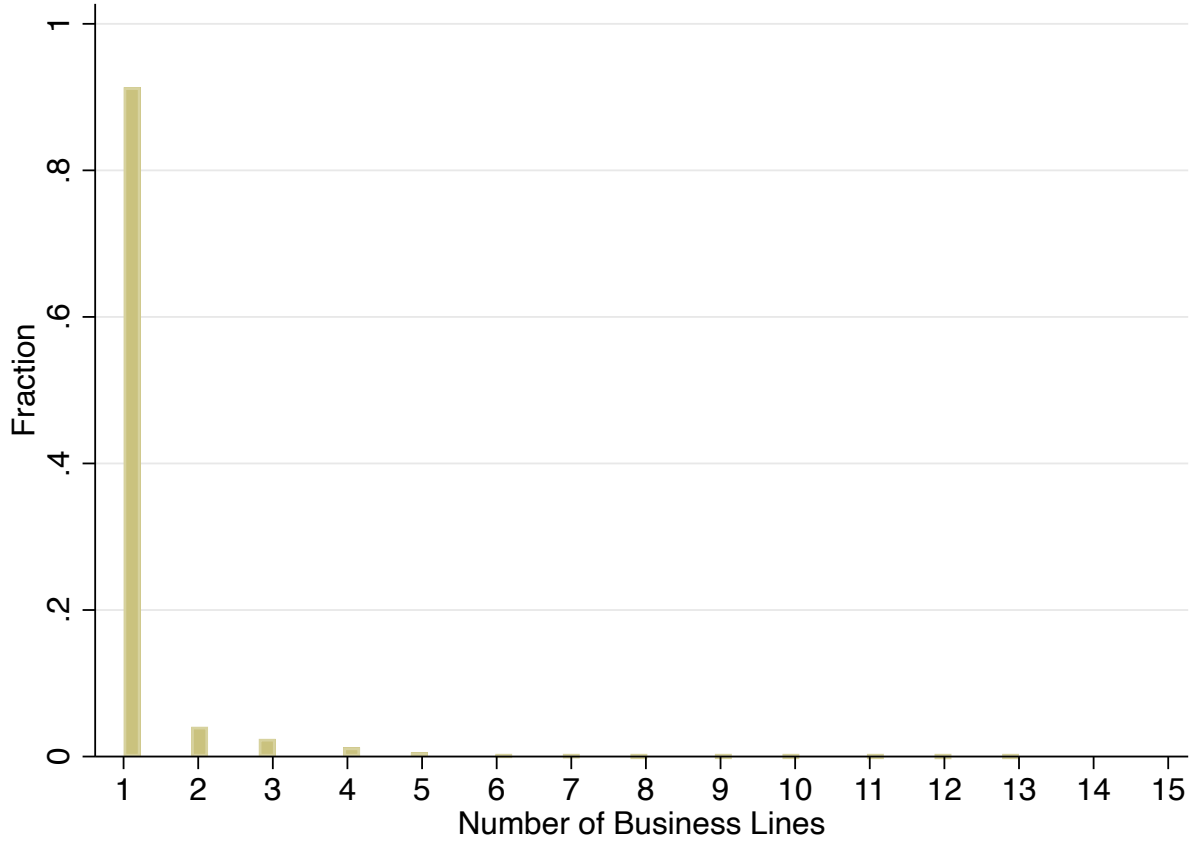
Table A.7: Pairwise Correlation Matrix

	Sales Growth	Total Intangible Growth	Knowledge Capital Growth	Organizational Capital Growth	External Intangible Growth
Sales Growth	1.00				
Total Intangible Growth	0.79*	1.00			
Knowledge Capital Growth	0.81*	0.83*	1.00		
Organizational Capital Growth	0.83*	0.85*	0.83*	1.00	
External Intangible Growth	0.33	0.61*	0.37	0.26	1.00

Note: This table documents pairwise correlation for sales growth and the growth of each component of intangible capital. *$p < 0.01$

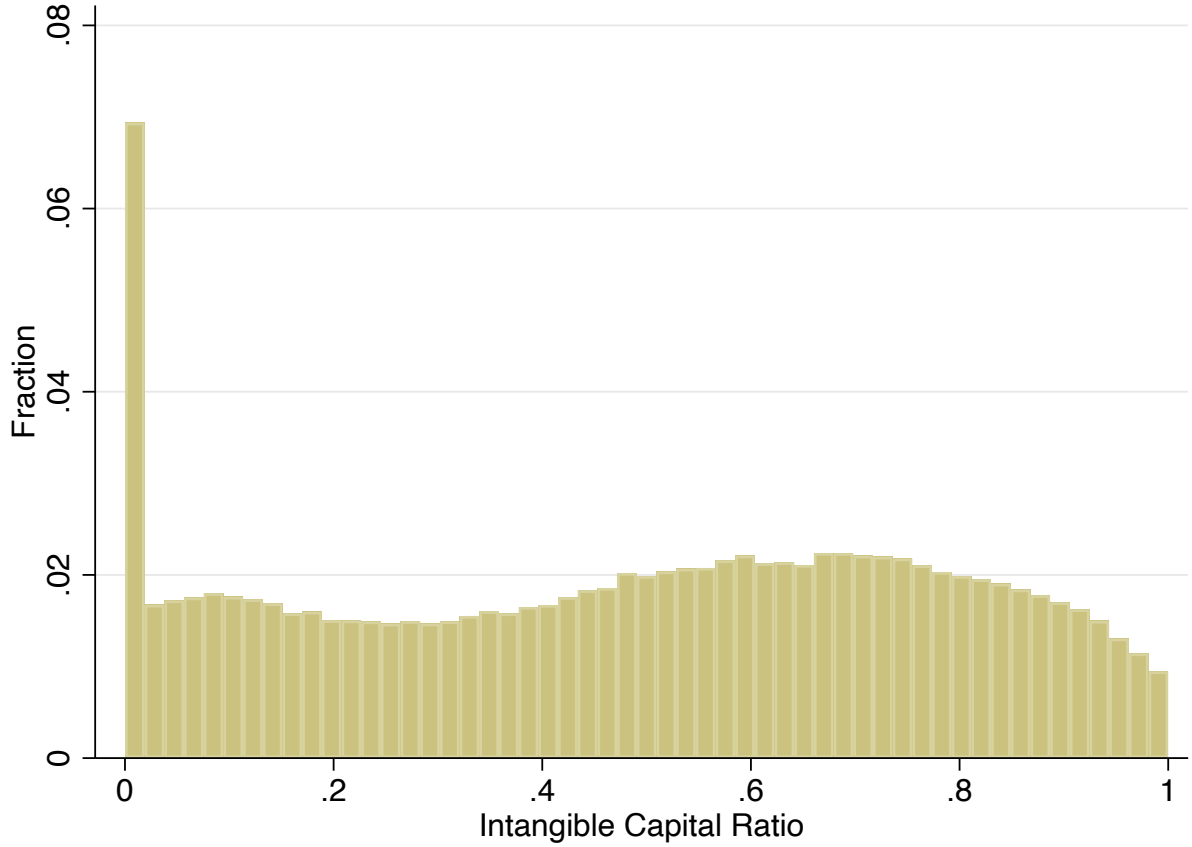
Appendix B Figures

Figure B.1: Histogram of Number of Business Lines



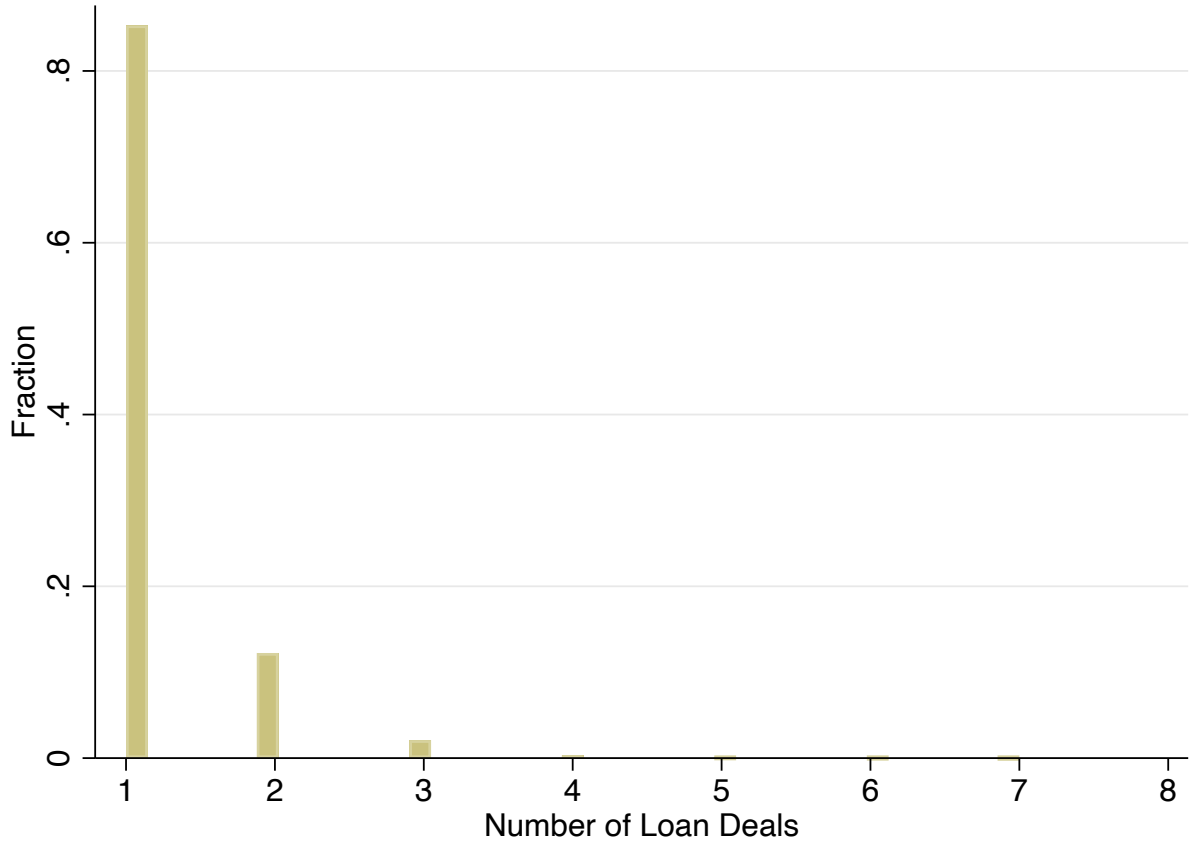
Note: This figure shows the histogram of number of business lines in the Compustat Segment sample.

Figure B.2: Histogram of Intangible Capital Ratio



Note: This figure shows the histogram of intangible capital ratio in the Compustat sample.

Figure B.3: Histogram of Number of Loan Deals



Note: This figure shows the histogram of number of loan deals in the Compustat-DealScan merged sample.