# Collateral Dynamics: Hurdles to Intangible Investment *

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**Abstract**

This paper quantifies how collateral distorts the composition of firms' investment. Using administrative firm data and loan-level information for private Austrian firms, I document that (i) secured credit is pervasive across the leverage distribution, (ii) unsecured loan rates rise with leverage while secured rates remain flat, and (iii) higher leverage is associated with lower intangible but not lower tangible investment. To rationalize these patterns I estimate a dynamic model of tangible and intangible investment in which debt is risky and priced against expected recovery. Tangible assets raise creditor recovery and thereby lower the rates on risky debt, creating an incentive to overinvest in tangibles. Making intangible capital pledgeable would raise its share of total investment by three percentage points among highly levered firms, and by less than one point on average. The estimates imply that low-productivity borrowers over-accumulate tangibles to obtain cheaper financing, slowing their adoption of intangibles.

*JEL classification*: G32, G31, E22, D25

*Keywords*: Collateral, secured debt, intangible capital, debt structure, corporate investment, firm dynamics, structural estimation

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# 1 Introduction

Over the last three decades intangible assets such as software, data, and licenses have become an increasingly important part of the productive capital stock of firms in advanced economies. Unlike machinery or real estate, these assets have little value in liquidation and can rarely be pledged to creditors. This shift has been linked to lower debt capacity and larger cash holdings, see Falato et al. (2022). That literature takes the composition of the capital stock as given and asks how it affects financing. I study the opposite causal direction: if collateral is valuable in obtaining external financing, the composition of the capital stock is not a purely technological choice either. Firms have an incentive to overinvest in tangible capital, whose collateral value lowers the cost of debt, and to underinvest in intangible capital, which offers no such benefit. The question is how large these distortions are, and which firms bear them.

I approach this question in two ways. First, I study the firms most exposed to the friction: private, bank-dependent small and medium-sized enterprises. These firms account for the majority of economic activity around the world. Using loan-level data matched to firm accounts, I find that secured credit is the primary form of debt across the entire leverage distribution and not confined to the distressed tail of firms. Second, to rationalize this pattern and quantify what it implies for investment, I estimate a dynamic model of financing and investment in which lenders price each contract against the recovery they expect in default. The intuition is that tangible capital does two things at once: it raises production capacity, and it raises what creditors recover if the firm fails. The second effect lowers the rate at which the firm borrows, so tangible capital carries a financing motive alongside its productive one. This motive does not require the collateral ceiling to bind. It operates through the price of credit, and therefore reaches any firm with risky debt.

Turning to the details of my analysis, I combine two proprietary datasets with balance sheet data from Orbis: loan-level records from the Austrian National Bank (OeNB), and income statement and gross investment data provided by the Austrian Micro Data Center (AMDC). Because private firms of this size are not required to publish their financials, this combination offers a unique view of their profitability and investments. The investment data further distinguish between asset types, which allows to observe gross investment in capitalized intangibles directly rather than inferring it from expensed flows. Austrian accounting confines intangibles to purchased assets, excluding organizational capital and brand value; but as Crouzet et al. (2022) note, these broader intangibles differ from physical capital along dimensions other than pledge-

ability, so the narrower measure isolates the margin of interest more cleanly. The loan-level records allow me to observe how secured and unsecured credit are priced and what collateral is pledged against them. I find that the rate on unsecured credit rises with a firm's leverage while the rate on secured credit does not, so the two instruments differ in how their price responds to default risk rather than by a fixed premium. In the firm accounts, higher leverage is associated with lower intangible investment and no change in tangible investment, so that more levered firms invest relatively more in the assets they can pledge.

These patterns are consistent with the dynamic partial-equilibrium model of leverage and investment in the spirit of Hennessy and Whited (2007), which I develop in Section 4. Firms combine two types of capital to produce output: tangible assets such as machinery and real estate, and intangible capital such as software. The two differ in their liquidation value, as only tangible capital has positive recovery value while intangible capital yields nothing. Recovery value matters here, in contrast to a frictionless Modigliani and Miller (1958) benchmark, for two reasons. First, firms have no access to external equity finance, an assumption that reflects the situation of most SMEs and that could be micro-founded with asymmetric information or issuance costs. Second, I do not require debt to be fully collateralized, so firms can default, which occurs when internal resources are insufficient to meet obligations as in Ivanov et al. (2026). Banks therefore price their loans against the liquidation value of the firm, and a higher share of tangible assets obtains cheaper financing. Shareholders receive nothing in default, so the liquidation estate is worth nothing to them, yet competitive lenders capitalize it into a lower rate today. Furthermore, in my model firms choose between secured and unsecured debt in the spirit of Rampini and Viswanathan (2025). Secured debt has priority over tangible assets in default, and since an asset can be pledged only once, it is limited by the tangible capital stock. As in their model, unsecured credit is still implicitly secured by the residual value of assets. In line with their prediction, levered firms encumber more of their assets to keep financing costs low, and the model accordingly reproduces the pattern in the data whereby unsecured borrowing is confined to firms with low leverage while the remainder finance themselves against collateral. Where in Li et al. (2016) collateral matters only through the quantity of borrowing the constraint supports, here it also feeds directly into the interest rate the firm pays, and therefore carries value even for firms far from their borrowing capacity. Finally, interest expense is deductible, so debt carries the usual tax advantage over internal funds.

I estimate the model targeting both financing and investment margins from the accounting data, together with moments from the loan data that let me quantify the friction more directly.

By targeting the share of secured debt I match firms' revealed preference for collateralized borrowing, and thereby discipline the relative importance of tangible capital for debt financing. The literature has quantified collateral constraints largely by targeting firm outcomes: balance-sheet leverage, or, as in Catherine et al. (2022), the reduced-form sensitivity of investment to collateral values. The loan data let me target the friction itself, through the share of debt that is secured.

I then use the model to quantify the distortion caused by the difference in recovery ratio between the two types of capital. Specifically, I compare two economies: the baseline, in which intangibles have no recovery value and cannot be pledged, and a counterfactual in which they are identical to tangibles on both counts. Technology is held at its estimated values, so any difference in behavior is attributable to the financing environment alone. I find only modest changes in aggregate investment but a substantial reallocation of its composition. Average leverage rises from 37.8 to 39.1 percent while total investment is essentially unchanged. The response is concentrated where the model predicts: among firms with leverage above fifty percent the intangible share rises from 15.8 to 18.8 percent, whereas firms whose debt is comfortably covered by their collateral are almost unaffected. This is what the pricing channel implies, since collateral is most valuable where debt carries default risk.

The paper provides new evidence on the relevance of secured debt, focusing on small and medium sized enterprises. There is a large body of theoretical literature on collateral and commitment reviewed by Donaldson and Piacentino (2026). Rampini and Viswanathan (2013) show that the fraction of tangible capital a technology requires is a central determinant of leverage, and that the lack of tangible assets accounts for much of the low-leverage puzzle. Lian and Ma (2021) appear to cut against this, classifying lending to large U.S. firms as predominantly cash-flow based rather than backed by specific assets; already for smaller public firms below the Compustat median, however, they find that asset-based lending dominates. In the loan-level data on private SMEs the secured share rises with leverage, as Rampini and Viswanathan (2025) predict, but it is high across the whole distribution. This highlights the importance of secured lending for the majority of firms. Cross-country evidence by Degryse et al. (2025) on the use of collateral in bank lending across the euro-area actually shows that Austria is representative of the use of collateral in many countries. The pricing of collateral is therefore relevant for the transmission of monetary policy through the collateral channel (Bernanke et al., 1999).

I also contribute to the literature on investment allocation and financing frictions. Almeida and

Campello (2007) show that pledgeable assets raise debt capacity; I quantify a second channel, in which pledgeable assets lower the price of credit and tilt the composition of investment toward tangibles. Falato et al. (2022) argue that falling asset tangibility has decreased debt capacity and pushed U.S. public firms towards higher cash holdings. I take up the converse margin: if pledgeability is that valuable, firms also tilt the capital mix toward the assets that support cheap financing. Modeling debt as risky and priced against expected recovery lets collateral lower the rate continuously, so the friction reaches firms far from their borrowing limit. Utilizing the loan-level data I can identify the friction from the secured share rather than from the capital mix itself, which is what allows me to ask how much of that mix the financing channel accounts for. Using the gross investment data I take up a prediction Hennessy (2004) states but does not test: that debt distorts the composition of investment and not only its level, here on the margin of pledgeability.

Finally, I contribute to the structural quantification of collateral frictions. These models are typically estimated to match balance-sheet leverage, as in Hennessy and Whited (2007), Li et al. (2016), or a reduced-form sensitivity, as in Catherine et al. (2022). Using loan-level data, I target a moment closer to the friction itself, the share of secured debt, which bears directly on how much of a firm's borrowing capacity rests on its tangible assets. The mechanism also adds a dimension to why pledging collateral is costly for small firms, documented by Pan et al. (2025) as a cost of encumbering assets a firm already owns. I identify a cost that operates earlier, in the choice of which assets to buy: firms move away from their unconstrained asset mix to secure cheaper financing, and this reallocation is itself a cost. Quantifying the aggregate and distributional effects of collateral requirements is policy relevant, since it determines which firms can invest in and adopt new technologies, which increasingly rely on intangible assets such as software. Crouzet and Eberly (2018) find in this context that the rise in intangibles coincided with the rise in concentration, demonstrating how concentration may be a by-product of efficiency gains among industry leaders. This paper adds a new perspective by showing that collateral constraints can reinforce such asymmetries, as constrained firms underinvest in scalable intangible technologies.

## 2 Data

I combine three datasets to obtain a comprehensive view of Austrian firms' balance sheets, income statements, and bank credit. The first is Moody's Orbis database, from which I obtain annual balance-sheet information for the near universe of private firms in Austria. To construct a unified sample of firms comparable in size and in their access to external finance, I restrict attention to small and medium-sized enterprises as defined by the European Commission, and exclude micro-enterprises.[0] This composition is representative of most European economies, in which small and medium-sized enterprises account for the majority of firms. Although Orbis reports detailed balance sheet information, it lacks income statements for the small firms that constitute most of our sample, due to their limited disclosure requirements. I obtain these variables from administrative records maintained by the Austrian Micro Data Center (AMDC), available from 2018 onward and described in Fuchs et al. (2024). Because the AMDC data in turn contain no balance-sheet information, merging the two sources yields a complete view of firms' accounts. From the AMDC dataset I take depreciation, sales, total revenues, total costs, and financial income and expenses. This allows me to construct earnings before taxes (EBT) as the difference between total revenues and total expenses, and earnings before interest and taxes (EBIT) by adding net financial expenses (financial expenses less financial income) back to EBT. The data on gross investment is also provided by AMDC and distinguishes investment in Property, Plant and Equipment (ISACH) from intangible investment (IINT), covering purchased rights and licences, concessions, and software; but not internally generated brands, goodwill, or research expenditure, which cannot be capitalized.

In terms of data cleaning I require firms to have positive fixed and total assets, as I use this for scaling, additionally I drop firms where total debt exceeds total assets. I omit financial, regulated, and extraterritorial entities. I winsorize all financial statement variables at the 1st and 99th percentiles to mitigate the effect of extreme outliers. Finally, I end up with a merged Orbis–AMDC dataset of 9709 firms over the 2018–2023 sample period.

To enrich the setting with loan-level variables, I merge Orbis with the Austrian subset of AnaCredit, the harmonized credit registry of the euro area, which records detailed information on bank lending to enterprises and to which I obtain access through the Austrian National

[0] Commission Recommendation 2003/361/EC classifies an enterprise as small or medium-sized if it employs fewer than 250 persons and has either turnover of at most EUR 50 million or a balance-sheet total of at most EUR 43 million; and as micro if it employs fewer than 10 persons and has turnover or a balance-sheet total of at most EUR 2 million. Because employment is reported inconsistently in Orbis, I classify firms on the financial thresholds alone, using firm-level averages of turnover and total assets over the sample period.

Bank (OeNB). AnaCredit reports loan characteristics, including instrument type, maturity, and interest rate, together with pledged collateral and measures of credit quality such as default status. The registry is available from 2018 at a monthly frequency. A credit instrument is subject to reporting when the total committed amount at the creditor–debtor level reaches or exceeds EUR 25,000 at any point during the reference period. I clean the data following Kosekova et al. (2026). I use Orbis-AnaCredit panel both to construct firm-level measures like the share of secured debt and to build a panel of newly originated term loans. I date an origination by the inception date of the instrument and identify it with the first reporting snapshot in which the instrument appears. I restrict attention to euro-denominated term loans to single Austrian debtors and exclude project finance, loans already in default at origination, and instruments with non-positive originated amounts; agreed interest rates outside a zero to thirty percent range are set to missing, following Kosekova et al. (2026). For each origination I retain the loan's characteristics, including its originated amount, maturity, agreed interest rate, and pledged collateral, and record whether it is secured. I then merge the firm's most recent year-end accounting data reported within the preceding twelve months.

**Table 1:** *Summary statistics*

| | *Mean* | *Std.* | *Median* | *Obs* |
|---|---|---|---|---|
| Panel A: Orbis-AMDC Data | | | | |
| Total Assets, €t | 12,129.5 | 26,812.2 | 5,814.4 | 52,159 |
| Leverage, % | 35.36 | 27.86 | 30.90 | 52,159 |
| EBIT, % | 11.35 | 109.34 | 7.63 | 52,159 |
| Cash, % | 14.77 | 17.95 | 7.48 | 52,159 |
| Age, years | 27.80 | 20.01 | 23.00 | 41,231 |
| Sales, €t | 17,003.2 | 31,978.7 | 7,695.0 | 52,159 |
| Sales growth (1yr) | 0.05 | 0.42 | 0.05 | 43,525 |
| Employees | 67.60 | 131.73 | 34.00 | 51,429 |
| Panel B: Orbis-OeNB Data | | | | |
| Total Assets, €t | 15,197 | 44,984 | 6,283 | 79,994 |
| Outstanding Debt, €t | 4,670 | 17,016 | 1,556 | 73,304 |
| Secured Debt, €t | 3,798 | 15,090 | 1,129 | 73,304 |
| Default, % | 0.86 | 9.24 | 0 | 79,994 |
| Panel C: Loan Originations | | | | |
| Originated Amount, €t | 90.16 | 1,130.94 | 15.68 | 212,661 |
| Interest rate, % | 2.51 | 2.60 | 1.99 | 212,661 |
| Maturity, months | 12.87 | 37.22 | 8 | 212,661 |

*Notes:* This table presents summary statistics for the sample of firms merged with accounting data from the AMDC (Panel A), the sample of firms from AnaCredit (Panel B), loan originations (Panel C).

In Panel A of Table 1, I can see that the median company in the Orbis-AMDC data holds EUR 5.8 million in book assets, though the distribution is right-skewed and includes substantially larger firms. Average leverage is 35.36 percent, with considerable variation across firms. The firm demographics show that the average firm has been in operation for almost 28 years and employs roughly 67 people.

Turning to the Orbis-OeNB data in Panel B, the median firm is of about the same size while the sample is slightly larger. Firms' outstanding debt documented in AnaCredit covers about four-fifths of total debt on the balance sheet, which already shows that these firms obtain most of their external financing through bank borrowing. It also becomes clear that the majority of this bank debt is secured, with EUR 3.8 million out of EUR 4.7 million on average. The magnitudes further indicate that firms of this size typically do not access syndicated loan or public debt markets. Finally, combining the annual data with the monthly default flag reported by banks, and dating default at the first month in which the flag is raised, I obtain an average annual default rate of 0.86 percent, which remains low even through and after the Covid shock in the sample.

Finally, my sample includes more than 200,000 term loan originations. Loan sizes are typical of bank credit to small and medium sized firms, with an average maturity of about one year and substantial variation from a few months to more than ten years. The average interest rate is 2.51 percent, reflecting both the low interest rate environment in the euro area during the sample period and the limited default risk of these firms.

# 3 Three Facts on Investment Composition and Collateral

This section presents three facts that motivate the dynamic model of Section 4. The first describes the structure of the debt that these firms use for external financing; the second examines how the price of that debt varies with leverage; the third documents how leverage relates to the composition of investment. Together, these reduced form patterns motivate a mechanism through which tangible assets confer financing advantages that intangible assets do not, which the structural model makes precise.

## 3.1 Fact 1. Secured debt backed by tangibles is the main source of financing

Fact 1 draws on the loan -level data to describe how the firms finance themselves. Figure 1 plots the distribution of the secured share of debt across leverage deciles. Two features stand out. The secured share is high throughout the distribution, with a mean of 51 percent even in the least levered decile, and it rises monotonically to 86 percent in the most levered. More striking is the collapse in dispersion: in the bottom decile a quarter of firms borrow entirely unsecured, whereas from the second decile onward the median firm finances itself exclusively against collateral, and in the top decile even the lower quartile exceeds 95 percent. The most levered firms are thus almost exclusively reliant on secured credit. This pattern is characteristic of what in Lian and Ma (2021) is framed as asset-based lending associated with smaller and more information-opaque firms, in contrast to the cash-flow-based lending prevalent among large public borrowers, and it is consistent with the evidence on small-firm financing in the United States in Berger and Udell (1998).

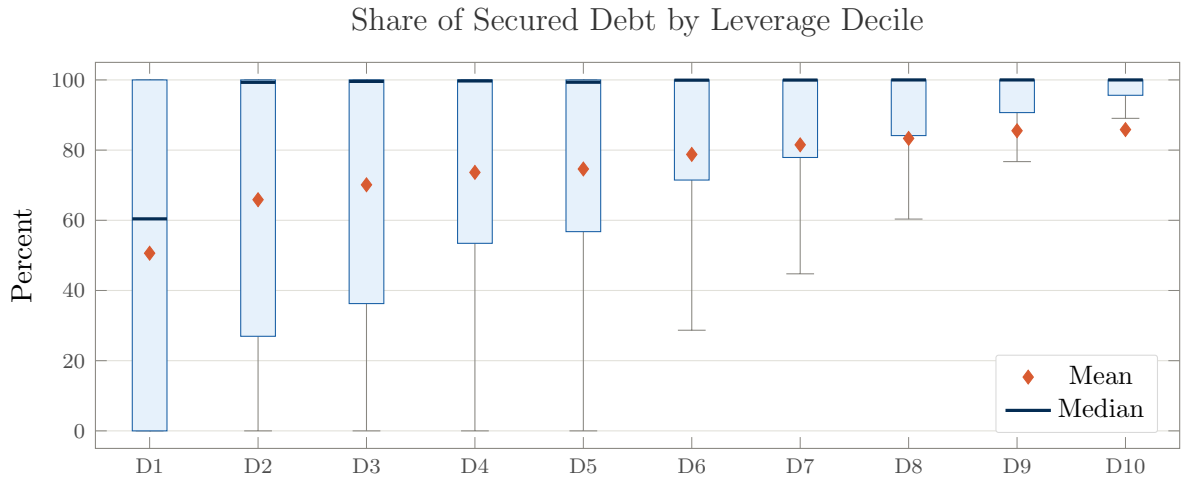



**Figure 1:** Firm-level secured share of debt by leverage decile, sorted from lowest to highest. Boxes give the interquartile range, the horizontal line the median, the marker the mean.

For large public firms in Compustat Rampini and Viswanathan (2025) document that secured debt is used primarily by borrowers below investment grade, so that collateral is primarily relevant in the riskier tail. Therefore an important new perspective is that among the small private firms secured debt is the norm at every point of the leverage distribution. The relation between leverage and the secured share is nonetheless the one their framework predicts: collateralization of secured debt with tangible assets enables higher leverage. For small firms however unsecured credit appears scarce or costly throughout, so the collateral constraint shapes financing for the typical firm rather than only the distressed one.

**Table 2:** *Secured vs. Unsecured Loan Originations*

| | *Mean Prob. Default (%)* | *Mean Size (T€)* | *Mean Maturity* | *Nobs* |
|---|---|---|---|---|
| Unsecured | 1.10 | 59.83 | 9.98 | 206,277 |
| Secured | 1.77 | 1,069.94 | 105.67 | 6,384 |

*Notes:* This table compares secured and unsecured loan originations. Probability of default is the firm-specific default probability estimated by the issuing bank. Maturity reports the average contract maturity, in months. Size reports the average originated amount in thousand euro.

Table 2 also speaks to the nature and availability of the two instruments contrasting secured and unsecured debt. Unsecured loans are more frequent but small and short-dated, averaging on the order of sixty thousand euro with a maturity of less then one year. Secured loans are far less frequent but much larger in size, averaging above one million euro, and considerably longer maturity, of about eight years. Measured as a stock, secured debt constitutes approximately four-fifths of outstanding borrowing, and the collateral pledged against it consists predominantly of real estate and other physical assets, see Appendix B. The large number of unsecured loans and the dominance of secured debt by value are therefore not in tension: unsecured credit provides short-term financing, whereas secured credit supplies the firm's long-term funding and does so against tangible collateral. Furthermore, secured borrowers display a higher average default probability than unsecured borrowers, which is consistent with collateral being required of riskier firms rather than signaling lower risk, in line with the secured-debt evidence in Benmelech et al. (2022), and Benmelech (2024).

### 3.2 Fact 2. Unsecured debt is priced more sensitively to leverage

Fact 1 is consistent with any model in which collateral relaxes a borrowing constraint, including the large class in which the pledgeable fraction of capital is fixed and the terms of borrowing are invariant to the collateral posted. Fact 2 distinguishes a narrower channel, in which collateral enters the pricing of credit rather than only its quantity. Table 3 regresses the annualized agreed

**Table 3:** Interest Rates and Leverage: Secured versus Unsecured Loans

| | Unsecured | Secured |
|---|---|---|
| | (1) | (2) |
| Leverage | 0.052** | 0.001 |
| | (0.025) | (0.010) |
| Log(Loan size) | −1.746 | −0.523 |
| | (1.141) | (1.660) |
| Log(Maturity) | 1.960 | 5.470 |
| | (2.557) | (6.757) |
| Observations | 206,277 | 6,384 |
| Loan Controls | Yes | Yes |
| Firm FE | Yes | Yes |
| Bank×Quarter FE | Yes | Yes |
| $R^2$ | 0.975 | 0.978 |
| $R^2$ (within) | 0.330 | 0.226 |
| Clustering | Firm, Bank | Firm, Bank |

*Notes:* The dependent variable is the annualized agreed rate in basis points. *Leverage* is firm leverage in percentage points, so that coefficients measure basis points per percentage point of leverage. Column (1) is estimated on unsecured originations and column (2) on secured originations. Both include controls for the amortization type and the interest rate type of the loan; column (2) additionally controls for the type of collateral pledged. Standard errors, double clustered by firm and by bank, in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

rate on firm leverage, estimated separately on secured and unsecured originations, with firm and bank-by-quarter fixed effects and loan-level controls. The firm effects absorb the level of borrower credit quality and any time-invariant relationship characteristics; the bank-by-quarter effects absorb variation in lender funding costs and credit supply. The coefficient of interest is therefore the slope of the rate schedule in leverage within firm, identified separately for each contract form. Higher leverage is associated with a significant increase in the unsecured rate, while the secured rate is unresponsive. The estimated magnitude is small, but likely understates the true sensitivity: rates are observed only on originated loans, and Fact 1 establishes that highly levered firms rarely originate unsecured debt. The coefficient is therefore identified largely off low-leverage firms that issue both forms of debt, which is a further reason to recover the relation within a structural model.

### 3.3 Fact 3. Firms with higher leverage invest relatively less in intangibles

Table 4 reports panel regressions of the two investment margins, each scaled by lagged total assets, on lagged leverage, profitability, cash holdings, sales growth and size. Column (3) takes as its dependent variable the standardized difference between the two margins, so that a positive

coefficient indicates a tilt toward the tangible margin. All specifications include sector and year fixed effects with standard errors clustered by firm.

**Table 4:** Tangible vs. Intangible Investment Margins and Firm Characteristics

| | Intangible Inv. | Tangible Inv. | Differential (Tangible − Intangible) |
|---|---|---|---|
| Leverage | $-0.0008^{***}$ | 0.0001 | $0.0378^{***}$ |
| | (0.0002) | (0.0031) | (0.0138) |
| Log(Total assets) | $-0.0414^{***}$ | $-0.5678^{***}$ | 0.0017 |
| | (0.0063) | (0.0941) | (0.0130) |
| EBIT / assets | 0.0002 | $0.0255^{***}$ | $0.0548^{***}$ |
| | (0.0002) | (0.0034) | (0.0110) |
| Sales growth | 0.0120 | $1.0595^{***}$ | $0.0398^{***}$ |
| | (0.0108) | (0.1870) | (0.0101) |
| Cash / assets | −0.0004 | $-0.0372^{***}$ | $-0.0540^{***}$ |
| | (0.0004) | (0.0044) | (0.0126) |
| Observations | 23,000 | 23,000 | 23,000 |
| Firms | 6,449 | 6,449 | 6,449 |
| Sector FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| $R^2$ (overall) | 0.068 | 0.050 | 0.069 |
| $R^2$ (within) | 0.050 | 0.005 | 0.020 |
| Clustering | Firm | Firm | Firm |

*Notes:* Each column is a panel OLS regression. In columns (1) and (2) the dependent variable is gross investment scaled by lagged total assets (in percentage points): intangible investment and tangible investment, respectively. In column (3) the dependent variable is the firm-year gap between the two margins, each standardized before differencing, so a positive coefficient indicates a tilt toward the tangible margin and a negative coefficient a tilt toward the intangible margin. All specifications include sector and year fixed effects and are estimated on the Orbis-AMDC sample, filtering for at least four observations per firm. All regressors are lagged one period $(t-1)$ relative to the dependent variable. Standard errors clustered by firm in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Higher leverage is associated with lower intangible investment (column 1) and with no detectable change in tangible investment (column 2), and hence with a higher tangible share of the total (column 3). The relation is thus concentrated entirely on the intangible margin: more levered firms do not acquire more tangible capital, they acquire fewer intangibles. The coefficient in levels is small in absolute terms, but so is intangible investment, which is both small relative to tangible investment and narrowly dispersed across firms; column (3) therefore expresses the same shift in units of the dispersion of the two margins, where it is more readily interpreted. Larger firms invest less on both margins, consistent with decreasing returns, and the two fall roughly in proportion, so the composition is unaffected.

The sign and location of the correlation are consistent with a collateral interpretation of the

investment mix. Because tangible assets can be pledged and intangible assets largely cannot, the debt capacity and the borrowing terms associated with a marginal unit of investment differ across the two margins, and firms carrying more debt may accordingly display a relatively lower intangible investment share. This connects to several strands of the literature: the role of asset tangibility in relaxing financing constraints in Almeida and Campello (2007); the joint determination of financing and the tangibility of the asset base in Rampini and Viswanathan (2013); and the debt-overhang mechanism of Hennessy (2004), in which leverage is associated with underinvestment that is harder to offset where additional secured borrowing cannot be raised. The remaining controls are informative about the channel. Cash holdings are associated with a higher intangible share, as a firm holding liquid balances is insulated from the repayment pressure through which collateral matters. Profitability and sales growth, by contrast, are associated with a higher tangible share.

This reduced form evidence serves as a motivation but since leverage and the composition of investment are chosen endogenously, a regression cannot identify the magnitude of a causal effect. Nor can the reduced form separate the two ways in which collateral might operate, through the quantity of debt a firm can raise or through the price at which it raises it, although Fact 2 indicates that both are present. Interpreting the correlation, and quantifying how much of the observed tilt toward tangible assets is attributable to financing frictions rather than to technology, requires a model in which leverage, investment composition and the price of credit are determined simultaneously.

# 4 Model

To rationalize the empirical relation between corporate debt structure and investment composition, I develop a dynamic partial equilibrium model of firm financing and investment. The economy consists of a unit continuum of firms and evolves in discrete time over an infinite horizon. In each period, a risk neutral manager chooses the firm's capital stock, cash holdings, as well as secured and unsecured debt to maximize the expected present value of distributions to shareholders.

## 4.1 Technology

Each firm combines tangible capital, $K_t$, and intangible capital, $K_i$, to produce output, $Y$. Production is subject to an idiosyncratic productivity shock, $z$, and follows a decreasing returns to scale production function in productivity and the two capital stocks:

$$Y(z, K_t, K_i) \;=\; z^{\,\nu}\Big(K_t^{\,\alpha}\, K_i^{\,1-\alpha}\Big)^{\theta}, \tag{1}$$

where $\alpha \in (0,1)$ determines the relative importance of tangible capital in production, while $\theta \in (0,1)$ captures decreasing returns to scale, and for tractability I normalize $\nu$ to $1-(1-\alpha)\theta$. Producing output requires a variable operating cost of $v \in (0,1)$ per unit of output, so that operating income in any period is $(1-v)\,Y(z, K_t, K_i)$. Corporate income is taxed at the rate $\tau \in (0,1)$. The tax base is operating income net of interest expense; so that debt carries the usual tax advantage relative to internal funds. Productivity follows an $AR(1)$ process in logs:

$$\ln z' = \rho \ln z + \varepsilon'_z, \qquad \varepsilon'_z \sim \mathcal{N}(0, \sigma_z^2). \tag{2}$$

Primes denote next period variables. The parameter $\rho$ governs the persistence of productivity, while $\sigma_z^2$ denotes the variance of innovations.

## 4.2 Investment

Capital stocks evolve according to standard accumulation identities:

$$K'_t = (1-\delta_t)\,K_t + I_t, \tag{3}$$

$$K'_i = (1-\delta_i)\,K_i + I_i, \tag{4}$$

where $I_t \geq 0$ and $I_i \geq 0$ are gross investment in tangible and intangible capital respectively, and $\delta_t, \delta_i \in (0,1)$ denote the depreciation rates of the two capital stocks. Adjusting either capital stock incurs costs:

$$A(K_t, K_i, I_t, I_i) \;=\; \psi_f(K_t + K_i)\,\mathbf{1}_{\{I_t \neq 0 \,\vee\, I_i \neq 0\}} + \frac{\psi_t}{2}\frac{I_t^2}{K_t} + \frac{\psi_i}{2}\frac{I_i^2}{K_i}. \tag{5}$$

Adjustment costs consist of both nonconvex and convex components, as in Abel and Eberly (1994). The first term represents a fixed adjustment cost, proportional to the firm's total capital stock, that is incurred whenever the firm adjusts either type of capital. The remaining terms capture convex adjustment costs for tangible and intangible investment, governed by the parameters $\psi_t > 0$ and $\psi_i > 0$, respectively. Including such adjustment costs helps the model reproduce firm investment dynamics that are difficult to generate using decreasing returns production technologies alone.

### 4.3 Timing and Financing

Firms can finance their expenditures using three sources of funds: operating profits, internal cash balances, or risky debt. The firm enters the period with tangible and intangible capital, $K_t$ and $K_i$, an outstanding stock of secured principal, $P$, and a signed liquid position, $c$, and observes current productivity, $z$. It then chooses next period's capital, debt and liquidity. Current productivity together with these choices defines the state, $\omega \;=\; (z, K_t', K_i', P', c')$, based on which lenders set rates.

Cash $c$ earns no interest, implying that the opportunity cost of holding liquid assets is the risk free interest rate, $r_f$, which firms take as given. Firms can issue two forms of debt: unsecured and secured. Unsecured is one period risky debt, denoted by $c < 0$, which must be repaid or refinanced when it matures in the following period. It is a short-term unsecured loan summarized in the state variable of negative cash holdings and lines up with the short maturity empirically documented in section 3.

Both contracts are transacted at par in principal, while interest is settled at issuance at the rates $r_S(\omega)$ and $r_U(\omega)$. Because interest is paid a period before the principal falls due, the amount prepaid per unit of face value is $\frac{r}{1+r}$ rather than $r$. A firm that borrows a principal of $|c'|$ therefore receives $|c'|/\big[1 + r_U(\omega)\big]$ from the lender and, since interest is deductible, a further $\tau\,\frac{r_U(\omega)}{1+r_U(\omega)}|c'|$ through the reduction in its tax bill, and owes $|c'|$ in the following period. Under this convention the amount due in any period is the face value of the position carried into it, so

that the inherited capital stocks, principal and liquid position are sufficient to determine current obligations and no lagged rate needs to be tracked. The inherited liquid position is accordingly settled at face value, whether it is cash returned to the firm or unsecured debt repaid by it, and the new position is taken on at par, so that saving reduces current payouts one for one and new unsecured borrowing raises current proceeds by its principal. Together the two contribute $c - c'$ to current resources.

Secured debt, with stock denoted by principal $P$, is long-term and backed by tangible capital. A fraction $\eta \in (0, 1]$ of the outstanding principal amortizes every period, reflecting a maturity of $\frac{1}{\eta}$ which I calibrate to match the observed maturity in the data. The surviving pool is repriced each period, so that interest is paid on the principal the firm carries forward rather than on the principal it inherited. Importantly, the firm can only choose new debt, it cannot repay more than the maturing fraction, which helps to match the persistence of leverage in the data:

$$P' \geq (1 - \eta)P. \tag{6}$$

Since every asset can only be pledged once (exclusivity), the amount of secured debt is limited by the tangible capital stock,

$$P' \leq (1 - \delta_t)K'_t. \tag{7}$$

Cash flows distributed to shareholders are determined by the firm's after tax operating income, its financing and investment decisions and its inherited position. Specifically, shareholder payouts equal after tax operating income plus net proceeds from debt issuance, minus net investment expenditures and interest payments, which are deductible for tax purposes:

$$\begin{aligned}
\mathcal{E}(z, K_t, K_i, P, c,\, K'_t, K'_i, P', c') = & \underbrace{(1-\tau)\left[(1-v)\; Y(z, K_t, K_i)\right]}_{\text{after tax operating profits}} \\
& - \underbrace{\Big[I_t + I_i\Big]}_{\text{gross investment}} - \underbrace{\Big[A(K_t, K_i, I_t, I_i)\Big]}_{\text{adjustment costs}} \\
& + \underbrace{\Big[P' - (1-\eta)P\Big]}_{\text{gross new borrowing}} - \underbrace{\eta P}_{\text{amortization paid}} \\
& - \underbrace{(1-\tau)\Big[\tfrac{r_S(\omega)}{1+r_S(\omega)}\, P' \;+\; \tfrac{r_U(\omega)}{1+r_U(\omega)} \max\{-c', 0\}\Big]}_{\text{after tax interest, settled at issuance}} \\
& + \underbrace{\Big[c - c'\Big]}_{\text{change in the liquid position at par}}.
\end{aligned} \tag{8}$$

The two secured principal terms describe the sequence within the period. The firm first repays the maturing fraction $\eta P$, leaving a surviving pool of $(1-\eta)P$, and then borrows against that base to reach its chosen principal $P'$, which raises $P' - (1-\eta)P$ in gross proceeds. Netting the two, the cash flow from secured principal is simply the change in the amount outstanding, $P' - P$, so that a firm which refinances its maturing debt in full neither raises nor pays out cash on the principal account. The amortization schedule therefore does not affect the level of payouts directly; it restricts the speed at which the firm may deleverage through (6).

I abstract from external equity issuance, which is equivalent to assuming that raising equity is prohibitively costly. Therefore the cashflows to shareholders must be non-negative, that is:

$$\mathcal{E}(z, K_t, K_i, P, c,\, K_t', K_i', P', c') \geq 0 \tag{9}$$

This assumption reflects the dominant financing channels of the private small and medium sized firms considered in the sample, which have no access to public equity markets, and typically limited access to private equity markets.

The manager discounts future distributions at $\beta = 1/(1+r_f)$, where $r_f$ denotes the net risk free rate, and chooses next period's capital stocks, secured principal and liquid position to maximize the value of the firm. The Bellman equation for the problem is

$$\begin{aligned}\Pi(z, K_t, K_i, P, c) \;=\; \max_{\{K_t', K_i', P', c'\}} \Big\{ & \mathcal{E}(z, K_t, K_i, P, c,\, K_t', K_i', P', c') \\ & +\; \beta\, \mathbb{E}_{z'|z}\big[\, \mathbf{1}_{\{(z', K_t', K_i', P', c') \notin \mathcal{D}\}}\, \Pi(z', K_t', K_i', P', c')\big] \Big\}\end{aligned} \tag{10}$$

subject to (3) to (9). The indicator reflects that the firm is liquidated in the default region $\mathcal{D}$, defined in Section 4.4, in which case shareholders receive nothing. Since cash earns no interest while shareholders discount at the risk free rate, holding liquidity is costly and is motivated entirely by the precautionary value of avoiding default.

### 4.4 Loan Contracts and Debt Pricing

I assume that a perfectly competitive financial intermediary sector provides firms with one period unsecured and long-term secured debt contracts. Neither contract need be fully backed by collateral, so that firms can default on their debt. Default arises from a shortage of liquid resources rather than from a strategic decision by shareholders. In particular, the firm defaults whenever its current resources are insufficient to meet its contractual obligations. I follow Ivanov

et al. (2026) with this assumption, who also consider this the realistic case for the small private firms in the sample. The assets available to service debt are

$$\mathcal{A}(z, K_t, K_i, P, c) = (1 - \tau)\left[(1 - v)\ Y(z, K_t, K_i)\right] + \chi(1 - \delta_t)K_t + \max\{c, 0\}, \tag{11}$$

where the first term is current operating income net of taxes and operating costs, the second term is the liquidation value of tangible capital at the recovery rate $\chi \in (0, 1)$, and the final term is the value of inherited cash. Because interest on both instruments is settled at issuance, the amount falling due in the current period is the face value of the positions carried into it,

$$\mathcal{O}(P, c) = P + \max\{-c, 0\}. \tag{12}$$

The first component is the outstanding secured principal and the second the maturing unsecured balance, which is present only when the inherited liquid position is negative.

The firm defaults whenever promised repayments exceed the resources available to meet them. The default region is therefore

$$\mathcal{D} \equiv \{(z, K_t, K_i, P, c) : \mathcal{A}(z, K_t, K_i, P, c) < \mathcal{O}(P, c)\}. \tag{13}$$

Since contractual rates do not enter (12), the default region depends on the state and on the recovery technology alone. In default, the firm is liquidated, creditors are repaid according to contractual priority, and shareholders receive zero.

The secured creditor has priority over the tangible collateral pool and therefore recovers

$$\mathcal{R}_S(K_t, P, c) = \min\{P,\ \chi(1 - \delta_t)K_t + \max\{c, 0\}\}. \tag{14}$$

The unsecured creditor receives a payment only when the firm has inherited unsecured debt and the liquidation value of tangible capital exceeds the secured claim. Its recovery is

$$\mathcal{R}_U(K_t, P, c) = \min\{\max\{-c, 0\},\ \max\{\chi(1 - \delta_t)K_t - P, 0\}\}. \tag{15}$$

Thus, secured creditors are paid first, while unsecured creditors receive at most the residual value of the tangible collateral pool. Note that the signed liquid position $c$ implies that a firm cannot simultaneously hold cash and unsecured debt. When $c \geq 0$, cash increases the resources available to avoid default, but there is no unsecured claim outstanding. When $c < 0$, the firm

has no cash and the unsecured creditor can recover only from tangible collateral remaining after the secured claim has been satisfied, which results in (15).

Intangible capital does not enter either recovery payoff because I assume it has no liquidation value. For those assets measured as intangibles in the data, such as individualized software that is difficult to pledge and seize as collateral, this is a natural assumption and fits the fact that banks rarely accept such assets as collateral, as discussed in section 3.

Competitive intermediaries price both contracts to earn the risk free return in expectation. For a chosen secured principal $P'$, the lender advances $P'/\big[1+r_S(\omega)\big]$ today, since interest is settled at issuance. It receives the face value $P'$ when the firm remains solvent and the recovery value $\mathcal{R}_S$ when the firm defaults. The secured loan rate therefore satisfies

$$\frac{P'}{1+r_S(\omega)} = \frac{1}{1+r_f}\,\mathbb{E}_{z'|z}\big[\mathbf{1}_{\{(z',K_t',K_i',P',c')\notin\mathcal{D}\}}\,P' + \mathbf{1}_{\{(z',K_t',K_i',P',c')\in\mathcal{D}\}}\,\mathcal{R}_S(K_t',P',c')\big], \tag{16}$$

where the expectation is taken over next period's productivity realization conditional on $z$. Dividing by $P'$ gives the lender's break even condition per unit of secured principal. When default is impossible the right hand side equals $P'/(1+r_f)$ and the secured rate reduces to the risk free rate.

Similarly, consider one period unsecured borrowing of principal $|c'|$, which matures in full. The unsecured lender advances $|c'|/\big[1+r_U(\omega)\big]$ and receives the face value $|c'|$ if the firm remains solvent in the following period and the recovery payoff $\mathcal{R}_U$ otherwise. The unsecured rate is determined by

$$\frac{|c'|}{1+r_U(\omega)} = \frac{1}{1+r_f}\,\mathbb{E}_{z'|z}\big[\mathbf{1}_{\{(z',K_t',K_i',P',c')\notin\mathcal{D}\}}\,|c'| + \mathbf{1}_{\{(z',K_t',K_i',P',c')\in\mathcal{D}\}}\,\mathcal{R}_U(K_t',P',c')\big]. \tag{17}$$

Figure 2 plots the secured and unsecured interest rates, $r_S(\omega)$ and $r_U(\omega)$, as functions of secured debt intensity, $P'/K_t'$, holding both capital stocks at their steady state values, fixing the unsecured position at its steady state level. Both interest rates are weakly increasing in the chosen level of secured leverage. The secured rate remains equal to the risk free rate as long as the outstanding secured principal is fully covered by the recoverable value of tangible capital. Once secured debt exceeds recoverable collateral, the secured rate begins to rise. However, because secured creditors have priority in default and recover a large share of their claims, secured borrowing remains relatively inexpensive even when default is almost certain.

The unsecured rate is considerably more sensitive to increases in secured debt. Higher secured leverage raises the firm's total repayment obligations and therefore increases the likelihood of

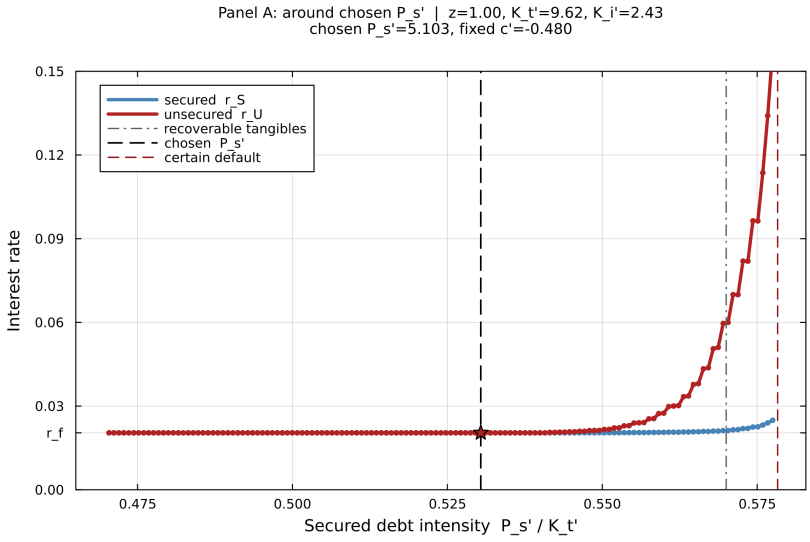



**Figure 2: Interest Rate: Secured vs. Unsecured**
This figure plots the secured interest rate $r_S(\omega)$ and the unsecured rate $r_U(\omega)$ as functions of secured debt intensity, $P'/K'_t$, holding both capital stocks and the unsecured position at their steady state values and setting $\ln z = 0$.

default. At the same time, because secured creditors are repaid first, it reduces the residual value available to unsecured lenders in default. Thus, unsecured creditors face both a higher probability of default and a lower recovery conditional on default. As the firm approaches the region of almost certain default, the unsecured rate consequently rises sharply, while the secured rate increases only modestly.

### 4.5 Tangibility of Investment and Leverage

Tangible capital plays a dual role. Beyond its direct contribution to output, it relaxes the collateral ceiling (7) and, by raising creditors' recovery in default, lowers the break even rates at which the firm borrows. To characterize these forces, let $\mu \geq 0$ be the multiplier on the collateral ceiling and let $\Pi_{K_t}$ denote the marginal value of installed tangible capital. Consider a state in which the firm adjusts both stocks, gross investment is interior, and the payout constraint is slack, so that $\Pi$ is differentiable at the optimum. The choice of $K'_t$ then satisfies

$$\underbrace{1+\psi_t\tfrac{I_t}{K_t}}_{\text{marginal cost}} = \underbrace{\mu\,(1-\delta_t)}_{\text{quantity margin}} \underbrace{-\,(1-\tau)\left[\frac{1}{\left[1+r_S(\omega)\right]^2}\frac{\partial r_S(\omega)}{\partial K'_t}\,P' + \frac{1}{\left[1+r_U(\omega)\right]^2}\frac{\partial r_U(\omega)}{\partial K'_t}\,\max\{-c',0\}\right]}_{\text{interest rate margin}}$$

$$+\;\beta\,\mathbb{E}_{z'|z}\left[\mathbf{1}_{\{\notin\mathcal{D}\}}\,\Pi_{K_t}\right], \tag{18}$$

where the indicator and the marginal value are evaluated at next period's state $(z', K_t', K_i', P', c')$ and $\Pi_{K_t}$ is derived in Appendix A.1. Since $\Pi = 0$ on the default boundary, movements in that boundary contribute no first order term to the firm's problem; they do shift creditors' payoffs, and that effect is precisely the interest rate margin. The condition for intangible capital takes the same form but without the first two terms on the right hand side: intangible capital cannot be pledged, so it does not appear in the collateral ceiling (7) and does not enter the multiplier $\mu$, and it has no liquidation value, so it leaves both recovery schedules (14) and (15) unchanged and neither rate responds to it. Intangible investment is therefore governed by its marginal product and adjustment costs alone.

The left hand side of (18) is the marginal cost of installing a unit of tangible capital, its purchase price plus the marginal convex adjustment cost. The right hand side collects the marginal benefits. The first term, $\mu(1 - \delta_t)$, is the quantity margin. Because $K_t'$ and $P'$ are chosen jointly, a unit of tangible capital relaxes the contemporaneous borrowing ceiling by its pledgeable value $(1 - \delta_t)$, valued at the shadow price $\mu$. The second term is the interest rate margin, through which extra collateral lowers the break even rate on the secured pool $P'$ and, when the firm borrows, on the unsecured balance $\max\{-c', 0\}$. Because interest is settled at issuance, this benefit accrues in the current period and is therefore undiscounted. The final term is the discounted marginal value of installed capital in surviving states, which comprises the after tax marginal product in production, the depreciated resale value of the stock carried forward net of future adjustment costs, and the saving on the fixed cost of adjusting.

The two collateral channels are active under different conditions. The quantity margin enters (18) only when the ceiling binds contemporaneously, but collateral retains quantity value even at $\mu = 0$, since relaxing the ceiling in future states is priced into the continuation value $\beta\,\mathbb{E}[\Pi_{K_t}]$. The interest rate margin differs in that it accrues immediately and undiscounted, and requires only that outstanding debt carry default risk: its secured component operates once the secured pool exceeds recoverable collateral, and its unsecured component whenever unsecured debt is not fully covered by the collateral left after the secured claim, so that $\partial r_S(\omega)/\partial K_t' < 0$ and $\partial r_U(\omega)/\partial K_t' < 0$ respectively. Appendix A.1 establishes both in detail. Because the unsecured creditor recovers only from $\max\{\chi(1 - \delta_t)K_t' - P', 0\}$, a unit of tangible capital in excess of the secured claim passes through to unsecured recovery, so $r_U$ responds to collateral even in the region where the secured rate is still flat at the risk free rate (Figure 2). The interest rate margin therefore tilts investment toward tangibles whenever some outstanding debt is risky, and the tilt is largest for firms where the marginal effect of collateral on borrowing rates is strongest.

This pricing channel distinguishes the model from collateralized borrowing frameworks in which the pledgeable fraction of capital is a fixed parameter, as in Li et al. (2016). There capital affects financing only through the quantity of borrowing, and the terms of that borrowing are invariant to the capital stock. Here tangible capital also shapes the price of debt, so it tilts the investment mix toward tangibles for any firm whose outstanding debt carries default risk.

# 5 Estimation and Counterfactual

I estimate the model on the sample of nonfinancial, unregulated private Austrian firms described in Section 2. A subset of parameters is calibrated outside the model, either because they map directly to observable institutional features or because the data identify them with little reference to the model's internal structure. To reproduce the eight-year average maturity of secured debt documented in Section 3, I set the amortization rate to $\eta = \frac{1}{8}$. I fix the risk-free rate at $r_f = 1\%$, which is close to the average one-year yield on Austrian government debt over the 2018–2023 sample, and set the tax rate to $\tau = 25\%$, the unified Austrian corporate rate over the same period. The two depreciation rates are read directly from the accounting data: in this class of models the firm over time replaces depreciated capital on average, so investment in a given capital stock, divided by that stock, recovers its depreciation rate. Tangible investment over tangible fixed assets yields $\delta_t = 0.18$, and the analogous ratio for intangibles yields $\delta_i = 0.55$. The gap is large but consistent with the composition of intangibles under conservative Austrian accounting, where the category is dominated by short-lived items such as software licenses that are written down quickly.

The remaining parameters, $(\theta, \alpha, \rho, \sigma, \psi_t, \psi_i, \psi_f, \chi, v)$, are estimated jointly by simulated method of moments, minimizing the distance between a set of moments computed on the simulated data and their empirical counterparts. I plug in the calibrated values from panel A of Table 5 and weight the moments by the optimal weight matrix, constructed as in Bazdresch et al. (2018), clustered by firm and year. Since the empirical moments are obtained from different data sets, the standard errors are computed following the procedure proposed by Cocci and Plagborg-Møller (2025).

The first four moments are the means and variances of log sales and total investment. Sales and investment are scaled by fixed assets. I add the serial correlations of log sales, and tangible and intangible investment, which discipline the dynamics of the shock and adjustment technologies.

One moment captures the asset composition: the mean share of tangible assets in fixed assets. Mean and serial correlation of debt-to-assets are chosen to match the financing dynamics of the simulated firms. Finally, the share of secured in total debt, which is constructed from the loan-level data disciplines the model's secured-debt mechanism directly. This gives eleven targeted moments in total. I construct empirical variables to correspond closely to their model analogues. In the AMDC firm data, sales (UMSATZ) and total investment (IGES) are scaled by fixed assets, which I define from Orbis as the sum of tangible (TFAS) and intangible (IFAS) fixed assets, excluding other fixed assets. The tangible asset share is tangible fixed assets over fixed assets, and the tangible investment share is investment in tangibles (ISACH) over total investment. Debt is the sum of short-term (LOAN) and long-term (LTDB) liabilities in Orbis, scaled by total assets (TOAS). The share of secured debt is constructed from the loan-level data as the volume of collateralized loans over total outstanding debt. In the simulated data, log sales are $\log\big(Y/(K_t+K_i)\big)$, leverage is $\big(P+\mathbf{1}_{\{c<0\}}|c|\big)/\big(K_t+K_i+\mathbf{1}_{\{c>0\}}c\big)$, the tangible asset share is $K_t/(K_t+K_i)$, and tangible investment is $\big(K_t'-(1-\delta_t)K_t\big)/(K_t+K_i)$, with intangible investment defined analogously. Total investment to fixed assets is $(I_t+I_i)/(K_t+K_i)$. The share of secured debt corresponds to $P/\big(P+\mathbf{1}_{\{c<0\}}|c|\big)$, the outstanding secured principal as a fraction of total debt.

While all of the model parameters affect all of the selected moments, some of these moments are particularly useful for parameter identification. First, variance and autocorrelation of log sales-to-fixed-assets ratio help identifying the driving shock process parameters $\sigma$, $\rho$. The mean of the ratio is naturally decreasing in the curvature of the production function $\theta$. The ratio of tangible assets is strongly determined by the relevance of tangible assets in the production function $\alpha$. The convex adjustment costs $\psi_t$ and $\psi_i$ are disciplined by the variances and auto-correlations of the two investment series, and the nonconvex cost $\psi_f$ by the within-firm variance of investment. The recovery rate $\chi$ is identified by the level of leverage together with the share of secured debt, since a higher recovery value widens the collateral-covered region over which the secured rate stays near the risk-free rate, raising both the attractiveness of borrowing against tangible capital and the fraction of debt that is secured. Finally, the variable operating cost $v$ shapes the firm's ability to generate internal funds, and through this affects both level of investment and leverage. I also consider the local identification measure from Andrews et al. (2017), depicted in the form of a heatmap in Figure 3 of Appendix C.

**Table 5: Model estimation**

A. Parameter estimates

| $\theta$ | $\rho$ | $\sigma$ | $\alpha$ | $\psi_f$ | $\psi_t$ | $\psi_i$ | $\chi$ | $v$ |
|---|---|---|---|---|---|---|---|---|
| 0.745 | 0.940 | 0.143 | 0.827 | 0.016 | 0.201 | 0.234 | 0.946 | 0.709 |
| (0.034) | (0.015) | (0.011) | (0.025) | (0.003) | (0.056) | (0.047) | (0.056) | (0.006) |

B. Targeted moments

| | Actual | Simulated | $t$-stat. |
|---|---|---|---|
| Mean log sales-to-fixed-assets | 0.755 | 0.775 | -0.694 |
| Variance log sales-to-fixed-assets | 0.096 | 0.065 | 3.284 |
| Serial correlation log sales-to-fixed-assets | 0.964 | 0.981 | -1.098 |
| Mean debt-to-assets | 0.354 | 0.349 | 0.797 |
| Serial correlation debt-to-assets | 0.862 | 0.911 | -2.170 |
| Mean investment-to-assets | 0.178 | 0.216 | -6.248 |
| Variance investment-to-assets | 0.017 | 0.030 | -15.817 |
| Share of tangible assets | 0.950 | 0.926 | 11.488 |
| Serial correlation tangible investment | 0.427 | 0.436 | -0.469 |
| Serial correlation intangible investment | 0.593 | 0.601 | -0.123 |
| Share of secured debt | 0.756 | 0.759 | -0.831 |

C. Untargeted moments

| | Actual | Simulated |
|---|---|---|
| Share of defaults | 0.008 | 0.013 |

*Notes:* This table reports the parameters and moments from the estimation of the model from Section 4. I use the full sample of firms from the AMDC data. The sample period is 2018–2023. The parameter $\theta$ is the curvature of the production function; $\rho$ is the serial correlation of the shock process; $\sigma$ is the standard deviation of the shock process; $\alpha$ is the share of tangible assets in the production function; $\psi_t$ ($\psi_i$) governs quadratic capital adjustment costs of (in)tangible assets; $\psi_F$ governs fixed adjustment costs; $\chi$ is the recovery value of tangible capital; and $v$ is the variable operating cost. "Sales-to-fixed-assets" is defined as sales divided by the sum of tangible and intangible assets on balance sheet, "debt-to-assets" as short-term and long-term debt divided by total assets; "investment-to-assets" is defined as gross investment divided by fixed assets, "Share of secured debt" is the ratio of debt backed by collateral divided by total debt in the loan registry. The $t$-statistics next to the simulated and actual moments are based on the null hypothesis of the equality of each of these moment pairs.

Panel A of Table 5 reports the parameter estimates. The curvature of the production function, together with the persistence and standard deviation of the productivity process, take values in line with those commonly obtained for this class of models (like for example Gao et al. (2021)), and all three are estimated precisely. The tangible-capital share is $\alpha = 0.827$, indicating a production technology weighted toward tangible capital. The adjustment-cost parameters are estimated at $\psi_f = 0.016$ for the fixed component and $\psi_t = 0.201$ and $\psi_i = 0.234$ for the quadratic components of tangible and intangible investment, respectively, values that sit within the range reported in previous literature. The recovery value of tangible capital is $\chi = 0.946$, because collateral in the data is drawn almost entirely from real estate and other physical assets with high resale value, a recovery rate near one is plausible, though this parameter is less sharply identified than the others. Moreover, given the conservative accounting rules prevailing

in Austria, the recovery value appears reasonable relative to the book value of tangible assets. The variable operating cost is estimated precisely at $v = 0.709$.

Panel B reports the moments used in estimation alongside their empirical counterparts. The model reproduces the level moments closely: the simulated means of log sales-to-fixed-assets, debt-to-assets, and investment-to-assets are all close to their data values, as are the serial correlations of sales and of tangible and intangible investment. The $t$-statistics of mean and variance of investment are statistically different in my simulated sample, which is expected given the sample: the target moments are themselves estimated with high precision, so even economically small differences can be statistically distinguishable. The one moment on which the model and the data diverge in economic terms is the tangible asset share which is slightly understated in the model (0.926 against 0.950), though the gap is less than three percentage points. The share of secured debt is matched very well indicating that the model captures the targeted strong preference for secured debt well.

Panel C reports the simulated default rate. The model reproduces a default frequency in the right range of the empirical default rate and average estimated probability of default by the banks. This offers support for the way the estimated technology and financing parameters interact to generate risky debt. Overall, the model reproduces the relevant features of the data well.

### 5.1 Counterfactual

With the estimated parameters at hand, I use the framework of Section 4 to quantify how much of the observed tilt toward tangible assets is caused by financial frictions rather than by technology. To do so I solve a counterfactual economy in which intangible capital is financially identical to tangible capital: it enters the liquidation estate at the recovery rate $\chi$, and therefore appears in the resources $\mathcal{A}$ and in both recovery schedules $\mathcal{R}_S$ and $\mathcal{R}_U$ in (14) and (15). Moreover, it is pledgeable, so that the collateral ceiling in (7) becomes $P' \leq (1-\delta_t)K_t' + (1-\delta_i)K_i'$. All technology parameters are held at their estimated values, so that any difference in behavior between the two economies is attributable to the financing environment alone. Holding productivity, both capital stocks, secured principal and the liquid position fixed, the change operates through three channels. First, a larger asset base raises the resources available to meet obligations and therefore contracts the default region, lowering the probability of default at unchanged financing choices. Second, conditional on default, it raises creditors' recovery. This reduces the interest rate, and it is largest for firms closer to the default region. Third, the relaxed borrowing ceiling

permits a given capital stock to support more secured borrowing. Financing conditions thus improve most where default risk is high, and are close to unchanged for firms that were never near the default boundary.

I compare the two economies along two dimensions. I first evaluate policy functions at identical grid states, which isolates the change in optimal behavior at a common $(z, K_t, K_i, P, c)$ and removes any composition effect arising from differences in the stationary distribution. I then compare the same simulated firm-years across economies under a common seed, conditional on survival in both, which preserves the realized productivity path and yields matched treatment effects on the simulated panel. Investment is scaled throughout by lagged fixed assets, and the intangible share is aggregate intangible investment over aggregate total investment.

In the matched simulated panel, pledgeable intangibles raise average leverage from 37.8 to 39.1 percent, an increase of 1.3 percentage points. Intangible investment rises from 4.17 to 4.22 percent of lagged fixed assets, an increase of 1.1 percent, while total investment falls slightly from 22.93 to 22.80 percent. The aggregate distortion is therefore not principally a shortfall in the level of investment but a distortion of its composition: the intangible share rises by about one percentage point. In the baseline economy part of the tangible stock is held for its collateral value rather than its marginal product, and once intangible capital performs the same function that motive disappears. The friction is better characterized as over-accumulation of tangible capital than as under-investment in intangibles.

The aggregate effects conceal substantial heterogeneity, concentrated where the model predicts. Classifying firms by the quartiles of the simulated productivity distribution, low-productivity firms respond most strongly: intangible investment rises by 3.4 percent, leverage rises from 45.4 to 47.8 percent, and the intangible share of investment rises from 9.38% by 0.85 percentage points. The effects are stronger still in the segments in which the interest rate margin is most active. Among firms with leverage above 50% the intangible share rises by 2.95 percentage points, and among secured-intensive firms by 2.21 points, in both cases accompanied by a sharp contraction in tangible investment as capital previously held for its collateral value is no longer required to support borrowing. Among high-productivity firms, by contrast, the intangible share is essentially unchanged. Finally, the equilibrium default rate is unchanged between the two economies: firms capitalize the improvement in borrowing terms by increasing leverage rather than by holding the same debt more safely. The counterfactual therefore benefits financially fragile firms by raising continuation values and reallocating investment toward intangibles, rather than generating a broad expansion in aggregate investment.

# 6 Conclusion

I investigate how financing frictions shape the composition of firm investment across assets of differing tangibility. First, I document the financing conditions of small private firms, which exhibit a pronounced preference for secured bank debt, and use loan-level data to quantify the pricing differential between secured and unsecured credit, which widens with leverage.

I then develop a structural framework to rationalize the findings. The model features endogenous pricing of risky debt, an optimal choice between secured and unsecured borrowing, and a joint investment decision over tangible and intangible capital. Firms with high productivity and low leverage face a low cost of unsecured credit and, as in the loan data, borrow unsecured. At higher leverage the unsecured rate rises steeply, since unsecured creditors face both a higher probability of default and a lower recovery once secured claims have been satisfied, and secured debt becomes the cheaper source of funds. Firms then tilt investment toward tangible assets beyond the level their marginal products alone would justify, holding tangible capital in part for its collateral value. A counterfactual in which intangible capital is fully pledgeable raises intangible investment by only 1.1 percent but produces a substantial reallocation of its composition: low-productivity firms raise their intangible share of investment by 2.3 percentage points and highly levered firms by 2.9, while high productivity firms are almost unaffected.

The distortion I identify is concentrated among firms that are already financially fragile, which matters for the design of policies targeting more investments in intangibles, such as public guarantee schemes and subsidized lending. Two extensions of the analysis seem worthwhile. Modeling loan pricing in more detail, including the role of bank capital requirements, would match the observed rate schedules more closely, and estimating the model by sector would accommodate the considerable heterogeneity in asset tangibility across industries.

# Appendix

# A Model Appendix

## A.1 Derivation of the Optimality Condition for Tangible Capital

Write the firm's problem with inherited state $(z, K_t, K_i, P, c)$, pricing state $\omega = (z, K_t', K_i', P', c')$ and $I_t = K_t' - (1-\delta_t)K_t$,

$$\Pi(z, K_t, K_i, P, c) = \max_{K_t', K_i', P', c'} \Big\{ \mathcal{E}(z, K_t, K_i, P, c, K_t', K_i', P', c') + \beta\, \mathbb{E}_{z'|z}\big[\mathbf{1}_{\{\notin \mathcal{D}\}} \Pi(z', K_t', K_i', P', c')\big] \Big\},$$

subject to the collateral ceiling (7), with multiplier $\mu \geq 0$, and the payout constraint (9). Consider a point at which the payout constraint is slack, so that the marginal value of a distributed dollar is unity, and at which $I_t \neq 0$, so that the nonconvex cost is locally constant.

**First-order condition.** Three components of (8) depend on $K_t'$: gross investment, the adjustment cost $A$, and the interest bill, since both rates are priced off the chosen state $\omega$ and hence off $K_t'$. Interest prepaid per unit of face value is $\frac{r}{1+r}$, with derivative $\big[1+r\big]^{-2}$ in the rate, so that using $\partial I_t / \partial K_t' = 1$,

$$\frac{\partial \mathcal{E}}{\partial K_t'} = -\Big(1 + \psi_t \tfrac{I_t}{K_t}\Big) - (1-\tau)\left[ \frac{1}{\big[1+r_S(\omega)\big]^2} \frac{\partial r_S(\omega)}{\partial K_t'} P' + \frac{1}{\big[1+r_U(\omega)\big]^2} \frac{\partial r_U(\omega)}{\partial K_t'} \max\{-c', 0\} \right],$$

while the ceiling contributes $\mu(1-\delta_t)$. Setting the total derivative to zero and rearranging gives (18). The multiplier $\mu$ is contemporaneous because the ceiling couples the current choices $(K_t', P')$; the inherited stock $K_t$ enters no current constraint, so no multiplier appears in the envelope. The interest rate margin is likewise contemporaneous and undiscounted, because interest is settled at issuance.

**Envelope condition.** Differentiating with respect to the inherited stock $K_t$, capital enters through two channels only: after-tax operating profits, and current investment through $\partial I_t / \partial K_t = -(1-\delta_t)$, which passes into both gross investment and the adjustment cost (5). Collecting terms,

$$\Pi_{K_t} = (1-\tau)(1-v)\frac{\partial Y}{\partial K_t} + (1-\delta_t)\left(1 + \psi_t \frac{I_t}{K_t}\right) + \frac{\psi_t}{2}\frac{I_t^2}{K_t^2} - \psi_f\, \mathbf{1}_{\{\text{adjust}\}}, \tag{A1}$$

$$\Pi_{K_i} = (1-\tau)(1-v)\frac{\partial Y}{\partial K_i} + (1-\delta_i)\left(1 + \psi_i \frac{I_i}{K_i}\right) + \frac{\psi_i}{2}\frac{I_i^2}{K_i^2} - \psi_f\, \mathbf{1}_{\{\text{adjust}\}}. \tag{A2}$$

No interest term appears in (A1), because $r_S$ and $r_U$ are functions of $\omega$ and therefore of $K_t'$ rather than of $K_t$: collateral affects the price of debt at the moment the position is taken on, not thereafter. The two envelope conditions are consequently symmetric, and the entire asymmetry between the two stocks operates through the first-order condition (18).

**Sign of the interest rate margin.** Rearranging the break even conditions (16) and (17) gives, for $j \in \{S, U\}$ with face values $F_S = P'$ and $F_U = |c'|$,

$$1 + r_j(\omega) = \frac{(1 + r_f)\, F_j}{V_j(\omega)}, \qquad V_j(\omega) \equiv \mathbb{E}_{z'|z}\left[\mathbf{1}_{\{\notin \mathcal{D}\}} F_j + \mathbf{1}_{\{\in \mathcal{D}\}} \mathcal{R}_j\right],$$

so that $r_j$ is a yield: it equals $r_f$ when default is impossible and rises without bound as $V_j \to 0$. Differentiating,

$$\frac{\partial r_j(\omega)}{\partial K_t'} = -\frac{(1 + r_f) F_j}{V_j(\omega)^2} \frac{\partial V_j(\omega)}{\partial K_t'},$$

so the derivative has the opposite sign to $\partial V_j / \partial K_t'$. Because $\mathcal{A}$ is increasing in $z'$ while $\mathcal{O}$ is independent of it, default occurs if and only if $z'$ falls below a threshold $\bar{z}'$, and since $\mathcal{A}$ is increasing in $K_t'$ the threshold satisfies $\partial \bar{z}' / \partial K_t' < 0$. Hence

$$\frac{\partial V_j(\omega)}{\partial K_t'} = \mathbb{E}_{z'|z}\left[\mathbf{1}_{\{\in \mathcal{D}\}} \frac{\partial \mathcal{R}_j}{\partial K_t'}\right] - f(\bar{z}') \frac{\partial \bar{z}'}{\partial K_t'} \left[F_j - \mathcal{R}_j(\bar{z}')\right],$$

where $f$ is the conditional density of $z'$. The second term is the boundary effect: a larger tangible stock shrinks the default region, replacing a recovery payoff by full repayment. It is weakly positive since $\mathcal{R}_j \leq F_j$ and $\partial \bar{z}' / \partial K_t' < 0$, and therefore reinforces the interior term. For the interior term, (14) gives

$$\frac{\partial \mathcal{R}_S}{\partial K_t'} = \begin{cases} \chi(1 - \delta_t) > 0 & \text{if } \chi(1 - \delta_t) K_t' + \max\{c', 0\} < P', \\ 0 & \text{otherwise,} \end{cases}$$

so that $\partial V_S / \partial K_t' \geq 0$ and hence $\partial r_S / \partial K_t' \leq 0$, strictly whenever the secured pool exceeds recoverable collateral in some default state. Likewise (15) gives

$$\frac{\partial \mathcal{R}_U}{\partial K_t'} = \begin{cases} \chi(1 - \delta_t) > 0 & \text{if } 0 < \chi(1 - \delta_t) K_t' - P' < |c'|, \\ 0 & \text{otherwise,} \end{cases}$$

so that $\partial r_U / \partial K_t' \leq 0$, strictly whenever unsecured debt is partially but not fully covered by the collateral remaining after the secured claim. Since $\left[1 + r_j\right]^{-2} > 0$, the interest rate margin in (18) is weakly positive.

**Differentiability.** $\Pi$ is differentiable except on the default boundary $\partial \mathcal{D}$ and at the kink $I_t = 0$. Since $\Pi = 0$ on $\partial \mathcal{D}$, the indicator $\mathbf{1}_{\{\notin \mathcal{D}\}}$ removes any boundary contribution to the firm's problem, so the expectation in (18) is well defined wherever the payout constraint is slack and $I_t \neq 0$. The boundary does contribute to creditors' payoffs, and that contribution is the second term in $\partial V_j / \partial K_t'$ above. ■

# B Data Appendix

**Table 6:** *Distribution of Protection Types in Loan Originations*

| | *Frequency* | *Ratio* |
|---|---|---|
| Commercial real estate | 1,614 | 25.61% |
| Financial guarantee | 1,206 | 19.14% |
| Residential real estate | 1,071 | 16.99% |
| Other physical collateral | 934 | 14.82% |
| Other assets | 1,477 | 23.44% |
| Total | 6,302 | 100% |

*Notes:* This table summarizes the distribution of collateral types among secured term loans. *Frequency* reports the number of loan-level observations by collateral type. *Ratio* reports each collateral type's share of total secured-loan observations, in percent. Commercial real estate includes eligible commercial real estate collateral, Financial guarantee includes guarantees with the character of credit substitutes, Residential real estate includes dwellings or residential buildings occupied by the owner or tenant. Other physical collateral includes for example machinery, ships, as well as aircrafts. 'Other assets' pools all protection types beyond the five most frequent within each instrument type, ranked by observation count.

# C Estimation Appendix

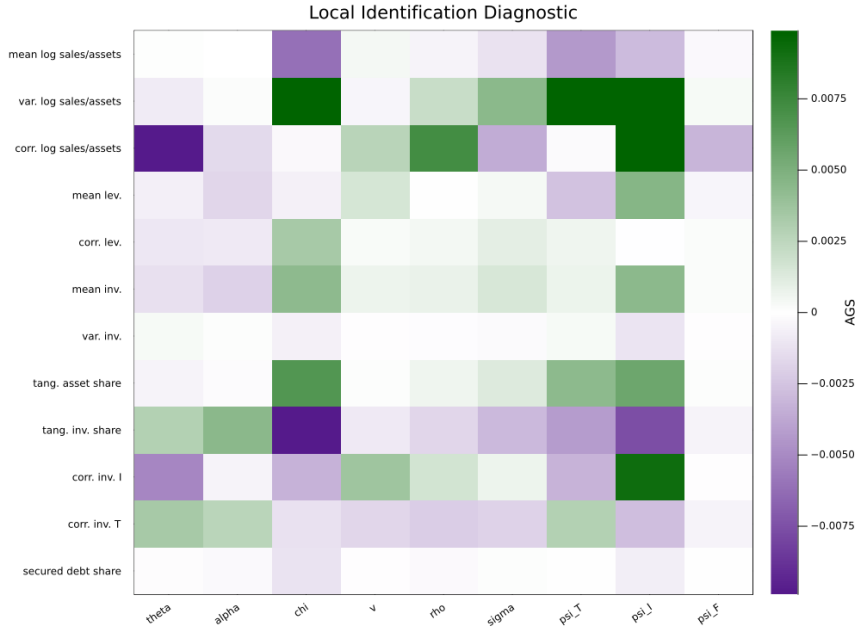



**Figure 3: Local Identification Diagnostic** This heat map reports the identification diagnostic of Andrews, Gentzkow, and Shapiro (2017). Each cell measures the effect on a given parameter of a one-standard-deviation change in a given moment.

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