Corporate Financing and Investment: The Firm-Level Credit Multiplier*

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Abstract

We study the effect of asset liquidity ("tangibility") on firm policies in the presence of financing constraints. We do so in a real options framework that allows for the simultaneous determination of investment and financing. In the presence of financing imperfections, firms that operate more tangible assets have larger credit capacity. By expanding the firm's capital base, the investment process engenders a feedback effect in which investment (in tangible assets) helps relax financing constraints, which in turn allows for additional investment, easing financing further, and so on. Our model formalizes the endogenous mechanism through which asset tangibility amplifies the impact of shocks to the firm's opportunity set onto the firm's investment and financing across time — a *firm-level credit multiplier*. Examining a large sample of manufacturing firms over the 1971–2005 period, we find support for our model's prediction that asset tangibility boosts investment spending when firms face financing constraints. We also verify that this result is driven by firms' debt issuance activities. Consistent with our identification strategy, the credit multiplier is absent from samples of financially unconstrained firms and samples of financially constrained firms with low incremental (asset-based) debt capacity.

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1 Introduction

Does financial contracting affect real corporate outcomes? Understanding the interplay between real and financial decisions is arguably one of the most important issues in financial economics. Accordingly, a large body of research in corporate finance examines when firms should invest and how they should finance their projects. The literature, however, often overlooks the impact of contracting frictions on firms' ability to raise funds for investment. The investment process is hence taken as *exogenous* to firms' financial status and financing decisions.

Financing frictions manifest themselves in many different ways. They typically make it harder for firms to raise fairly-priced funds to finance their projects. As a result, the availability of financing — rather than the availability of investment opportunities — drives firms' investment spending. Some of the most commonly observed financing frictions stem from the limited enforceability of contracts, especially in poor states of the world. Ample evidence suggests, for example, that firms strategically default on their contractual obligations when liquidation values are too low to keep investors committed to termination (e.g., Gilson et al. (1990) and Altman (1991)). Theoretical models recognize this problem and characterize financing arrangements that commit investors to costly termination outcomes (see, e.g., Harris and Raviv (1990) and Bolton and Scharfstein (1990)). Although they vary in their design, the key element that makes these contracts enforceable has a common real-world counterpart: the salability or "tangibility" of the firm's assets.[1] The tangibility of a firm's assets may not only be tied to the firm's investment process (asset tangibility is a natural function of the firm's line of business and capital accumulation process), but also to the firm's ability to raise external funds.

This paper explores an inherent attribute of the firm — the tangibility of its assets — to characterize the *endogenous* relation between firms' real and financial decisions in the presence of financing imperfections. It does so within a real options framework. Because the tangibility of a firm's assets affects its ability to pledge collateral, asset tangibility reduces the firm's default risk and enlarges its credit capacity. Critically, by expanding the firm's capital base, the investment process engenders a feedback effect in which investment (in tangible assets) helps relax financing constraints, which in turn allows for additional investment, easing financing further, and so on. Our model formalizes the endogenous mechanism through which asset tangibility amplifies the impact of shocks to the firm's opportunity set onto the firm's investment and financing across time — a firm-level *dynamic credit multiplier.* To our knowledge, this paper presents the first study to formally derive and empirically test the cross-sectional implications of asset liquidity for interactions

[1] Hereinafter, the term "asset tangibility" is generally adopted and meant to summarize the *liquidation value* and *ease of redeployment* of a firm's capital from the perspective of outside creditors in the event of default.

between financing and investment decisions.[2]

The real options framework is uniquely suitable for our analysis. Among other features, it allows us to compute security values, it characterizes dynamic aspects of the credit multiplier at the firm level, and it helps us gauge the impact of financing–investment interactions upon a number of variables that are of wide interest for empirical research (such as Tobin's Q and debt issuance). As we derive closed-form solutions from our model, we are also able to use numerical simulations as a tool to describe more subtle arguments of our theory. The real options framework also allows us to easily introduce heterogeneity in the way financing constraints are manifested, ranging from a possibly binding "quantity constraint" (i.e., access only to risk-free debt, limited by the firm's available collateral) to a less restrictive "pricing constraint" (when firms have access to risky debt). As such, our characterization of financing constraints enriches the literature and yields new predictions for the role of asset tangibility in underlying a financing–investment channel mechanism. Our analysis shows that a static approach to the relation between asset tangibility and credit capacity cannot flesh out the nuances of a credit multiplier underlying firms' investment and financing behaviors.

Our model's central results guide us in performing novel empirical tests on the extensively studied relation between corporate investment and Q. Our model shows, for example, that the impact of the credit multiplier on investment is only significant for firms that face financing frictions and that it increases with the degree of tangibility of those firms' assets. Empirically, both Q and asset tangibility are expected to affect investment behavior, but the model's credit multiplier effect implies that the *interaction* of these two variables will have a strong positive impact on investment in a cross section of financially constrained firms. Put differently, our theory predicts that positive innovations to investment prospects prompt stronger responses in observed capital spending when the firm solves a constrained optimization problem and its assets are more pledgeable.[3,4]

We test our theory using a large sample of manufacturing firms over the 1971–2005 period. As is standard in the corporate investment literature, we identify the testable predictions of our model based on comparisons between firms that are likely to face pronounced financing constraints and firms that are likely to be less constrained. We employ multiple schemes to partition the data into constrained and unconstrained subsamples; these are based on observable firm characteristics such as payout policy, firm size, and debt ratings (bond and commercial paper ratings). In addition,

[2] In the macroeconomics literature, Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) characterize the credit multiplier for the aggregate economy. A few papers in the corporate finance literature consider ideas that are related to our analysis. As we discuss shortly, however, their methods, goals, and results are different from ours.

[3] In the unconstrained solution, observed capital spending naturally responds to shocks to investment opportunities, but this effect is *not* magnified by asset tangibility.

[4] We provide a thorough treatment to the potential problem that Q is a proxy for investment opportunities that is measured with error. Notice that the conventional concern with Q is that mismeasurement will lead to an "attenuation bias." However, as we show via Monte Carlo simulations (see Appendix B), this bias makes it *more difficult* to find *any effect* of Q on investment, including the multiplier effect proposed by our theoretical model.

our tests consider both firm- and industry-level measures of asset tangibility. Our firm-level proxy gauges the expected liquidation value of a firm's main categories of operating assets: fixed capital, inventories, and accounts receivable (based on Berger et al.'s (1996) study on asset liquidation values). Our industry-level proxy captures the ease with which lenders may redeploy a borrower's assets. Specifically, Bureau of Census data on the demand for used capital are employed to measure the level of activity in the market for second-hand assets amongst high-value users of a firm's capital; that is, amongst other firms in the same industry (cf. Shleifer and Vishny (1992)).

Consistent with the predictions of our model, under each one of the constraint partition schemes considered, we find that asset tangibility promotes investment through a credit multiplier effect for constrained firms, but not for unconstrained firms. Our first set of tests, which build on standard investment regressions, reveals the economically significant role played by asset tangibility in influencing investment across financially constrained firms. As discussed above, because of the role of asset tangibility in simultaneously boosting financing and investment, our theory implies that the credit multiplier will be more finely identified in the cross section by interacting asset tangibility with Q. Consistent with this prediction, our second set of tests shows that estimates for this interaction term reliably explain investment across financially constrained firms. We also find that this interaction effect is even more pronounced in a third set of results, in which we split constrained firms into subsamples with low and high incremental (or "spare") debt capacity.[5] In particular, in line with our theory, we find that constrained firms with largely untapped debt capacity display the strongest relation between investment and asset tangibility interacted with Q. Notably, none of the effects just described are found in the cross section of financially unconstrained firms.

We perform an exhaustive round of checks to verify that our results also obtain under alternative test specifications and methods. We show, for example, that our results do not rely on *a priori* assignments of firms into financing constraint categories, such as those based on observables like firm size and debt ratings. In particular, we also estimate switching regressions in which the probability that firms face constrained access to credit is jointly estimated with the structural investment equations — i.e., constraint assignments are *endogenous* to investment. More generally, our results obtain when we use maximum likelihood estimations (switching regressions), GMM estimations, error-consistent estimations in which Q is replaced with Cummins et al.'s (2006) *RealQ* (based on analysts' earnings forecasts), and IV estimations that employ the projection of Q on industry product prices in lieu of Q. Under each of these alternative tests, the impact of asset tangibility on constrained firms' financing–investment interactions remains economically and statistically significant. Throughout the analysis, we show that our inferences are invariant to the use of firm- or

[5] These partitions are based, e.g., on the component of long-term debt that is not explained by asset tangibility.

industry-level proxies for asset tangibility.

To further characterize our proposed mechanism, we also look at the effect of asset tangibility on the interplay between firms' capital structure decisions and investment spending. Surprisingly, there is only limited empirical work on the link between tangibility and capital structure. Existing studies largely document a positive correlation between the ratio of fixed-to-total assets and financial leverage (see, e.g., Rajan and Zingales (1995)). The evidence in the literature is broadly consistent with the idea that asset tangibility matters for raising external financing. However, it is silent on the role of asset tangibility in underlying a channel between financial contracting and real outcomes such as corporate investment. Our tests show that asset tangibility magnifies the effect of shocks to investment opportunities onto debt taking when firms are financially constrained, but not when they are unconstrained. In other words, the tangibility-led amplification effect that is found for investment spending is also observed for debt policies when firms face financing frictions. The evidence we report for leverage decisions agrees with the predictions of our credit multiplier theory.

The papers closest to ours are Almeida and Campello (2007) and Hennessy et al. (2007). Almeida and Campello find that cash flow has a larger impact on investment when assets are more tangible. In contrast to their empirical investigation, we develop a full-blown model of the role played by asset tangibility in underlying an endogenous link between financing and investment decisions in the presence of financing imperfections. Differently from Almeida and Campello, we do not seek to take a stand on the interpretation of the sensitivity of investment to cash flows. In addition, our analysis shows how debt policies are affected by asset tangibility, while those authors' study provides no characterization of firm financial policies. Hennessy et al. develop a dynamic Q-theoretical investment model with financing frictions that features risk-free debt and costly external equity. With their financing mix as a special case, our model encompasses arbitrary mixtures of risk-free and risky debt, as well as costly external equity. Our tests complement their findings in that we focus on an alternative empirical specification and employ different methods for identification. We note that Hennessy et al.'s study is silent on the credit multiplier and its implications, which is the focus of our analysis.[6]

The remainder of the paper is organized as follows. Section 2 embeds asset tangibility and financing constraints into a real options framework for analyzing financing–investment interactions. Motivated by the model's main predictions, Section 3 implements our empirical methodology to examine the role of asset tangibility in a large sample of manufacturing firms in the United States over a 35-year window. Section 4 concludes. All technical developments are relegated to the appendix.

[6] In contrast to our focus on investment, Morellec (2001) shows that more liquid assets exacerbate bondholder–shareholder conflicts over disinvestment, providing a role for covenants that restrict the disposition of assets. Other related papers have focused on constrained optimization problems that create a motive for cash balances in advance of future investment opportunities when external financing is costly (e.g., Kim et al. (1998) and Mello and Parsons (2000)).

2 The Model

We use a partial equilibrium framework to study the effect of asset tangibility on financing and investment decisions when firms face financing constraints; i.e., when firms cannot find fairly-priced funding for all of their profitable investments.[7] Capital market frictions make the Modigliani-Miller theorem inapplicable, generating interesting interactions between financing and investment. Our approach builds on the real options framework used in related analyses (e.g., Mello and Parsons (1992)).

2.1 Setting

2.1.1 Production

In an industry with stochastic demand, we consider a firm that sells output that is produced with fixed inputs (physical capital) and variable inputs (labor). The firm is risk-neutral and discounts profits at a constant interest rate $r > 0$. Time is continuous and uncertainty is modeled by a complete probability space $(\Omega, \mathcal{F}, \mathcal{P})$. At time t, K_t and N_t denote, respectively, the stock of fixed and variable inputs. While labor, N_t, is freely and instantaneously adjustable, physical capital, K_t, is irreversible and cannot be adjusted freely. The industry is competitive and output price evolves stochastically according to a diffusion process:

$$dP_t = \mu\left(P_t, t\right) dt + \sigma\left(P_t, t\right) dW_t, \tag{1}$$

where $\mu(\cdot)$ is the drift rate of output price changes, $\sigma(\cdot)$ is the standard deviation of output price changes, dW_t denotes the increment of a Wiener process, and the initial level of the output price is $P_0 > 0$. We assume that the drift and volatility satisfy the necessary conditions for the existence of a unique solution to the stochastic differential equation in Eq. (1) (cf., Karatzas and Shreve (1988)).

The diffusion process for the industry's state variable in Eq. (1) is sufficiently general to allow for competitive dynamics that affect the path of P_t. For instance, an Ornstein-Uhlenbeck process would proxy for cyclical patterns in the industry resulting from entry and exit, while a geometric process would capture trend effects in rising or declining industries. Exogenous shocks to technology, consumer preferences, input prices, etc. can change competitive dynamics in the industry, and hence firms' investment opportunity set. To this end, our empirical tests will later emphasize the consequences of such changes to the firm's investment demand.

The firm's operating profits (i.e., revenue minus cost of variable inputs) are given at time t by:

$$\pi(K_t, P_t) = P_t K_t^x N_t^y - w N_t, \tag{2}$$

where the cost per unit of N_t is denoted by w. For this standard production technology, we assume that the Cobb-Douglas revenue function in Eq. (2) displays decreasing returns to scale with respect to N_t (i.e., $y < 1$), but increasing returns to scale when both inputs are variable (i.e., $x + y > 1$).

[7] See Bernanke et al. (2000) for models on how financing frictions influence macroeconomic dynamics.

2.1.2 Financing and Investment

We consider a firm that has an initial capital stock, K_0, and preexisting debt with perpetual coupon payments, b_0.[8] The firm has an option to expand its capital by K_1, which requires an irreversible investment cost λ_1 (normalized to 1) per unit of new capital.[9] At the time of investment, $I_t = \lambda_1 K_1$ can be financed by: (1) equity, (2) debt, or (3) a mix of debt and equity. We use $\theta \in (0, 1)$ to identify the fraction of I_t that is equity-financed. The overall level of I_t may be regarded as the sum of convex and non-convex adjustment costs as in Cooper and Haltiwanger (2006).

We model the pledgeability of the firm's assets by assuming that the transfer of the firm's physical assets in default entails costs that are proportional to those assets. More precisely, if the firm's assets are seized by its creditors, only a fraction, $\tau < 1$, of the firm's physical capital, K_t, is recovered. τ is a function of the nature of the firm's assets (e.g., assets such as land and machinery are easier to verify and foreclose than patents and trademarks), as well as industry characteristics, such as capital utilization rates and used capital redeployability (demand for foreclosed assets).

We consider that the firm may face "financing frictions." In contrast to the extant literature, we provide a rich characterization of the manner in which financing frictions are manifested. To anticipate the intuition, we consider that creditors impose a constraint on debt requiring $B(\cdot) \leq \rho R(\cdot)$, where $B(\cdot)$ denotes the value of the firm's debt and $R(\cdot)$ denotes the value of asset recoveries in the event of default. We let $\rho \geq 1$. Accordingly, when $\rho = 1$, the firm faces a "quantity constraint" that makes its debt risk-free. Alternatively, for $\rho > 1$, creditors permit the issuance of risky debt. The pricing of this risky debt should be primarily a function of the firm's default probability, but if the firm faces financing frictions — i.e., its debt endogenizes deadweight costs arising from agency problems or informational frictions — there exists a "price constraint" (this can be seen as a "discount" relative to the frictionless market value of debt). The parameter ρ thus captures the degree to which the firm is financially constrained: when $\rho = 1$ the firm's credit is quantity constrained, while for a higher value of ρ (above 1, but below a certain threshold) the firm is price constrained. Let us characterize these constraints more formally.

The maximum value of additional debt (i.e., incremental debt capacity) of the firm equals:

$$\overline{B}(K_t, P_t, b_t, \tau) = \min\{\underbrace{\rho[R(K_t, P_t, \tau) - b_0/r]}_{\text{Constrained pricing of } B}, \underbrace{B(K_t, P_t, \overline{b}(K_t, P_t, \tau) - b_0, \tau)}_{\text{Frictionless pricing of } B}\}, \tag{3}$$

where $K_t \in \{K_0, K_0 + K_1\}$, b_0 denotes the perpetual coupon payments from preexisting debt, and

$$\overline{b}(K_t, P_t, \tau) \in \arg\max_{b_t} B(K_t, P_t, b_t, \tau) \tag{4}$$

[8] E.g., debt was issued in the past to finance existing assets K_0 at the investment cost $\lambda_0 > 0$ — b_0 is the outcome of prior financing decisions. We have verified that endogenizing b_0 leads to qualitatively similar results.

[9] We note that deciding *how much to invest* (the capacity choice K_1) in a static model corresponds to *when to invest* in a dynamic model for a given capacity K_1 (see Dixit and Pindyck (1994)). Simply put, *earlier investment* timing leads, in expectation, to *more investment* in a present value sense. We discuss this point further in our empirical tests.

denotes the firm's debt coupon capacity. For a concave function $B(\cdot)$, the firm's debt value reaches a maximum for a finite debt coupon $\overline{b}$, which we derive analytically.

On one end of the continuum, the term $R(K_t, P_t, \tau) - b_0/r$ in Eq. (3) captures the maximum amount of additional *risk-free debt* available to the firm. In particular, if $\rho = 1$, the firm can only issue new debt up to the difference between the recovery value of its assets and the present value of its preexisting debt — the firm is *quantity constrained* for $\rho = 1$. On the other end, the term $B(K_t, P_t, \overline{b} - b_0, \tau)$ in Eq. (3) corresponds to the maximum value of additional *risky debt* under full ("fair market") valuation. This frictionless debt value accounts for arguments influencing the firm's future profits (physical assets, K_t, and output price, P_t), its preexisting debt (b_0), and the expected value of its assets in default (asset tangibility, τ, and K_t). When $\rho > 1$, the firm can issue risky debt. In the presence of financing frictions, however, the firm's risky debt is valued at a price that is lower than $B(K_t, P_t, \overline{b} - b_0, \tau)$. We thus say that the firm is *price constrained* in a region of ρ ranging from 1 to the threshold point where the incremental risky debt value reaches $B(K_t, P_t, \overline{b} - b_0, \tau)$ — we denote by $\overline{\rho}$ this threshold value for ρ. In sum, a firm is *financially constrained* when $1 \leq \rho < \overline{\rho}$.

It is useful to illustrate the role of ρ in our characterization of financing constraints. Figure 1 depicts the firm's incremental debt capacity, $\overline{B}$, as a function of ρ when asset tangibility, τ, is low (solid line) or high (dashed line). In this example, a quantity-constrained firm, for which $\rho = 1$, can issue \$100 (\$150) of *risk-free* debt for a low (high) value of τ.[10] In some region where ρ assumes values above 1 (i.e., as the firm's borrowing constraint is gradually relaxed), the firm's debt capacity is given by $\rho[R(K_t, P_t, \tau) - b_0/r]$ in Eq. (3). This term increases in ρ and τ, as depicted by the sloped lines in Figure 1. Noteworthy, for higher values of τ, the firm's debt capacity increases at a higher rate when ρ increases (the dashed slope is steeper). The dashed line also levels off at lower threshold values for ρ (i.e., $\overline{\rho}^H = 1.15 < 1.49 = \overline{\rho}^L$). Hence asset tangibility minimizes the range of ρ for which the firm is financially constrained.[11] Finally, note that the firm with a higher τ can issue more *risky* debt under frictionless debt pricing. This intuitive result obtains as the level of the flat line in Figure 1 is set by $B(K_t, P_t, \overline{b} - b_0, \tau)$ in Eq. (3). In the current example, the frictionless debt capacity equals \$149.5 (\$173.5) for the firm with a low (high) τ.

Figure 1 provides early insights into some of our main results. When financing is not frictionless ($\rho < \overline{\rho}$), access to financing, $\overline{B}$, increases with both ρ and τ. Since the firm is investing suboptimally, access to more (or cheaper) funds translates into more investment. When financing is frictionless ($\rho > \overline{\rho}$), $\overline{B}$ still increases with τ, but the firm may not invest more as a result (see Eq. (15)). In other words, the credit multiplier effect of asset tangibility necessitates the existence of financing frictions.

[10] Here we use the results from Proposition 1 and the parameter values that we employ in the simulations of Section 2.3 below; hence, for low τ at $\rho = 1$, $R(K_t, P_t, \tau) - b_0/r = \tau \times V(K_t, P_t) - 10/0.08 = 0.45 \times 500 - 125 = 100$.

[11] In our empirical tests, we allow for asset tangibility to affect the degree to which the firm is financially constrained.

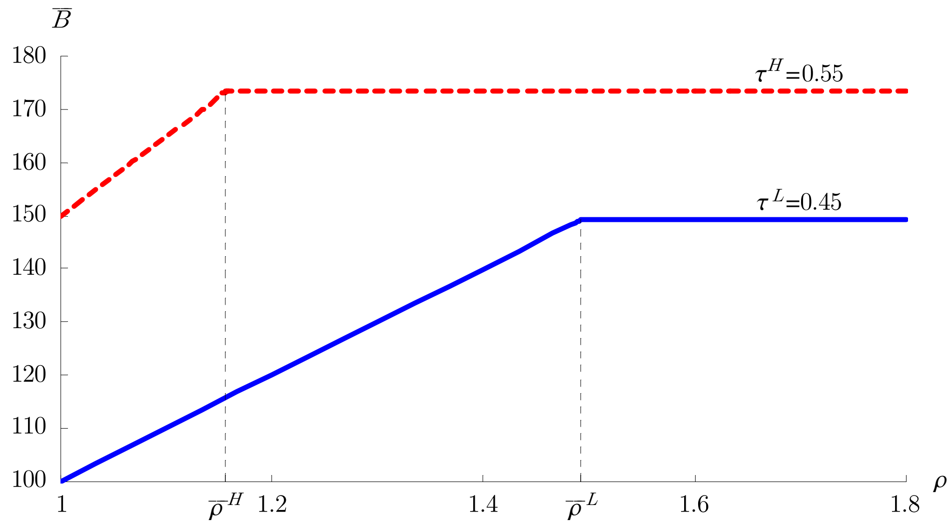

Figure 1. Asset Tangibility, Financing Constraints, and Incremental Debt Capacity
The figure charts incremental debt capacity, $\overline{B}$, as a function ρ for $\tau = 0.55$ (dashed line) or $\tau = 0.45$ (solid line). Other parameters are $\mu = 1\%$, $\sigma = 20\%$, $b_0 = 10$, $r = 8\%$, $w = 0.1$, $x = 0.75$, $y = 0.5$, $K_0 = 1$, $K_1 = 1$, and $P_0 = 1$.

Our model also allows for equity financing. To fill its financing gap, the firm can float equity or use a mix of debt and equity. For the equity-financed portion of investment, θI_t, the firm may incur extra "issuance costs." In particular, for a firm facing financing frictions, each equity-financed dollar of investment costs \$$(1 + \iota)$, where $\iota > 0$ represents costs above regular flotation costs.[12]

2.2 Optimal Policies

2.2.1 Operating Policies

Before analyzing the impact of asset tangibility on the link between financing and investment policies, we need to determine value-maximizing operating policies for variable and fixed production inputs. Optimizing the firm's operating profits in Eq. (2) with respect to the variable production inputs, N_t, implies that variable input at time t is chosen according to:

$$N_t^* (K_t, P_t) = \left(\frac{y P_t}{w K_t^{-x}} \right)^{1/(1-y)} . \tag{5}$$

As a result, the firm's operating profits are given by:

$$\pi(K_t, P_t) = K_t^{\alpha} P_t^{\beta} \Pi (w, x, y) , \tag{6}$$

where $\Pi (w, x, y) = (y^{\alpha y} - y^{\alpha}) w^{-\alpha y} > 0$, $\alpha = x/(1-y) > 1$, and $\beta = 1/(1-y) > 1$.

For any level of K_t and P_t, the firm determines an optimal level of variable inputs according to Eq. (5). Notice that this generates increasing returns to scale for investment in fixed inputs, which is captured by the capital elasticity parameter $\alpha > 1$. In addition, price changes lead to non-linear changes in the firm's profitability through the price elasticity parameter $\beta > 1$.

[12] Equivalently, flotation costs are normalized to zero for unconstrained firms in that this is a relative statement.

2.2.2 Investment and Financing Policies

After selecting variable inputs optimally, we turn to optimizing the firm's operating profits in Eq. (6) with respect to the fixed inputs. Starting from time $t = 0$, the value of the firm's assets underlies a channel through which exogenous industry price shocks influence the firm's investment and financing policies. To wit, the maximizing firm will (1) install more capital when the output price rises the first time to the critical investment threshold $p^i \geq P_0$, (2) default on its debt when the output price declines the first time to the critical default threshold $p^d \leq P_0$, or (3) choose optimal inaction if the industry's output price P_t fluctuates within $\left(p^d, p^i\right)$. Crucially, these critical price points are implicit functions of, among other things, the firm's installed capital and its asset tangibility.

To characterize the firm-level dynamics of the credit multiplier, we first need to derive the values of debt and equity, taking into account current and future capital levels. Let $\mathcal{T}^i$ denote the first time that the output price rises to the critical investment threshold p^i, while $\mathcal{T}^d$ and $\widetilde{\mathcal{T}}^d$ denote the default passage times before and after investment. At every point in time prior to default, the firm's operating profits net of debt payments are paid out to shareholders and hence the value of shareholders' contingent claims on the firm is given by:

$$\begin{aligned} S(K_0, P_0, b_0) \;=\; \mathbb{E}^{P_0} \Bigg[& \int_0^{\mathcal{T}^d \wedge \mathcal{T}^i} \underbrace{e^{-rt}\left[\pi(K_0, P_t) - b_0\right]}_{\text{Pre-investment dividends}} dt + 1_{\mathcal{T}^d > \mathcal{T}^i} \times \\ & \int_{\mathcal{T}^i}^{\widetilde{\mathcal{T}}^d} \underbrace{e^{-rt}\left[\pi\left(K_0 + K_1, P_t\right) - (b_0 + b_1)\right]}_{\text{Post-investment dividends}} dt - \underbrace{e^{-r\mathcal{T}^i}\theta(1+\iota) I_{\mathcal{T}^i}}_{\text{Investment cost}} \Bigg], \end{aligned} \tag{7}$$

where $\mathbb{E}^{P_t}[\cdot]$ denotes the conditional expectation operator when the current output price is P_0, 1_ω is the indicator function of state ω, and b_1 are coupon payments from debt issued at time $\mathcal{T}^i$. Analogously, at every point in time prior to default, creditors collect coupon payments, while they obtain recoveries in the event of default. The value of creditors' claims on the firm is given by:

$$\begin{aligned} B\left(K_0, P_0, b_0, \tau\right) \;=\; \mathbb{E}^{P_0} \Bigg[& \int_0^{\mathcal{T}^d \wedge \mathcal{T}^i} \underbrace{e^{-rt} b_0}_{\text{Debt service}} \; dt + 1_{\mathcal{T}^d < \mathcal{T}^i} \underbrace{e^{-r\mathcal{T}^d} R\left(K_{\mathcal{T}^d}, P_{\mathcal{T}^d}, \tau\right)}_{\text{Pre-investment recoveries}} + 1_{\mathcal{T}^d > \mathcal{T}^i} \times \\ & \left(\int_{\mathcal{T}^i}^{\widetilde{\mathcal{T}}^d} \underbrace{e^{-rt}\left(b_0 + b_1\right)}_{\text{Debt service}} dt - \underbrace{e^{-r\mathcal{T}^i}(1-\theta) I_{\mathcal{T}^i}}_{\text{Investment cost}} + \underbrace{e^{-r\widetilde{\mathcal{T}}^d} R\left(K_{\widetilde{\mathcal{T}}^d}, P_{\widetilde{\mathcal{T}}^d}, \tau\right)}_{\text{Post-investment recoveries}} \right) \Bigg], \end{aligned} \tag{8}$$

where $R\left(K_t, P_t, \tau\right) = \tau V\left(K_t, P_t\right)$, with

$$V\left(K_t, P_0\right) = \mathbb{E}^{P_0}\left[\int_0^\infty e^{-r(s-t)} \pi\left(K_t, P_s\right) ds\right]. \tag{9}$$

Eqs. (7)–(9) describe the sources of firm value from the vantage point of shareholders and creditors. The unlevered firm value, $V(\cdot)$, provides the basis for recoveries, $R(\cdot)$, that lenders can capture in the event of default. All else equal, firms with more tangible assets (higher τ) have a smaller wedge between recovery and unlevered firm values. Noteworthy, the values of debt and equity have a familiar form. The value of debt in Eq. (8), denoted $B(\cdot)$, is equal to the discounted value of coupon payments plus the value of recoveries in the event of default (before and after investment). In addition, debt value reflects the expected injection of funds $(1-\theta)I_{\mathcal{T}^i}$ at the investment time $\mathcal{T}^i$, which is the critical point when coupon flows to creditors and recoveries switch to a higher level (where the latter effect is due to the increase in the firm's capital base, K). The value of equity in Eq. (7), denoted $S(\cdot)$, is equal to the discounted value of operating profits net of debt coupon payments (before and after investment) with truncation of payments in the event of default, minus the discounted value of the equity-financed portion of investment costs $\theta(1+\iota)I_{\mathcal{T}^i}$.

With the preceding valuation results we can analytically characterize financing and investment policies of the firm. For a given financing mix (θ) and financing conditions (ρ), the firm invests when the output price rises for the first time to p^i, the point at which it is optimal for shareholders to incur the investment cost θI for switching from K_0 to K_0+K_1. Liquidation takes place when the output price falls for the first time to p^d, implied by credit constraints. The solution to this problem yields a closed-form solution for the firm's debt coupon capacity, $\overline{b}$, in our central proposition:

Proposition 1 *Let $\mu(P_t,t)=\mu P_t$ and $\sigma(P_t,t)=\sigma P_t$ be given by Eq. (1). The value of the firm's physical assets at time t equals the present value of the expected stream of operating profits:*

$$V(K_t,P_t)=\frac{K_t^\alpha\;P_t^\beta\;\Pi(w,x,y)}{r-\beta\mu-\beta(\beta-1)\sigma^2/2}. \tag{10}$$

The value-maximizing policy is to invest when the output price P_t reaches the upper threshold p^i the first time from below. If a mixture of debt and equity is used to finance investment (i.e., $0<\theta<1$), then p^i is the smallest value that simultaneously solves the following two expressions:

$$(i)\ (1-\theta)I_t\leq\overline{B}(\cdot)=\min\left\{\rho\left[R\left(K_0+K_1,p^i,\tau\right)-b_0/r\right],B\left(K_0+K_1,p^i,\overline{b}\left(K_0+K_1,p^i,\tau\right)-b_0,\tau\right)\right\}, \tag{11}$$

where the debt coupon that solves (4) is given by

$$\overline{b}(K_0+K_1,P_t,\tau)=\frac{P_t^\beta}{\tilde{\gamma}}\left[\left(\frac{\beta-\nu}{\beta}\right)\left(1-\frac{r\,\tilde{\gamma}\,\tau\,(K_0+K_1)^\alpha\;\Pi(w,x,y)}{r-\beta\mu-\beta(\beta-1)\sigma^2/2}\right)\right]^{\beta/\nu}, \tag{12}$$

where $\nu<0$ is the negative root of the quadratic equation $z\mu+z(z-1)\sigma^2/2-r=0$; and

$$(ii)\qquad \partial S(K_0,P_t,b_0)/\partial P_t|_{P_t=p^i}=\partial S(K_0+K_1,P_t,b_0+b_1)/\partial P_t|_{P_t=p^i}\,. \tag{13}$$

Finally, creditors seize the firm's assets when the output price P_t reaches the lower threshold p^d before (or after) investment the first time from above

$$p^d(K_0,P_0,b_0,\tau)=(\gamma b_0)^{1/\beta}\ \ (or\ \tilde{p}^d(K_{\mathcal{T}^i},P_{\mathcal{T}^i},b_{\mathcal{T}^i},\tau)=(\tilde{\gamma}(b_0+b_1))^{1/\beta}), \tag{14}$$

where the constants γ (or $\tilde{\gamma}$) $\in\Re_+$ is determined by the degree of financial constrainedness $\rho\geq 1$.

Proof. *See Appendix A.* ■

Proposition 1 shows that the tangibility of the firm's assets underlies an endogenous financing–investment mechanism that shapes the firm's investment process. Two effects — both born out of financing imperfections — are key to this mechanism: the *debt capacity* and the *default risk* effects. Before characterizing the credit multiplier, we discuss these effects separately.

Consider a firm with spare debt capacity in the polar case of $\theta = 0$ (debt-financed investment). In Eq. (11), a low value of ρ (i.e., $\rho \to 1$) captures a higher degree of constrainedness in that the firm can issue very little risky debt or, in the limit (when $\rho = 1$), only risk-free debt. From Eq. (9), note that R increases with τ, and hence even a severely constrained firm's debt capacity grows with asset tangibility. As shown in Eq. (12), the firm's capacity for issuing debt is a function of various firm and industry characteristics, such as growth and volatility of output prices, the stock of physical capital, and asset tangibility. Accordingly, we have $\partial R/\partial\tau > 0$ and $\partial\overline{b}/\partial\tau > 0$, which imply $\partial\overline{B}/\partial\tau > 0$. In words, more tangible capital strengthens the firm's ability to issue additional risk-free and, if permissible, risky debt (tangibility relaxes a "quantity constraint"). We call this the *debt capacity effect.*[13]

An additional effect emerges when the firm has a non-negligible ability to issue risky debt ($\rho > 1$); i.e., when one considers default risk. In our model, default is determined by creditors' recovery requirements, which take into account the firm's preexisting debt, capital stock, profitability, and asset tangibility. The parameter $\tilde{\gamma}$ in Eq. (14) maps creditors' requirements from stipulated recoveries into critical output prices for seizing the firm's assets. Higher (lower) values of $\tilde{\gamma}$ imply that the firm defaults at a higher (lower) output price level; that is, $\partial p^d/\partial\tilde{\gamma} > 0$. Notice that higher creditor requirements (higher values of $\tilde{\gamma}$) are akin to stricter financing constraints (lower values of ρ).[14] Else the same, the firm with a higher probability of getting into default has to make higher payments to its creditors (its risky debt is costlier). Anything that reduces $\tilde{\gamma}$, such as higher profitability or more capital stock, lowers the firm's output price default, and a lower likelihood of default gives the firm access to more, cheaper financing (a "price constraint" relaxation). Indeed, see from Eqs. (12) and (11) that $\partial\overline{B}/\partial\tilde{\gamma} < 0$. We call this the *default risk effect.* Clearly, the firm's assets are more valuable to creditors at any given output price level if they are more tangible, but note that the default risk effect does not depend only on τ — this effect is distinct from the above debt capacity effect.

For the general case of $\theta \in [0, 1)$, *both* the debt capacity and the default risk effects influence investment spending.[15] The interplay between these two effects can be best seen from Eq. (12), which implies $\partial\overline{B}/\partial\tilde{\gamma}\partial\tau > 0$. In words, a credit constrained firm with access to risky debt derives

[13]Much of the research on the credit multiplier is restricted to the analysis of pure *quantity constraints* (à la Hart and Moore (1994)). For example, Almeida and Campello (2007) use a static characterization of a quantity constraint-based credit multiplier to study the empirical sensitivity of investment to cash flows.

[14]For example, creditors may want to trigger liquidation at disproportionately higher output prices when they perceive the firm to be poorly governed (agency problems) or too opaque (asymmetric information).

[15]In the special case where the new investment is completely equity-financed (i.e., $\theta = 1$), only condition (13) determines investment. Under this scenario, only the default risk effect is observed. That effect arises, in particular, because of the firm's preexisting debt, which need not be risk-free unless $b_0 \to 0$.

more credit capacity from investing in more tangible assets.

The combination of the debt capacity and the default risk effects gives rise to the *firm-level credit multiplier* — an effect that differs from the credit multiplier discussed in the macroeconomics literature (e.g., Kiyotaki and Moore (1997)). Investment increases the firm's capital stock (K), and the more tangible the firm's capital (τ), the higher the associated recovery value (R), the lower the default risk (p^d, or $\tilde{\gamma}$), hence the more additional credit capacity ($\overline{B}$) is created. Consider a positive innovation to investment opportunities; in particular, rising product demand (higher P). The firm's demand for investment increases with output prices. As the firm invests, its capital base increases. If the firm's assets are intangible, an increase in the firm's asset base does not boost recovery values. More tangible assets, however, provide for higher recovery values. Higher recovery values reduce the cost of default, hence the default risk premium embedded in the firm's debt. The access to more, cheaper credit allows for further firm investment and so on — investment is amplified by a financing feedback that arises endogenously in the presence of credit frictions. This financing–investment mechanism propagates over time, but at a diminishing rate (dictated by τ). In essence, greater credit capacity triggers faster investment responses to innovations to investment opportunities (a lower p^i). Put differently, after a given period of time following a shock to investment opportunities, firms with more tangible assets will have invested invest more than firms with less tangible assets.

The effects just described becomes less accentuated as the firm becomes less financially constrained (i.e., when $\rho \to \overline{\rho}$). To see this, notice that an unconstrained firm has frictionless access to credit that supports investment at the breakeven price:

$$p_{be}^i = \left[\frac{\left[r - \beta\mu - \beta\left(\beta - 1\right)\sigma^2/2 \right] K_1 \ \lambda_1}{\Pi\left(w, x, y\right)\left[\left(K_0 + K_1\right)^{\alpha} - K_0^{\alpha}\right]} \right]^{1/\beta}. \tag{15}$$

From Eq. (15), note that the unconstrained firm's investment trigger price is *invariant* to asset tangibility (i.e., $\partial p_{be}^i / \partial\tau = 0$). Simply put, the tangibility-led credit multiplier disappears in the absence of financing constraints.

The central implication of the firm-level credit multiplier is that asset tangibility amplifies the impact of exogenous shocks to the firm's investment opportunity set onto the firm's financing and investment. This financing–investment interplay is dynamic in nature and creates an endogenous relationship between financing and investment decisions when the firm faces credit imperfections. Our analysis is in sharp contrast to those in which investment is exogenous to the firm's financial status and financing decisions.

2.3 Simulations

We use simulations to gauge the quantitative implications of Proposition 1. These simulations reinforce the intuition behind the endogenous financing–investment mechanism that was formally derived in the last section. We note that, in addition to the qualitative aspects of Proposition 1, the firm-level credit multiplier has subtle quantitative nuances that are unique and can only be uncovered numerically. For example, as shown below, when asset tangibility varies, the model's debt capacity and default risk effects display differential curvature and convergence behaviors for different degrees of financing constraints.

We consider a baseline environment in which the investment opportunity has a net present value of zero at the initial output price, which is thus the breakeven price at which the financially unconstrained firm invests. Accordingly, we use the following parameterization for a representative financially constrained firm: $\mu = 1\%$, $\sigma = 20\%$, $\rho = 1.25$, $\iota = 1.1$, $b_0 = 9.5$, $r = 8\%$, $w = 0.1$, $x = 0.75$, $y = 0.5$, $K_0 = 1$, $K_1 = 1$, and $P_0 = 1$.[16] For the investment opportunity to have a net present value of zero at the initial output price, $P_0 = 1$, we set $\lambda_1 = 375$. The calibration implies fairly realistic leverage ratios across time; for example, the leverage ratio is 24.7% at the initial output price (before investment). For illustration purposes, we use $\rho = 1.45$, $b_0 = 16.5$, and $\iota = 1.05$ to characterize a *less* constrained firm.

Figures 2A and 2B chart debt incremental capacity, $\bar{b} - b_0$, and default threshold, p^d, respectively, as a function of asset tangibility, τ, for different degrees of credit constraints, ρ. The solid (dashed) line represents a firm facing higher (lower) financing frictions, $\rho = 1.25$ ($\rho = 1.45$). Figure 2A shows that a more financially constrained firm has a lower incremental debt capacity. Said differently, that firm has access to a given amount of new debt only at a higher output price than an otherwise identical but less constrained firm. The figure also shows that debt capacity increases with asset tangibility (recall, $\partial\bar{b}/\partial\tau > 0$ from Proposition 1). These simulated results capture the aforementioned *debt capacity effect*. More interestingly, observe from Figure 2A that the wedge differential in incremental debt capacity of the two firms declines with asset tangibility (i.e., the difference in the slopes of the two schedules shrinks with τ). This shows that the impact of asset tangibility on debt capacity is stronger for the more constrained firm (recall, $\partial\bar{b}/\partial\tilde{\gamma}\partial\tau > 0$).

We set our calibration exercise so that investment entails a large increase in firm asset size. It is interesting to see what happens to firm leverage, since it changes with asset tangibility over time. When tangibility is low ($\tau = 0.2$), $\bar{b} - b_0$ equals initially 5.3 for the more constrained firm, recall b_0 was 9.5. In this case, the firm's leverage ratio declines at the point of investment (the asset expansion leads to lower leverage as low tangibility does not allow for a large increase in debt capacity). For an intermediate value of tangibility ($\tau = 0.5$), $\bar{b} - b_0$ equals 13.1 at the initial price point. That is, the firm's debt increases, matching the new size of the firm's asset base, leading to a higher leverage ratio.

[16] See Hackbarth et al. (2006) or Strebulaev (2007) for discussions of parameter choices for structural models.

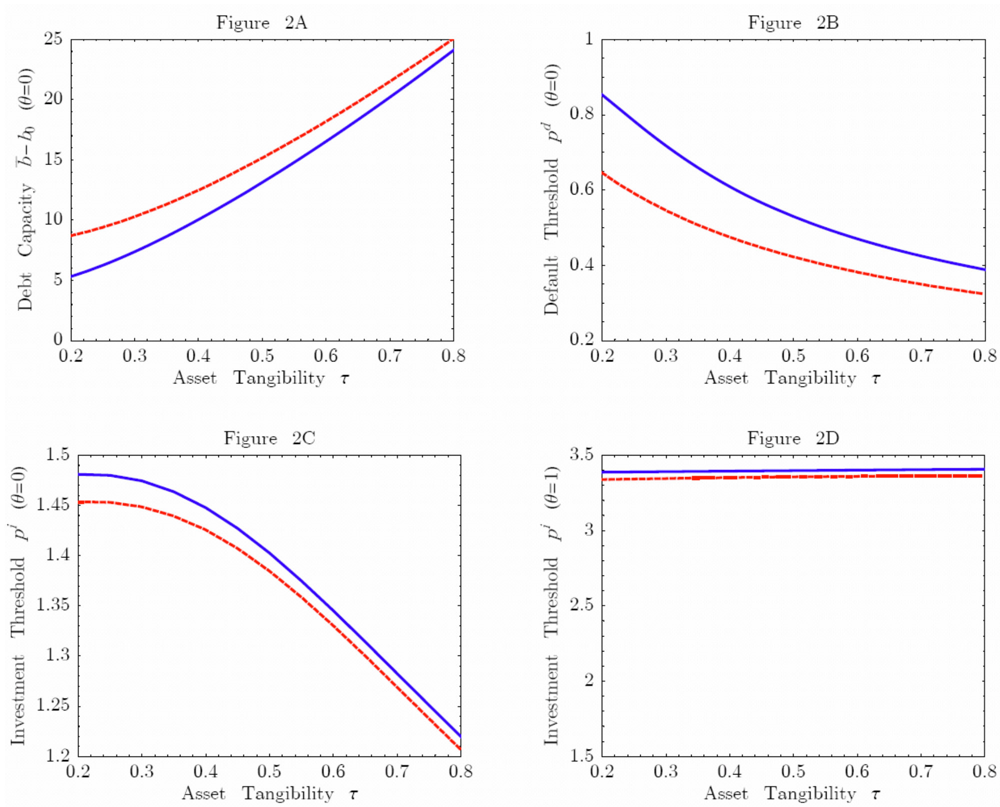

Figure 2. Asset Tangibility, Financing Constraints, and Investment

Figures 2A–2C plot debt capacity, $\bar{b}$, default threshold, p^d, and investment threshold, p^i, for debt-financed investment ($\theta = 0$), as a function of asset tangibility, τ, when the firm is more financially constrained (solid line) or less financially constrained (dotted line). Figure 2D charts investment threshold, p^i, for equity-financed investment ($\theta = 1$), as a function of asset tangibility, τ, when equity flotation costs are higher (solid line) or lower (dotted line). The parameter values are $\mu = 1\%$, $\sigma = 20\%$, $\rho \in \{1.25, 1.45\}$, $\iota \in \{1.1, 1.2\}$, $b_0 \in \{9.5, 16.5\}$, $r = 8\%$, $w = 0.1$, $x = 0.75$, $y = 0.5$, $K_0 = 1$, $K_1 = 1$, $P_0 = 1$, and $\lambda_1 = 375$; the investment opportunity has a net present value of zero at P_0.

Figure 2B captures the *default risk effect*. The more constrained firm has a higher output price default threshold (recall, $\partial p^d / \partial \tilde{\gamma} > 0$). In addition, default thresholds fall with the rise in asset tangibility. Notably, the wedge differential in default thresholds of the two schedules declines with asset tangibility. This again illustrates the interplay between financing constraints and asset tangibility: the more constrained firm gains more (i.e., observes a larger decline in p^d) from investing in more tangible assets.

To show how investment decisions (p^i) are influenced by tangibility (τ) under different financing schemes, we consider the two polar cases of fully debt-financed investment ($\theta = 0$) and fully equity-financed investment ($\theta = 1$) in Figures 2C and 2D, respectively. Intermediate scenarios are convex combinations of these two polar cases. Again, a solid (dashed) line is used to represent higher (lower) financing frictions.

From Figure 2C, notice that the investment threshold is lower for the firm that is less credit constrained — the greater availability of risky debt helps the firm to fund investment earlier. The two schedules decline with asset tangibility, but more so at higher levels of tangibility. In addition, the decline is more pronounced for the more constrained firm — as seen in the figure, the wedge differential in investment thresholds of the two schedules declines with asset tangibility. All of these dynamics follow from the interplay between the debt capacity and default risk effects (cf. Proposition 1).

To put our results into context, we compare them with existing models of contracting frictions and investment. The standard theme of credit constraints revolves around the idea of limited pledgeability of firm assets leading to quantity-type constraints (i.e., $\rho = 1$ in our model). In this class of models, where default risk effect and pricing constraints are absent, debt capacity — hence investment — is a linear function of asset tangibility. Simulating those models in the framework of Figure 2C (i.e., with a focus on investment) yields parallel, downward-sloping straight lines. The simulations of our model, in contrast, show that there are remarkable non-linear relations between asset tangibility, credit constraints, and investment. Our model suggests that the interplay between the standard debt capacity effect and the default risk effect can enrich our understanding of the endogenous link between firm financing and investment.

Finally, in contrast to full (or partial) debt financing, Figure 2D shows that the investment threshold under full equity financing is largely invariant to asset tangibility. In this limiting case, asset tangibility influences investment only via the default risk effect, which also vanishes as $b_0 \to 0$.

It remains as an empirical question whether the credit multiplier influences firms' observed investment and financing decisions along the lines of our model. Naturally, the strength of the credit multiplier phenomenon depends on numerous industry and firm characteristics, such as industry output prices, the redeployability of physical assets within the industry, the firm's degree of financial constrainedness, the firm's incremental debt capacity, the sources of external financing, etc. The tests that follow feature empirical counterparts to each of one these elements of our theory.

3 Data and Empirical Test Design

3.1 Data Description

Our sample selection approach follows that of Gilchrist and Himmelberg (1995), Almeida et al. (2004), and Almeida and Campello (2007). We consider the universe of U.S. manufacturing firms (SICs 2000–3999) over the 1971–2005 period with data available from COMPUSTAT on total assets, market capitalization, capital expenditures, and plant property and equipment (capital stock). We eliminate firm-years for which the value of capital stock is less than \$1 million, those displaying real asset or sales growth exceeding 100%, and those with negative Q or with Q in excess of 10 (we define Q shortly). The first selection rule eliminates very small firms from the sample, for which linear investment models are likely inadequate (see Gilchrist and Himmelberg (1995)). The second data cut-off eliminates those firm-years registering large jumps in their business fundamentals (size and sales); these are typically indicative of mergers, reorganizations, and other major corporate events. The third cut-off is introduced as a first, crude attempt to minimize the impact of problems in the measurement of investment opportunities, and to improve the fitness of our investment demand model. Among many others, Abel and Eberly (2001) and Cummins et al. (2006) use similar cut-offs and discuss the poor empirical fit of linear investment equations at high levels of Q. We deflate all series to 1971 dollars using the CPI.

Our basic sample consists of an unbalanced panel with 65,508 firm-year observations with 6,316 unique firms. Table 1 describes the computation and reports summary statistics for the variables used in our main tests. Since our sampling and variable construction methods follow that of the literature, it is not surprising that the numbers we report in Table 1 resemble those found in related studies (e.g., Almeida and Campello (2007)). In the interest of brevity, we omit a detailed discussion of the sample summary statistics.

Insert Table 1 About Here

3.2 Empirical Specification

The central result of our theory is that of a feedback effect between investment and financing in the presence of credit constraints: tangible assets ease financing, which amplifies the response of firm investment spending to shifts in firm investment opportunities. We develop two empirical models to test our credit multiplier ideas, one concerns investment, the other concerns financing decisions.

First, we specify a multiplicative-type model relating investment spending (I) to investment opportunities (Q) and asset tangibility (τ). In doing so, we closely follow the intuition behind Proposition 1 in that we emphasize the marginal contribution of asset tangibility to the credit multiplier effect. In particular, we consider:

$$i_t = \alpha_1 Q_{t-1} + \alpha_2 \tau_{t-1} + \alpha_3 \left(Q_{t-1} \times \tau_{t-1} \right), \tag{16}$$

where $i_t = I_t / K_{t-1}$ denotes capital-normalized investment over time t. Our credit multiplier theory predicts that the interaction term $Q \times \tau$ has a *positive* coefficient in an investment equation like (16) when the firm faces financing constraints; in short, the firm invests relatively more in response to positive investment opportunities when its assets allow for more credit capacity. No such effects should be observed in a cross section of financially unconstrained firms.

To operationalize our proposed test, we experiment with a parsimonious model of investment demand. We do so by augmenting the standard Q-theory investment equation with a proxy for asset tangibility and an interaction term that allows the role of Q to vary with asset tangibility. Define *Investment* as the ratio of capital expenditures (COMPUSTAT item #128) to beginning-of-period capital stock (lagged item #8). Q is our basic proxy for investment opportunities, computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 $\times$ item #25) $-$ item #60 $-$ item #74) / (item #6). We define *Tangibility* shortly (see Section 3.3). Our first empirical model can be written as follows:

$$\begin{aligned} Investment_{i,t} &= \alpha_1 Q_{i,t-1} + \alpha_2 Tangibility_{i,t-1} + \alpha_3 \left(Q \times Tangibility\right)_{i,t-1} \\ &\quad + \sum_i Firm_i + \sum_t Year_t + \varepsilon_{i,t}, \end{aligned} \tag{17}$$

where *Firm* and *Year* capture firm- and year-specific effects, respectively. All of our estimations correct the regression error structure for within-firm correlation (firm clustering) and heteroskedasticity using White-Huber's error-consistent estimator.

It is worth noting that a large literature includes a firm's cash flow in investment regressions such as Eq. (17). Our model does not generate explicit predictions for firm cash flows, but in the robustness checks that follow we also include cash flows in our model specifications. This allows for comparisons with previous studies and serves the purpose of checking whether our findings could be explained by income shocks (see Section 4.1.3).

Secondly, we study a model of external financing. Define $DebtIssuance$ as the change in the ratio of short- and long-term debt (item #9 + item #34) to lagged book value of assets (item #6). We regress this measure of debt taking on Q, *Tangibility*, and an interaction term that allows the role of Q to vary with *Tangibility*. Our second empirical model can be expressed as:

$$\begin{aligned} DebtIssuance_{i,t} &= \alpha_1 Q_{i,t-1} + \alpha_2 Tangibility_{i,t-1} + \alpha_3 \left(Q \times Tangibility\right)_{i,t-1} \\ &\quad + \sum_i Firm_i + \sum_t Year_t + \varepsilon_{i,t}. \end{aligned} \tag{18}$$

Following the standard literature, we allow the coefficient vector $\boldsymbol{\alpha}$ to vary with the degree to which the firm faces financing constraints by way of estimating our empirical models separately across samples of constrained and unconstrained firms. In contrast to much of the literature, we also estimate $\boldsymbol{\alpha}$ using a maximum likelihood methodology in which constrained and unconstrained firm assignments are determined jointly with the investment (or debt taking) process (see Section 3.4).

According to our theory, the extent to which investment opportunities matters for constrained investment (alternatively, debt taking) should be an increasing function of asset tangibility. While Eq. (17) (Eq. (18)) is a direct linear measure of the influence of tangibility on investment (debt) sensitivities, note that its interactive form makes the interpretation of the estimated coefficients less obvious. For instance, if one wants to assess the partial effect of Q on *Investment* ($DebtIssuance$), one has to read off the result from $\alpha_1 + \alpha_3 \times Tangibility$. Hence, in contrast to other papers in the literature, the estimate returned for α_1 alone says little about the impact of Q on investment demand (debt taking). That coefficient represents the impact of Q when *Tangibility* equals zero, a point that lies outside of the empirical distribution of our measures of asset tangibility. As we discuss below, the summary statistics of Table 1 will aid in the interpretation of the estimates returned by our interactive model.

3.3 Proxies for Asset Tangibility

We measure asset tangibility (*Tangibility*) in two alternative ways. First, we construct a firm-level measure of expected asset liquidation values that borrows from Berger et al. (1996). In determining whether investors rationally value their firms' abandonment option, Berger et al. gather data on the proceeds from discontinued operations reported by a sample of manufacturing firms over the 1984–1993 period. The authors find that a dollar of book value yields, on average, 72 cents in exit value for total receivables, 55 cents for inventory, and 54 cents for fixed assets. Following their study, we estimate liquidation values for the firm-years in our sample via the computation:

$$Tangibility = 0.715 \times Receivables + 0.547 \times Inventory + 0.535 \times Capital,$$

where *Receivables* is COMPUSTAT item #2, *Inventory* is item #3, and *Capital* is item #8. As in Berger et al., we add the value of cash holdings (item #1) to this measure and scale the result by total book assets. Although we believe that the nature of the firm production process largely determines the firm's asset allocation across fixed capital, inventories, etc., there could be some degree of endogeneity in this measure of tangibility. For example, one could argue that whether a firm is constrained might affect its investments in more tangible assets and thus its debt capacity. The argument for an endogeneity bias in our tests along these lines, nonetheless, becomes weak as we use an alternative measure of tangibility that is exogenous to the firm's policies.[17]

The second measure of tangibility that we use is an industry-level, time-variant proxy that gauges the ease with which lenders can liquidate a firm's productive capital. Following Kessides (1990) and Worthington (1995), we measure asset redeployability using the ratio of used to total (i.e., used plus new) fixed depreciable capital expenditures in an industry. The idea that the degree of activity in asset resale markets (i.e., demand for second-hand capital) affects financial contractibility is formalized in Shleifer and Vishny (1992). To construct the intended measure, starting from 1981, we hand-collect data for used and new capital acquisitions at the four-digit SIC level from the Bureau of Census' *Annual Survey of the Manufacturers*. Data on plant and equipment acquisitions are compiled by the Bureau every year, but the last survey identifying both used and new capital acquisitions was published in 1996. Besides the shorter time coverage, we note that estimations based on this measure of asset tangibility use smaller sample sizes because not all of COMPUSTAT's SIC codes are present in the Census data.

[17] To tackle this point even further, our switching regression estimations explicitly include asset tangibility as a determinant of the firm's financial constraint status.

3.4 Financially Constrained and Financially Unconstrained Groupings

Our tests require splitting firms according to measures of financing constraints. There are many plausible approaches to sorting firms into financially "constrained" and "unconstrained" categories. Since we do not have strong priors about which approach is best, we adopt multiple alternative schemes to categorize the firms in our sample. Admittedly, one limitation concerning existing constraint classifications schemes is that they do not help differentiate between what our theory characterizes as "quantity" and "price" constraints. Both of those effects are likely to be captured by the constraint categorizations described in this section. While we cannot resolve this empirical limitation directly, in tests conducted below we further refine our constraint classifications according to measures of "spare debt capacity" (i.e., we use a double-sorting approach).

Our basic approach follows the standard literature, using *ex-ante* financial constraint sortings that are based on firm observables, such as payout policy, firm size, and debt ratings. In particular, we adopt the sorting schemes discussed in Almeida et al. (2004) and Acharya et al. (2007):

- Scheme #1: In every year over the 1971–2005 period, we rank firms based on their payout ratio and assign to the financially constrained (unconstrained) category those firms in the bottom (top) three deciles of the payout distribution. We compute the payout ratio as the ratio of total distributions (dividends plus stock repurchases) to assets.[18] The intuition that financially constrained firms have lower payout follows from Fazzari et al. (1988), who argue that reluctance to distribute funds is caused by a wedge between the costs of internal and external financing.

- Scheme #2: We rank firms based on their total assets throughout the 1971–2005 period and assign to the financially constrained (unconstrained) category those firms in the bottom (top) three deciles of the asset size distribution. The rankings are again performed on an annual basis. This approach resembles Gilchrist and Himmelberg (1995) and Erickson and Whited (2000), who distinguish groups of financially constrained and unconstrained firms on the basis of size. The argument for size as a good measure of financing constraints is that small firms are typically young and less well known and thus more likely to face capital market frictions.

- Scheme #3: We retrieve data on firms' bond ratings and categorize those firms that never had their public debt rated during our sample period as financially constrained. Given that unconstrained firms may choose not to use debt financing (thus not receiving a debt rating), we only assign to the constrained subsample those firm-years that *both* lack a rating and report pos-

[18] Accordingly, firms that do not pay dividends but do substantial stock repurchases are not classified as constrained. Also note that the deciles are set according to the distribution of the payout ratios reported by the firms (rather than the count of reporting firms). This yields an unequal number of observations being assigned to each of the constraint groups as many firms have a zero payout policy.

itive debt (see Faulkender and Petersen (2006)).[19] Financially unconstrained firms are those whose bonds have been rated during the sample period. Related approaches for characterizing financing constraints are used by Gilchrist and Himmelberg (1995) and Cummins et al. (2006). The advantage of this measure of constraints over the former two is that it gauges the *market*'s assessment of a firm's credit quality. The same rationale applies to the next measure.

- Scheme #4: We retrieve data on firms' commercial paper ratings and categorize as financially constrained those firms that never display any ratings during our sample period. Observations from those firms are only assigned to the constrained subsample in years in which positive debt is reported. Firms that issued rated commercial paper at some point during the sample period are considered unconstrained. This approach follows from the work of Calomiris et al. (1995) on the characteristics of commercial paper issuers.

Table 2 reports the number of firm-years under each of the financial constraint categories used in our analysis. According to the payout scheme, for example, there are 27,658 financially constrained firm-years and 19,549 financially unconstrained firm-years. The table also shows the extent to which the four classification schemes are related. For example, out of the 27,658 firm-years classified as constrained according to the payout scheme, 12,857 are also constrained according to the size scheme, while a much smaller fraction, 3,689 firm-years, are classified as unconstrained. The remaining firm-years represent payout-constrained firms that are neither constrained nor unconstrained according to size. In general, there is a positive association among the four measures of financing constraints. For example, most small (large) firms lack (have) bond ratings. Also, most small (large) firms make low (high) payouts. However, the table also makes it clear that these cross-group correlations are far from perfect. This works against our tests finding consistent results across all classification schemes.

Insert Table 2 About Here

One potential drawback of the *ex-ante* sorting approach described above is that it does not allow the investment process to work as a determinant of the financial constraint status — the constraint categorization is exogenously given. In turn, we consider an alternative categorization approach that endogenizes the constraint status together with other variables in a structural model. The approach, borrowed from Hovakimian and Titman (2006), uses a switching regression framework with unknown sample separation to estimate investment regressions. One advantage of this estimator is that we can simultaneously use all of the above sorting information (i.e., dividend policy, size, bond ratings, and commercial paper ratings) together with asset tangibility to categorize firms. Almeida

[19] Firms with no bond ratings and no debt are not considered constrained, but our results are unaffected by how we treat these firms. The same approach is used for firms with no commercial paper ratings and no debt in Scheme #4.

and Campello (2007) provide a detailed description of the switching regression estimator (see also Hu and Schiantarelli (1998)). Here, we provide a brief summary of this methodology.

Assume that there are two different investment regimes, which we denote by "regime 1" and "regime 2." While the number of investment regimes is given, the points of structural change are not observable and are estimated together with the investment equations. The model is composed of the following system of equations (estimated simultaneously):

$$I_{1it} = \mathbf{X}_{it}\alpha_1 + \varepsilon_{1it} \tag{19}$$

$$I_{2it} = \mathbf{X}_{it}\alpha_2 + \varepsilon_{2it} \tag{20}$$

$$y^*_{it} = \mathbf{Z}_{it}\phi + u_{it}. \tag{21}$$

Eqs. (19) and (20) are the structural equations of the system; they are essentially two versions of our baseline investment model in Eq. (17). Let $\mathbf{X}_{it}$ be the vector of explanatory variables, and $\boldsymbol{\alpha}$ be the vector of coefficients that relates the variables in $\mathbf{X}$ to investment I_{1it} and I_{2it}. Differential investment behavior across firms in regime 1 and regime 2 is captured by differences between α_1 and α_2. Eq. (21) is the selection equation that establishes the firm's likelihood of being in regime 1 or regime 2. The vector $\mathbf{Z}_{it}$ contains the determinants of a firm's propensity of being in either regime. Observed investment is given by:

$$\begin{aligned} I_{it} &= I_{1it} \text{ if } y^*_{it} < 0 \\ I_{it} &= I_{2it} \text{ if } y^*_{it} \geq 0, \end{aligned} \tag{22}$$

where y^*_{it} is a latent variable that gauges the likelihood that the firm is in the first or in the second regime.

The parameters α_1, α_2, and ϕ are estimated via maximum likelihood. To estimate those parameters, we assume that the error terms ε_1, ε_2, and u are jointly normally distributed. Critically, the estimator's covariance matrix allows for nonzero correlation between shocks to investment and shocks to firms' characteristics — this makes the model we use an 'endogenous switching regression.'[20] As such, the extent to which investment spending differs across the two regimes and the likelihood that firms are assigned to either regime are *simultaneously* determined.

Finally, to identify the system we need to determine which regime is the constrained one and which regime is the unconstrained one. The algorithm in Eqs. (19)–(22) creates two groups of firms that differ according to their investment behavior, but it does not tell the econometrician which firms are constrained. To achieve identification, we need to use priors about which firm

[20] To be precise, the covariance matrix has the form $\Omega = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{1u} \\ \sigma_{21} & \sigma_{22} & \sigma_{2u} \\ \sigma_{u1} & \sigma_{u2} & 1 \end{bmatrix}$, where $\text{var}(u)$ is normalized to 1.

characteristics that are likely to be associated with financing constraints. We do so using the same characteristics employed in the *ex-ante* sortings (payout, size, and ratings). We also include *Tangibility*, since as described by our model, asset tangibility can ameliorate financing constraints.

4 Empirical Results

Following the model's main predictions, we first examine corporate investment and then turn to cross-sectional patterns in debt financing (debt capacity and debt issuance).

4.1 Tests on Investment Spending

For the cross-sectional analysis of corporate investment, we estimate a base regression and an interactive regression. In addition, we perform numerous robustness tests to rule out alternative explanations of our main findings.

4.1.1 The Base Regression Model

We build intuition for our study's empirical tests by way of estimating a simpler version of Eq. (17). In this version, corporate investment is modeled as a linear function of only Q and *Tangibility*. We would expect both of these variables to retain some explanatory power over the cross-sectional variation of investment. In particular, absent empirical biases, investment spending should respond to proxies for investment opportunities across all sets of firms (both financially constrained and unconstrained firms). As for asset tangibility, we would expect it to be a strong determinant of investment across financially constrained firms, carrying less importance (if any) in the cross section of financially unconstrained firms.

Table 3 reports estimation results for the base regression model using financial constraint partitions that are based on our four *ex-ante* characterizations. Panel A collects the results returned when we use our firm-level measure of asset tangibility (based on Berger et al. (1996)). Panel B has the same layout, but uses the industry-level measure of asset tangibility (based on the Bureau of Census data). For each of the eight constrained/unconstrained comparison pairs in Table 3 (both panels), we observe that *Investment* responds very significantly to Q across all estimations and partitions. Interestingly, Q is particularly strong across financially constrained firms. This is noteworthy because much of the debate about empirical biases in investment regressions in the last decade (see, e.g., Erickson and Whited (2000)) revolved around an attenuation bias that appeared to affect constrained firms' Q in a pronounced fashion. Like other recent studies (e.g., Baker et al. (2003) and Campello and Graham (2007)), however, we find no evidence that attenuation bias in Q disproportionately affects financially constrained firms' investment regressions.

<u>Insert Table 3 About Here</u>

Also noteworthy is the response of *Investment* to *Tangibility*. Consistent with the basic logic of our theory, asset tangibility is systematically, positively associated with investment spending when firms are financially constrained. And our estimates suggest that this relation is economically strong. For example, the estimate associated with the first partition we report in Table 3 (see row 1 in Panel A) implies that a one standard deviation increase in *Tangibility* leads to an increase of 6.7% ($= 0.5605 \times 0.1196$) in *Investment*, an increase that is equivalent to 25.6% ($= 0.0670/0.2617$) of the average investment rate of our sample. These pronounced effects are not observed across financially unconstrained firms. For those firms, the coefficients returned for *Tangibility* are either significantly lower than those returned for constrained firms (Panel A) or statistically insignificant (Panel B).

Table 4 reports estimations that are similar in nature to those in Table 3; however, they employ a switching regression approach with endogenous (as opposed to exogenous) sample separation; as discussed in Section 3.4. We observe the same patterns discussed just above. Notably, this happens regardless of the proxy used for asset tangibility (see Panels A and B).

Insert Table 4 About Here

4.1.2 The Multiplier Effect (Interactive Model)

Our model's central insight is related to the amplifying effect of asset tangibility on the response of investment spending to investment opportunities in the presence of financing constraints — the credit multiplier. As previously discussed, a direct way to gauge the multiplier effect in the data is to interact Q with *Tangibility*. We now perform several tests of the main prediction of our model, estimating Eq. (17) across various subsamples.

Our main empirical findings are reported in Table 5, which has the same layout of Table 3. The results presented are remarkably strong: for every single comparison pair, the interaction term of Q and *Tangibility* is highly significant and positive for constrained firms, while either negative or indistinguishable from zero for unconstrained firms. Indeed, one can generally reject with high statistical confidence (lower than 1% test-level) the hypothesis that the coefficients of interest are similar across the two constraint types. Noteworthy, the table reveals not only the existence of an important interactive (multiplier) effect of *Tangibility* across financially constrained firms, but also that much of the unconditional impact of Q on *Investment* for constrained firms (as reported in Table 3) is transmitted via *Tangibility*. Simply put, the direct effect of Q on *Investment* across constrained firms, though still positive, dwarfs in comparison with the effect that comes via its interaction with *Tangibility*.

The findings in Panels A and B of Table 5 are remarkably consistent with the credit multiplier. Essentially, they show that, in the presence of financing frictions, investment spending responds more strongly to the arrival of new investment opportunities when a firm's assets provide more valuable collateral. To illustrate the economic importance of the estimates in the table, consider again the one reported in the first row of Panel A in the table. While Q alone (i.e., uninteracted) has only a small effect on investment, a one standard deviation change in Q (= 0.5196), measured at the average level of *Tangibility* (= 0.5583), leads to a 6.0% (= 0.0148 + 0.0456) increase in *Investment* (approximately 23.1% of the average sample rate of investment).

<u>Insert Table 5 About Here</u>

Similar to what we did for the set of tests featuring the base regression model, we also perform tests for the interactive model in which firm assignments to constrained/unconstrained partitions are selected endogenously with the investment process. The results for these switching regressions are reported in Table 6. The estimates in that table are consistent with those presented in Table 5. They, too, suggest the functioning of a multiplier effect in which *Tangibility* amplifies the impact of Q on *Investment* when firms are constrained, but not when they are unconstrained.

4.1.3 Robustness of the Multiplier Effect

This section collects a battery of tests designed to verify the robustness of our central findings. Notice that the tables above already showcase the robustness of our results in that tests are performed under various alternative proxies for the main empirical wrinkles of the model (financing constraints and asset tangibility) as well as under alternative empirical methodologies (least square regressions and maximum likelihood estimations). Among other things, in this section we experiment with additional estimation procedures, consider the issue of mismeasurement in Q, include firm cash flows in our specifications, and examine our model's notion that changes in investment opportunities that originate from industry price shocks are magnified by asset tangibility. To save space, we only report estimation results associated with the firm-level proxy for asset tangibility.[21]

GMM Estimations OLS estimations of investment models are known to suffer from a number of potential biases. As such, one could wonder about the robustness of our main results relative to estimation approaches that ameliorate issues such as endogeneity and heteroskedasticity.

In Table 7, we re-estimate the models of Table 5 (our main results) via GMM. We use up to three lags of the variables included in Eq. (17) in our set of instruments (see Cummins et al. (2006)). While those included variables are in *level* form, our instruments are in *differenced* form. The GMM estimations return coefficients that are both economically and statistically more significant than those from the OLS model, yet the inferences that we obtain are similar. Once again, *Tangibility* significantly strengthens the effect of Q on *Investment* for financially constrained firms, but not for unconstrained firms.

<u>Insert Table 7 About Here</u>

[21] Results from tests using the industry-level measure of tangibility are available from the authors.

In the last two columns of Table 7, we report the diagnostic test statistics associated with our instrumental set. Those instruments seem to be well-suited for the equations we fit to the data. For instance, note that the *lowest* p-value associated with Hansen's (1982) test of overidentifying restrictions is as high as 20%. Moreover, the partial F-statistics from the (first-stage) regression of the endogenous regressors on the set of excluded instruments is highly significant in each of the models estimated.[22] In short, these diagnostic statistics suggest that our instruments are valid and relevant.

Mismeasurement in the Proxy for Investment Opportunities Prior work on investment estimations has cited concerns with the possibility that the standard proxy for investment opportunities, Q, could suffer from pronounced mismeasurement (e.g., Cummins et al. (2006) and Erickson and Whited (2000)). One problem with mismeasurement is that it introduces a downward bias in the variable affected by it. In our application, the possibility that Q is severely mismeasured would lead the OLS estimator to over-reject the hypothesis that Q is different from zero. As we have shown in our base tests, however, Q is statistically significant in *all* of the regressions in which it is not further interacted with *Tangibility*. When we interact Q with *Tangibility*, Q still remains the main driver of investment, only now via the interaction term.

It is not obvious to show how an attenuation bias in Q could systematically explain our findings. For instance, the impact of that bias on other estimates would depend on the degree of covariance between Q and *Tangibility*. As it turns out, we find that such covariance is insignificant for both of our measures of tangibility. Nevertheless, we note that the existing literature proposes remedies for mismeasurement in Q that are easy to implement. Bond and Cummins (2000, 2001) and Cummins et al. (2006), for example, contend that Q is likely to capture the firm's investment opportunities with error because equity market values (in the numerator of Q) often deviate from firm fundamentals, thereby misrepresenting the firm's marginal product of investment. Those papers propose, instead, a proxy for Q (called *RealQ*) that is derived from earnings projections made by financial analysts. The empirical implementation of *RealQ* mimics exactly that of standard Q, except that one proxies for the unobserved future marginal products of capital with an approximation for the future average products based on long-term earnings forecasts from IBES.[23] Studies using *RealQ* show that it systematically outperforms standard Q in empirical investment regressions. A limitation of this approach, however, is that only a relatively small subset of firms in COMPUSTAT has long-term earnings forecasts reported in IBES. Additionally, note that IBES only consistently reports earnings forecasts starting in 1989. These data considerations significantly reduce the sample used in our *RealQ* tests.

[22] The *lowest* Shea's (1997) R^2 is 15%.

[23] Relevant details and program codes needed to compute *RealQ* can be found in the following website: http://www.aeaweb.org/articles/issue_detail.php?journal=AER&volume=96&issue=3&issue_date=June%202006.

In Table 8, we re-estimate the models of Table 5 (Panel A) replacing Q with *RealQ*. We again find strong support for our theory's main prediction: *Tangibility* reliably amplifies the impact of Q (i.e., *RealQ*) on *Investment* for financially constrained firms, but not for unconstrained firms.

Insert Table 8 About Here

Another potential concern with mismeasurement in Q is whether this could bias upward the $Q \times Tangibility$ interaction term. Noting that the literature is silent on the effect of mismeasured variables in interaction terms, we address this problem by performing a series of Monte Carlo experiments. In Appendix B, we show that coefficient estimates of an interaction term that contains one (or even two) mismeasured variables are also biased towards zero. In other words, a measurement problem in Q would make it *harder* for our tests to find the effect of the credit multiplier via the $Q \times Tangibility$ interaction term.

Including Cash Flows in the Benchmark Model The original Q theory of investment does not prescribe a role for cash flows as a driver of investment. Since the work of Fazzari et al. (1988), however, it has become common practice to include cash flows in empirical investment equations as a way to gauge the impact of financing constraints on investment decisions. Noteworthy, Fazzari et al.'s proposed interpretation of investment–cash flow sensitivities has been criticized on theoretical grounds (e.g., Kaplan and Zingales (1997)) as well as on grounds that empirical biases may plague estimates of that sensitivity (Gomes (2001) and Cummins et al. (2006)). In addition to these limitations, we note that our theory does not have explicit predictions for the role of cash flows. As result, we chose to omit cash flows from our benchmark regression model. Nevertheless, it might be worth it experimenting with the inclusion of firm cash flows in our estimations. Doing so will allow for comparisons with previous studies and also serve the purpose of checking whether our findings could be explained by stories based on the response of investment to income shocks.[24]

In Table 9, we estimate models similar to those of Table 5 (Panel A), but now including lagged $CashFlow$ (COMPUSTAT item #18 plus item #14, scaled by lagged item #8) as an additional control. Consistent with prior studies, our estimations suggest that constrained firms' investment is positively affected by cash flows; however, their investment–cash flow sensitivities are only marginally statistically significant (at the 10 to 5% test level). The salient feature of this new round of estimations is that our inferences about the credit multiplier effect remain unchanged. In particular, the new estimates for the $Q \times Tangibility$ term closely resemble those of our benchmark regressions, but with a slight loss in statistical significance. For completeness, we experiment with alternative

[24] Following Almeida and Campello (2007), we also add an interaction term between cash flows and tangibility; however, our results remain unaffected by the inclusion of that additional control (tables available upon request).

definitions and lagging structures for *CashFlow*.[25] But these, too, lead to similar conclusions.

<u>Insert Table 9 About Here</u>

Proxying for Investment Opportunities with Shocks to Industry Prices The literal interpretation of our model suggests that exogenous shocks to industry prices have an impact on investment demand that is magnified by the tangibility of the firm's asset. It is thus feasible to tie the empirics closer to the model by checking whether changes in industry prices that are reflected in the firm's Q — and not just Q in general — also lead to the investment responses that we have reported above. To do so, we isolate the component of firm-level Q that is associated with industry prices in a straightforward manner. In particular, we regress Q on changes in product price indices (PPI) for manufacturing industries and focus on the effect of that projected value (denoted *ProjQ*) on investment spending. The PPI series are collected at the four-digit SIC level from the Bureau of Labor Statistics. These series are reported on a monthly basis and we compute the annual average index for each industry before differencing those series. A limitation of this test is that while for most industries in our sample PPIs were computed by the Bureau starting from the early 1970's, for some (about one-third) that calculation only started in the mid-1980's. Moreover, the Bureau discontinued the computation of PPIs for SIC-defined industries in 2003.

In Table 10, we re-estimate the models of Table 5 (Panel A) replacing Q with the projection of Q on changes in product market prices (*ProjQ*). The increase in the significance of our proposed proxy for investment opportunities, *ProjQ*, relative to that of the standard approach, Q, is quite noticeable. More importantly, this table again confirms the multiplier effect of *Tangibility* in magnifying the influence of Q (i.e., *ProjQ*) on *Investment* for financially constrained firms. At the same time, the investment spending of unconstrained firms is unaffected by the interplay of *Tangibility* and *ProjQ*.

<u>Insert Table 10 About Here</u>

Investment Rates and Investment Timing A strict reading of our modeling could cast doubt on the use of standard investment equations as a way to test our theory. In particular, note that we model the impact of financing frictions on the firm's investment process via the "timing" of investment — how credit considerations may delay or accelerate investment. The multiplier effect is such that asset tangibility enables the constrained firm to respond more promptly to positive innovations to its investment opportunities, with a cumulative effect that works towards amplifying its investment spending over time. Empirically, we do not exactly observe the timing of investment. Instead, we work with discrete data and can only observe investment rates within a pre-specified time window

[25] For example, *CashFlow* obtains a more positive significant coefficient when, following Baker et al. (2003), we do not lag it and scale it by total assets (as opposed to capital stock).

(in our case, yearly spans). In this way, our empirical tests are predicated on the notion that if two constrained firms receive a similar investment demand shock in one period, the investment spending of the firm with more tangible assets will respond more quickly and pronouncedly — due to the multiplier effect — and that more of this effect will be reflected (or capitalized) in its financial statements by the end of the following period. Our empirical results are consistent with this testing hypothesis.

Despite the plausibility of the argument that ties our tests to the literature on the *cross-sectional* relation of investment and Q, we can better characterize our multiplier results by looking at *within-firm* evidence of investment growth rates (or "accelerated investment"). We can do this by modifying the left-hand side variable of our benchmark model (Eq. (17)). Rather than looking at the (*level*) ratio of capital expenditures to capital stock as the dependent variable, we can look at the firm's *change* in capital spending rate to gauge whether Q and *Tangibility* lead to an increase (or "acceleration") in a firm's rate of investment from one year to the next. We measure this rate of accelerated investment as the log difference in capital expenditures (*Capex*, or COMPUSTAT item #128) over years $t-1$ and t, scaled by expenditures at $t-1$. That is, we replace $Investment_{i,t}$ in Eq. (17) with $Log(Capex_{i,t}/Capex_{i,t-1})$.

In Table 11, we re-estimate the models of Table 5 (Panel A) using $Log(Capex_{i,t}/Capex_{i,t-1})$ as the dependent variable. The estimates from this table suggest that *Tangibility* amplifies the impact of Q on the pace of investment spending of financially constrained firms. In contrast, the pace of investment of unconstrained firms seems largely unaffected by the interplay between *Tangibility* and Q (if anything *Tangibility* dampens the effect of Q on investment growth rates).

INSERT TABLE 11 ABOUT HERE

4.2 Tests on Debt Capacity and Debt Taking

Our theory on the multiplier effect of asset tangibility on investment is predicated on the notion that tangibility enhances external financing capacity; in particular, that it helps support additional debt financing. While the results thus far are consistent with this hypothesis, we have not examined the empirical relation between debt financing and investment that underlies the credit multiplier in the model. We do so in this section. Specifically, expanding our testing approach, we perform a number of experiments considering the role incremental ("spare") debt capacity and debt taking decisions.

4.2.1 Debt Capacity

Our results suggest that asset tangibility helps constrained firms obtain more credit following positive innovations to investment opportunities. As a result, they invest more in response to those innovations. Until now, the tests concerning this idea were performed without explicitly accounting for the firm's finances. In other words, we did not consider whether the firm's *ex-ante* indebtness

— recall b_0 from our model — would allow it to take advantage of the enhanced debt capacity provided by new investment in tangible assets. For instance, if a firm is already highly indebted prior to the positive shock to investment, then it should be less able to invest as a function of asset tangibility; that is, according to the model, the credit multiplier would be weaker or even fail. In contrast, the credit multiplier is likely to be more pronounced when innovations affect firms with more spare debt capacity.

It is difficult to gauge a firm's *ex-ante* debt capacity. However, our model provides for a viable, albeit potentially incomplete, characterization of incremental debt capacity. Recall, we argue that the ability to obtain credit is a increasing function of a firm's asset tangibility. Accordingly, the correlation between the firm's leverage and the degree of its asset tangibility could provide information about the firm's spare debt capacity: if a firm carries less (more) leverage on its balance sheet than other firms with similar asset tangibility, then that firm is likely to have higher (lower) incremental debt capacity.[26]

This insight helps us construct an empirical proxy for spare debt capacity. That proxy is based on the component of a firm's long-term debt that is *not* explained by the firm's asset tangibility. This component can be directly gauged from the residuals of a regression of *Leverage* (or, item #9 ÷ item #6) on *Tangibility.* While the magnitude of those regression residuals may be of little economic interest, those residuals are useful in assessing spare debt capacity in that they can be employed to rank firms into categories. We proceed in this way, ranking firm-years into a "high" ("low") debt capacity category if the leverage regression residuals associated with those firm-years fall into the bottom (top) three deciles of the distribution of the residuals. To check that the results we obtain from this experiment are economically sensible, we also rank firms into low and high debt capacity according to their lagged, raw leverage ratios.[27] Both of these rankings are performed on an annual basis.

Table 12 shows what happens when we condition our interactive models on firms' spare debt capacity. Panel A presents results for the debt capacity sorting scheme that is based on leverage residuals. Panel B is similarly structured, but high and low debt capacity categories are based on rankings of raw leverage ratios. Only financially constrained firms are used to perform the tests in Table 12, since only those firms' investment is affected by the credit multiplier. The results presented in Panels A and B of Table 12 are remarkably strong and internally consistent. They show that, among constrained firms, the credit multiplier reported in previous tables (e.g., Table 5) is strongest across firms with high debt capacity, and nonexistent across firms with low debt capacity. Notably, this is exactly what one should expect given the dynamics of the credit multiplier our

[26] In the capital structure literature, Campello (2006) uses a related approach.

[27] Clearly, one must recognize that a firm can display a "relatively high" leverage ratio and still have the ability to take on more additional debt. Because of this ambiguity, one should be careful in interpreting the second debt capacity ranking scheme. Yet, at a minimum, the raw leverage ranking is likely to contain some useful information for observations on the extremes of the leverage distribution in our sample.

theory has characterized.

Insert Table 12 About Here

4.2.2 Debt Taking

We argue that asset tangibility magnifies the impact of investment opportunities on observed investment spending through a financing channel. This happens because of a feedback effect between investment and financing in the presence of financing constraints — our theory predicts that the two processes should move in tandem. We empirically test this logic by turning to firms' debt taking behavior. We do so in a regression framework in which debt taking ($DebtIssuance$) is on the left-hand side, while on the right-hand side we include the set of drivers we used for tests on investment. This empirical specification is represented by Eq. (18) above.

Table 13 reveals several interesting aspects of our debt taking tests. First, as reported by many existing studies, leverage increases are negatively associated with Q and positively associated with *Tangibility*. Second, the estimates for tangibility interacted with Q substantiate the dynamics of our credit multiplier: when firms are constrained, they take on more debt in response to increases in investment opportunities when their assets are more tangible. This interactive model for debt taking provides further evidence on our model's insight that *Tangibility* and Q jointly influence investment via a financing channel for financially constrained firms, but not for unconstrained firms.

Before concluding, it is worth noting that the results in Table 13 suggest that firms with very high asset tangibility (above the 75^{th} percentile of the distribution of *Tangibility*) observe no direct relation between Q and $DebtIssuance$ — i.e., the Q-interaction term dominates the Q-intercept term. Notably, this is similar to the relation between Q and $DebtIssuance$ across financially unconstrained firms. At lower levels of *Tangibility*, in contrast, increases in Q are met with sharp declines in debt. These findings are at the very heart of the impact of financing constraints on corporate policies. Our estimates imply that contracting imperfections can lead to a negative association between investment opportunities and external financing, but that this adverse effect can be attenuated by variables that enhance the contracting environment, such as asset tangibility. This firm-level effect is similar to the arguments made by Bernanke et al. (1996, 2000) in their pioneering work on the credit multiplier in the aggregate economy. These authors argue that the impact of financing imperfections stemming from agency problems and asymmetric information issues are minimized when firms have enough collateral. In that case, firms borrow from the capital markets whenever they are hit by positive innovations in investment opportunities. As collateral values drop, however, financing frictions become more relevant. Firms with good prospects (higher Q) then shy away from borrowing funds in the credit markets.

Insert Table 13 About Here

5 Concluding Remarks

We characterize the effect of asset tangibility on investment spending when financing and investment are simultaneously determined. Allowing for capital markets imperfections in a real options framework, we study firms that sell output in an industry with stochastic demand and want to expand their capital stock. For financially constrained firms, acquiring assets that can be used as collateral alleviates default risk and enlarges debt capacity, which further boots investment. Our theory predicts that financially constrained firms with more tangible assets invest more and borrow more in response to positive shocks to investment opportunities, with an endogenous financing–investment feedback effect that propagates itself ("credit multiplier").

Our model's central insights guide us in conducting empirical tests — based on the roles of asset tangibility and capital market frictions — to shed new light on the relation between investment spending and Q. More specifically, while both Q and tangibility are expected to explain the firm's investment, the model's credit multiplier predicts that the *interaction* of these two variables should have an even stronger positive impact on investment in the cross section of financially constrained firms. Based on a large sample of manufacturing firms over the 1971–2005 period, a variety of tests strongly support our model's main predictions. Consistent with our identification strategy, we show also that the credit multiplier is absent from samples of financially unconstrained firms and financially constrained firms with low incremental debt capacity. Finally, estimation results on debt issuance as a function of Q, tangibility, and Q interacted with tangibility lend further support to our dynamic credit multiplier effect. In particular, when firms are financially constrained, they take on more debt in response to increases in investment opportunities when their assets are more tangible.

The set of results generated by this study suggests that further extension of this research agenda may prove fruitful. More generally, our findings indicate that contracting imperfections may have important, yet understudied implications for corporate financial decisions. In future research, it would be interesting to examine whether the availability of collateral can, for example, explain differences in the evolution of financial leverage ratios over time, and across firms. Likewise, it would be interesting to examine whether collateral alleviates external contracting problems in ways that affect various financial policies of the firm (such as cash management and dividend distributions).

Appendix A

In this appendix, we derive the necessary steps to prove Proposition 1. We focus on the results for the general model with $\theta \in (0,1)$, since the results for the polar cases of fully debt-financed and equity-financed investment are subsumed as special cases of the general model's solution. Given (1), the value $F(P_t, t)$ of an arbitrary claim paying $\phi\, P_t^{\beta} \;+\; \kappa$ satisfies the equilibrium condition:

$$r\, F(P_t, t) \;\;=\;\; \phi\, P_t^{\beta} \;+\; \kappa \;+\; \frac{1}{dt}\, \mathbb{E}^{P_t}\big[F(P_{t+dt}, t)\big]\;. \tag{A.1}$$

The expression on the left-hand side of (A.1) is the equilibrium return an investor requires. The first two terms on the right-hand side of (A.1) are the flow benefits in period t, while the third term is the expected capital gain from period t to $t + dt$. Applying Itô's Lemma to (A.1) yields a partial differential equation:

$$r\, F(P_t, t) \;\;=\;\; \phi\, P_t^{\beta} \;+\; \kappa \;+\; \frac{\partial F(P_t,t)}{\partial t} \;+\; \frac{1}{2}\,\sigma^2(P_t,t)\, P_t^2\, \frac{F(P_t,t)}{\partial P_t^2} \;+\; \mu(P_t,t)\, P_t\, \frac{\partial F(P_t,t)}{\partial P_t}\;, \tag{A.2}$$

which under the assumption of $\mu\,(P_t, t) = \mu P_t$ and $\sigma\,(P_t, t) = \sigma P_t$ has the general solution:

$$F(P_t) \;\;=\;\; A_1\, P_t{}^{\nu} \;+\; A_2\, P_t^{\vartheta} \;+\; \frac{\phi\, P_t^{\beta}}{r - \beta\mu - \beta\,(\beta-1)\,\sigma^2/2} \;+\; \frac{\kappa}{r}\;, \tag{A.3}$$

where $\nu < 0$ and $\vartheta > 1$ denote the characteristic roots of the quadratic equation $r \;=\; 0.5\,\sigma^2\,(x - 1)\,x \;+\; \mu\, x$. We assume that β, μ, σ, and r satisfy $\beta\mu + \beta\,(\beta-1)\,\sigma^2/2 \;<\; r$, and use suitable boundary conditions to pin down the unknown constants A_1 and A_2.

When we evaluate (9), both constants in (A.3) are equal to zero, which together with $\phi = 1$ and $\kappa = 0$, yield the unlevered firm value in (10). The solution to (8) for debt value before investment is:

$$\begin{aligned} B\,(K_0, P_t, b_0) \;\;=\;\; & \frac{b_0}{r}\left[1 - \mathcal{L}\,(P_t) - \mathcal{H}\,(P_t)\left(\frac{p^i}{\tilde{p}^d}\right)^{\nu}\right] + R\left(K_0, p^d, \tau\right)\mathcal{L}\,(P_t) \\ & + \left\{\frac{b_1}{r}\left[1 - \left(\frac{p^i}{\tilde{p}^d}\right)^{\nu}\right] + R\left(K_0 + K_1, \tilde{p}^d, \tau\right)\left(\frac{p^i}{\tilde{p}^d}\right)^{\nu} - (1-\theta)\,\lambda_1 K_1\right\}\mathcal{H}\,(P_t)\,, \end{aligned} \tag{A.4}$$

which follows from $\phi = 0$ and $\kappa = b_0$ in (A.3) as well as the value-matching conditions

$$B\left(K_0, p^d, b_0\right) = R\left(K_0, p^d, \tau\right), \tag{A.5}$$

and

$$B\left(K_0, p^i, b_0\right) = B\left(K_0 + K_1, p^i, b_t\right) - (1-\theta)\,\lambda_1 K_1, \tag{A.6}$$

where debt value after investment follows from similar arguments:

$$B\,(K_0 + K_1, P_t, b_t) = \frac{b_t}{r}\left[1 - \left(\frac{P_t}{\tilde{p}^d}\right)^{\nu}\right] + R\left(K_0 + K_1, \tilde{p}^d, \tau\right)\left(\frac{P_t}{\tilde{p}^d}\right)^{\nu}, \tag{A.7}$$

and where $b_t = b_0$ if no additional debt is issued and $b_t = b_0 + b_1$ if additional debt with perpetual payments b_1 is issued. In the expression for $B(K_0, P_t, b_0)$, the stochastic discount factors $\mathcal{L}(P_t)$ and $\mathcal{H}(P_t)$ for reaching the lower threshold (p^d) or the higher threshold (p^i) from the current output price $P_t \in (p^d, p^i)$ are defined by

$$\mathcal{L}(P_t) = \frac{(p^i)^\vartheta P_t^\nu - (p^i)^\nu P_t^\vartheta}{(p^i)^\vartheta (p^d)^\nu - (p^i)^\nu (p^d)^\vartheta} \tag{A.8}$$

and

$$\mathcal{H}(P_t) = \frac{P_t^\vartheta (p^d)^\nu - P_t^\nu (p^d)^\vartheta}{(p^i)^\vartheta (p^d)^\nu - (p^i)^\nu (p^d)^\vartheta}. \tag{A.9}$$

The solution to (7) for equity value before investment is:

$$\begin{aligned} S(K_0, P_t, b_0) \;\; = \;\; & \left[V(K_0, P_0) - \frac{b_0}{r}\right] - \left[V\left(K_0, p^d\right) - \frac{b_0}{r}\right] \mathcal{L}(P_t) + \left\{V\left(K_0 + K_1, p^i\right) - \frac{b_1}{r}\right. \\ & \left. - V\left(K_0, p^i\right) - \left[V\left(K_0 + K_1, \tilde{p}^d\right) - \frac{b_t}{r}\right] \left(\frac{p^i}{\tilde{p}^d}\right)^\nu - \theta(1-\iota)\lambda_1 K_1\right\} \mathcal{H}(P_t), \end{aligned}$$

which follows from $\phi = 1$ and $\kappa = -b_0$ in (A.3) as well as the value-matching conditions:

$$S\left(K_0, p^d, b_0\right) = 0, \tag{A.10}$$

and

$$S\left(K_0, p^i, b_0\right) = S\left(K_0 + K_1, p^i, b_0 + b_1\right) - \theta(1-\iota)\lambda_1 K_1, \tag{A.11}$$

where equity value after investment follows from similar arguments:

$$S(K_0 + K_1, P_t, b_t) = \left[V(K_0 + K_1, P_t) - \frac{b_t}{r}\right] - \left[V\left(K_0 + K_1, \tilde{p}^d\right) - \frac{b_t}{r}\right] \left(\frac{P_t}{\tilde{p}^d}\right)^\nu. \tag{A.12}$$

To derive the firm's debt capacity $\overline{b}(K_t, P_t)$ in (12), first notice that at the first instant after investment has been undertaken debt value turns into (A.7). For a sufficiently large value of ρ, the quantity constraint in (3) does not bind and hence the debt capacity that solves (4) is determined by maximizing the expression in (A.7) with respect to b_t and simplifying.

Finally, based on standard smooth-pasting arguments (see, e.g., Dumas (1991)), the optimality condition in (13) is equivalent to the first-order condition:

$$\frac{\partial S(K_0, P_t, b_t)}{\partial p^i} = \frac{\partial S(K_0 + K_1, P_t, b_t)}{\partial p^i}, \tag{A.13}$$

where equity value after investment on the right-hand side of (A.13) is given in (A.12).

Appendix B

In this appendix, we examine the effect of mismeasurement on coefficient estimates returned for Q interacted with $Tangibility$. In particular, we study the role of measurement error in one and two independent variables employing Monte Carlo experiments.

In a first set of experiments, we simulate our interactive model considering the case in which only one right-hand side variable is measured with error. That is, we consider:

$$Investment_{i,t} = \alpha_0 + \alpha_1 Q_{i,t-1} + \alpha_2 Tangibility_{i,t-1} + \alpha_3 \left(Q \times Tangibility\right)_{i,t-1} + e_{i,t}, \qquad \text{(B.1)}$$

where $e_{i,t}$ is $i.i.d.$ and the observable variable Q is mismeasured. In particular,

$$Q_{i,t} = Q^*_{i,t} + \varepsilon_{i,t}, \qquad \text{(B.2)}$$

where Q^* is the unobservable, true variable, and the measurement error $\varepsilon_{i,t}$ is $i.i.d.$ and independent of $e_{i,t}$. This specification is equivalent to assuming $cov(Q^*_{i,t}, \varepsilon_{i,t}) = 0$ and $cov\left(Q_{i,t}, \varepsilon_{i,t}\right) = var\left(\varepsilon_{i,t}\right)$, which corresponds to the classical errors-in-variables problem.

To study the potential bias in estimates of α_3 (the credit multiplier effect) due to measurement error in Q, we consider three different distributions for innovations $\left(e_i, \varepsilon_i\right)'$: (1) a standard normal distribution, (2) a log-normal distribution, and (3) a chi-square distribution with 3 degrees of freedom. Without loss of generality, we normalize the simulated parameter values of α_i to unity for all $i \in \{0, 1, 2, 3\}$. To allow for various correlation structures, we generate random samples of Q and $Tangibility$ from the above distributions, multiply the resulting vectors by the matrix $cov(Q, Tangibility)$, and generate $Q \times Tangibility$. We use four alternative correlation matrices, where the diagonal elements are equal to 1 and off-diagonal elements equal to 0, 0.25, 0.5, and 0.75. We perform simulations for various sample sizes. Since the estimation results are qualitatively similar across different sample sizes, we tabulate the result for $n = 500$ (results for other sample sizes are available upon request). For each simulation the number of repetitions is 10,000.

Table B.1.
Mismeasurement in Q

		Correlation Structure			
Distribution		0	0.25	0.5	0.75
	α_1	0.4996	0.4518	0.3093	0.1097
Normal	α_2	1.0024	1.2580	1.5519	1.8540
	α_3	0.4994	0.5640	0.6699	0.7501
	α_1	0.5043	–0.4706	–1.2694	–2.2365
Log-normal	α_2	0.9950	0.6526	1.6451	3.2811
	α_3	0.5007	0.9230	0.9598	0.9431
	α_1	0.4995	–0.3904	–1.8363	–3.5637
Chi-square	α_2	0.9952	1.5044	2.8623	5.3707
	α_3	0.5003	0.7052	0.8072	0.8192

Table B.1 collects the least squares estimates based on our simulated data. The table shows that the coefficients involving Q are likely biased in the presence of mismeasurement. Crucially, however, Table B.1 shows that the observed biases work *against* finding evidence for our credit multiplier theory. In particular: (1) as expected, the estimates of α_1 are biased downwardly; (2) notably, estimates of α_3 are also biased downwardly; and (3) the estimates of α_2 could be downwardly or upwardly biased, depending on the assumed correlation structure.

In a second set of experiments, we examine the case in which two explanatory variables are mismeasured. That is, *both* Q and $Tangibility$ suffer from measurement error. To handle this more general case, we incorporate another mismeasurement equation into the simulation framework; that is, the simulated data is now generated by equations (B.1), (B.2), and

$$Tangibility_{i,t} = Tangibility^{*}_{i,t} + \epsilon_{i,t}, \tag{B.3}$$

where $Tangibility^{*}$ is the additional unobservable variable, and the additional measurement error ϵ_i is *i.i.d.* and independent of e_i and ε_i.

Table B.2 summarizes our findings for the second set of Monte Carlo experiments. The estimation results for the case when Q and $Tangibility$ are imprecisely measured are qualitatively similar to the ones for the case when only Q is measured with error. The main difference between the two sets of results is that estimates of α_2 are now, as expected, also downwardly biased.

Table B.2.
Mismeasurement in Q and $Tangibility$

		Correlation Structure			
Distribution		0	0.25	0.5	0.75
	α_1	0.5009	0.6100	0.6921	0.7539
Normal	α_2	0.4997	0.6096	0.6918	0.7525
	α_3	0.2499	0.3058	0.4217	0.5318
	α_1	0.5075	–0.9881	–1.7457	–1.9533
Log-normal	α_2	0.4978	–1.0091	–1.7624	–1.9655
	α_3	0.2498	0.8279	1.0075	1.0499
	α_1	0.5010	–0.2923	–1.5517	–2.2807
Chi-square	α_2	0.4968	–0.2915	–1.5593	–2.2929
	α_3	0.2500	0.5076	0.7473	0.8691

The above simulations have shown that the coefficients of interest for our tests are biased downward when there are measurement errors in one or two of the explanatory variables of our main regression specification (Eq. (17)). More concretely, they indicate that mismeasurement in Q and/or $Tangibility$ also lead to an attenuation bias in the coefficient returned for the interactive term $Q \times Tangibility$. Altogether, these potential biases make it *more difficult* for one to detect a significant role for our credit multiplier theory in the data.

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Table 1. Sample Descriptive Statistics

This table displays summary statistics for the main variables used in the empirical estimations. All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). *Assets* is the firm's total assets (COMSPUSTAT's item #6), expressed in millions of CPI-adjusted 1971 dollars. *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). There are two baseline measures of asset tangibility (*Tangibility*) that we construct at an annual frequency. The first is based on a firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). The second is an industry-level measure of asset redeployment; available from 1981 through 1996 (data taken from the Bureau of Census' *Annual Survey of Manufacturers*). *Leverage* is computed as item #9 divided by item #6. *DebtIssuance* is the change in long- (Δitem #9) and short-term debt (Δitem #34) over lagged total assets.

Variables	Statistics					
	Mean	Median	Std. Dev.	25^{th} Pct.	75^{th} Pct.	Obs.
Assets	155.6	14.1	690.2	4.3	60.8	65,107
Investment	0.2617	0.1884	0.2584	0.1159	0.3088	58,633
Q	0.8733	0.7695	0.5196	0.6355	0.9494	65,107
Tangibility (two definitions)						
Firm-Level Asset Liquidation	0.5583	0.5648	0.1196	0.5035	0.6118	64,788
Industry-Level Asset Redeployment	0.0742	0.0573	0.0522	0.0410	0.0899	14,402
Leverage	0.1713	01404	0.1655	0.0377	0.2573	64,788
*DebtIss*uance	0.0015	–0.0079	0.1449	–0.0485	0.0242	57,087

Table 2. Cross-Classification of Financial Constraint Types

This table displays firm-year cross-classifications for the various criteria used to categorize firms as either financially constrained or unconstrained (see text for definitions). To ease visualization, we assign the letter (C) for constrained firms and (U) for unconstrained firms in each row/column. All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999).

Financial Constraints Criteria		Div. Payout		Firm Size		Bond Ratings		CP Ratings	
		(C)	(U)	(C)	(U)	(C)	(U)	(C)	(U)
1. Payout Policy									
Constrained Firms	(C)	27,658							
Unconstrained Firms	(U)		19,549						
2. Firm Size									
Constrained Firms	(C)	12,857	2,750	19,550					
Unconstrained Firms	(U)	3,689	9,849		19,549				
3. Bond Ratings									
Constrained Firms	(C)	23,723	14,786	19,108	11,391	52,915			
Unconstrained Firms	(U)	3,935	4,763	442	8,158		12,192		
4. Comm. Paper Ratings									
Constrained Firms	(C)	26,964	16,896	19,533	15,106	52,822	7,571	60,393	
Unconstrained Firms	(U)	694	2,653	17	4,443	93	4,621		4,714

Table 3. Investment Spending, Q, and Asset Tangibility: Base Regressions Using Ex-Ante Constraint Partitions

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the base investment model (omitting the Q-interactive term from Eq. (17)). The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). In Panel A, *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). In Panel B, *Tangibility* is an annual, industry-level measure of asset redeployment; available from 1981 through 1996 (data taken from the Bureau of Census' *Annual Survey of Manufacturers*). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Panel A: Tangibility proxied by annual, firm-level liquidation values (based on Berger et al. (1996))

Dependent Variable	Independent Variables		R^2	Obs.
Investment	Q	*Tangibility*		
Financial Constraints Criteria				
1. Payout Policy				
Constrained Firms	0.1284***	0.5605***	0.07	22,512
	(0.0088)	(0.0328)		
Unconstrained Firms	0.0605***	0.0891*	0.02	17,915
	(0.0065)	(0.0458)		
2. Firm Size				
Constrained Firms	0.1090***	0.6491***	0.06	17,259
	(0.0104)	(0.0455)		
Unconstrained Firms	0.0663***	0.1557***	0.05	17,949
	(0.0073)	(0.0235)		
3. Bond Ratings				
Constrained Firms	0.0940***	0.4251***	0.05	45,226
	(0.0056)	(0.0252)		
Unconstrained Firms	0.0804***	0.0787**	0.03	11,051
	(0.0104)	(0.0321)		
4. Comm. Paper Ratings				
Constrained Firms	0.0939***	0.3978**	0.05	51,893
	(0.0055)	(0.0229)		
Unconstrained Firms	0.0780***	0.0857	0.06	4,384
	(0.0097)	(0.0574)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 3. – Continued

Panel B: Tangibility proxied by annual, industry-level asset redeployability (based on redeployment of used capital)

Dependent Variable *Investment*	Independent Variables Q	*Tangibility*	R^2	Obs.
Financial Constraints Criteria				
1. Payout Policy				
Constrained Firms	0.1958*** (0.0191)	0.1459* (0.0847)	0.05	5,795
Unconstrained Firms	0.0978*** (0.0145)	–0.0743* (0.0431)	0.03	3,509
2. Firm Size				
Constrained Firms	0.1840*** (0.0268)	0.2148* (0.1127)	0.04	3,715
Unconstrained Firms	0.1173*** (0.0152)	–0.0677 (0.0463)	0.05	3,470
3. Bond Ratings				
Constrained Firms	0.1670*** (0.0142)	0.1604*** (0.0531)	0.05	10,744
Unconstrained Firms	0.1793*** (0.0299)	–0.0438 (0.0696)	0.05	1,779
4. Comm. Paper Ratings				
Constrained Firms	0.1685*** (0.0140)	0.1505*** (0.0489)	0.05	11,874
Unconstrained Firms	0.1487*** (0.0434)	–0.1116 (0.0797)	0.08	649

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 4. Investment Spending, Q, and Asset Tangibility: Base Regressions Using Endogenous Constraint Partitions

This table displays results from the base investment model (Eq. (17) without the Q-interactive term) estimated via switching regressions. The equations are estimated with firm- and time-fixed effects. The switching regression estimations allow for endogenous selection into "financially constrained" and "financially unconstrained" categories via maximum likelihood methods. The"regime selection" regression (unreported) uses payout ratio, asset size, a dummy for bond ratings, a dummy for commercial paper ratings, and *Tangibility* as selection variables to classify firms into constraint categories. *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). In Panel A, *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). In Panel B, *Tangibility* is an annual, industry-level measure of asset redeployment; available from 1981 through 1996 (data taken from the Bureau of Census' *Annual Survey of Manufacturers*). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Panel A: Tangibility proxied by annual, firm-level liquidation values (based on Berger et al. (1996))

Dependent Variable	Independent Variables		R^2	Obs.
Investment	Q	*Tangibility*		
Constrained Firms	0.0708*** (0.0039)	0.2906*** (0.0153)	0.05	56,252
Unconstrained Firms	0.0842*** (0.0150)	0.1315 (0.1376)	0.02	56,252

Panel B: Tangibility proxied by annual, industry-level asset redeployability (based on redeployment of used capital)

Dependent Variable	Independent Variables		R^2	Obs.
Investment	Q	*Tangibility*		
Constrained Firms	0.2779*** (0.0588)	0.1511*** (0.0573)	0.11	9,522
Unconstrained Firm	0.1281*** (0.0129)	0.0263 (0.0334)	0.05	9,522

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 5. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Using Ex-Ante Constraint Partitions

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text). The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). In Panel A, *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). In Panel B, *Tangibility* is an annual, industry-level measure of asset redeployment; available from 1981 through 1996 (data taken from the Bureau of Census' *Annual Survey of Manufacturers*). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Panel A: Tangibility proxied by annual, firm-level liquidation values (based on Berger et al. (1996))

Dependent Variable	Independent Variables			R^2	Obs.
Investment	Q	*Tangibility*	$Q \times$ *Tangibility*		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	0.0285	0.4214***	0.1571***	0.07	22,512
	(0.0310)	(0.0525)	(0.0505)		
Unconstrained Firms	0.1139***	0.1656***	–0.0884*	0.02	17,915
	(0.0312)	(0.0510)	(0.0524)		
2. Firm Size					
Constrained Firms	0.0165	0.5264***	0.1421**	0.07	17,259
	(0.0423)	(0.0693)	(0.0692)		
Unconstrained Firms	0.1311***	0.2572***	–0.1099**	0.05	17,949
	(0.0290)	(0.0521)	(0.0526)		
3. Bond Ratings					
Constrained Firms	0.0196	0.3239***	0.1177***	0.05	45,226
	(0.0244)	(0.0400)	(0.0408)		
Unconstrained Firms	0.1357***	0.2664***	–0.0962	0.03	11,051
	(0.0486)	(0.0844)	(0.0869)		
4. Comm. Paper Ratings					
Constrained Firms	0.0247	0.3026***	0.1101***	0.05	51,893
	(0.0236)	(0.0382)	(0.0393)		
Unconstrained Firms	0.1691***	0.2377***	–0.1596**	0.06	4,384
	(0.0470)	(0.0743)	(0.0786)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 5. – Continued

Panel B: Tangibility proxied by annual, industry-level asset redeployability (based on redeployment of used capital)

Dependent Variable	Independent Variables			R^2	Obs.
Investment	Q	*Tangibility*	$Q \times$ *Tangibility*		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	0.0832***	–0.0819	0.5800***	0.05	5,795
	(0.0210)	(0.2610)	(0.2186)		
Unconstrained Firms	0.0941***	–0.1651	0.1269	0.03	3,509
	(0.0161)	(0.1506)	(0.2034)		
2. Firm Size					
Constrained Firms	0.0488***	–0.4246	0.8431***	0.05	3,715
	(0.0206)	(0.3025)	(0.2386)		
Unconstrained Firms	0.1091***	–0.3011	0.2966	0.05	3,470
	(0.0164)	(0.1997)	(0.2584)		
3. Bond Ratings					
Constrained Firms	0.0480***	–0.3033*	0.4689**	0.05	10,744
	(0.0148)	(0.1686)	(0.2223)		
Unconstrained Firms	0.1764***	–0.0953	0.0624	0.05	1,779
	(0.0323)	(0.1959)	(0.2534)		
4. Comm. Paper Ratings					
Constrained Firms	0.0511***	–0.2807*	0.4218**	0.05	11,874
	(0.0146)	(0.0125)	(0.2068)		
Unconstrained Firms	0.1457***	–0.1823	0.0927	0.08	649
	(0.0441)	(0.4421)	(0.6253)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 6. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Using Endogenous Constraint Partitions

This table displays results from the credit multiplier investment model estimated via switching regressions (Eq. (17) in the text). The equations are estimated with firm- and time-fixed effects. The switching regression estimations allow for endogenous selection into "financially constrained" and "financially unconstrained" categories via maximum likelihood methods. The"regime selection" regression (unreported) uses payout ratio, asset size, a dummy for bond ratings, a dummy for commercial paper ratings, and *Tangibility* as selection variables to classify firms into constraint categories. *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). In Panel A, *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). In Panel B, *Tangibility* is an annual, industry-level measure of asset redeployment; available from 1981 through 1996 (data taken from the Bureau of Census' *Annual Survey of Manufacturers*). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Panel A: Tangibility proxied by annual, firm-level liquidation values (based on Berger et al. (1996))

Dependent Variable		Independent Variables		R^2	Obs.
Investment	Q	*Tangibility*	$Q \times Tangibility$		
Constrained Firms	0.1723*	0.1965	0.3996***	0.04	56,252
	(0.0911)	(0.1865)	(0.1339)		
Unconstrained Firms	0.0308*	0.2305***	0.0601	0.05	56,252
	(0.0171)	(0.0267)	(0.0393)		

Panel B: Tangibility proxied by annual, industry-level asset redeployability (based on redeployment of used capital)

Dependent Variable		Independent Variables		R^2	Obs.
Investment	Q	*Tangibility*	$Q \times Tangibility$		
Constrained Firms	0.1098***	–0.1310	0.4048***	0.05	9,522
	(0.0134)	(0.1160)	(0.1484)		
Unconstrained Firm	0.2935***	–0.2796	–0.2334	0.11	9,522
	(0.0814)	(0.2891)	(0.7777)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 7. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Using GMM Estimations

This table displays GMM-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text). The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). The instruments include lags 1 through 3 of the model's differenced right-hand side variables. All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses. Diagnostic statistics for instrument overidentification restrictions (p-values for Hansen's J-statistics) and instrument relevance (first-stage F-statistics' p-values) are also reported.

Dependent Variable *Investment*	Independent Variables Q	*Tangibility*	$Q \times$ *Tangibility*	P-Value of Hansen's J-statistic	P-Value of First-Stage F-Test
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	–0.4064**	–0.3889	0.9699***	0.58	0.00
	(0.2055)	(0.2816)	(0.3407)		
Unconstrained Firms	0.2091	0.0663	–0.0418	0.83	0.00
	(0.3174)	(0.4557)	(0.5428)		
2. Firm Size					
Constrained Firms	–0.3934**	–0.1949	0.7940***	0.20	0.00
	(0.1847)	(0.2365)	(0.3085)		
Unconstrained Firms	0.2875	0.2067	–0.1501	0.92	0.00
	(0.3858)	(0.6083)	(0.6678)		
3. Bond Ratings					
Constrained Firms	–0.3009**	–0.4071**	0.7964***	0.88	0.00
	(0.1402)	(0.1927)	(0.2379)		
Unconstrained Firms	0.1181	–0.0978	0.2431	0.22	0.00
	(0.3196)	(0.5197)	(0.5881)		
4. Comm. Paper Ratings					
Constrained Firms	–0.3330**	–0.4649**	0.8509***	0.96	0.00
	(0.1439)	(0.1990)	(0.2437)		
Unconstrained Firms	0.3489	0.1171	–0.1239	0.33	0.00
	(0.2962)	(0.4907)	(0.5224)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 8. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Replacing Q with Cummins et al.'s (2006) *RealQ*

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text), where conventional Q is replaced by Cummins et al.'s (2006) measurement-robust *RealQ* (based on long-term earning forecasts from IBES). IBES forecast are collected starting in 1989. The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). All firm data are collected from COMPUSTAT's annual industrial tapes. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Dependent Variable	Independent Variables			R^2	Obs.
Investment	*RealQ*	*Tangibility*	*RealQ* ×*Tangibility*		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	–0.0798 (0.0587)	0.4653*** (0.0953)	0.1757*** (0.0547)	0.04	2,271
Unconstrained Firms	0.1153** (0.0573)	0.1199** (0.0589)	–0.0479 (0.0965)	0.03	3,162
2. Firm Size					
Constrained Firms	0.0314 (0.0783)	0.6304*** (0.1840)	0.1343*** (0.0437)	0.03	578
Unconstrained Firms	0.0017 (0.0622)	0.1585*** (0.0613)	–0.1294 (0.1000)	0.03	3,611
3. Bond Ratings					
Constrained Firms	0.0255 (0.0525)	0.2837*** (0.0667)	0.1343** (0.0618)	0.03	5,307
Unconstrained Firms	0.0068 (0.0663)	0.2519*** (0.0741)	–0.0568 (0.1168)	0.02	1,673
4. Comm. Paper Ratings					
Constrained Firms	–0.0169 (0.0489)	0.2856*** (0.0608)	0.1191*** (0.0366)	0.03	6,161
Unconstrained Firms	0.0104 (0.0486)	0.1848*** (0.0702)	0.0503 (0.1006)	0.03	819

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 9. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Including $CashFlow$

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text), with the inclusion of cash flow as a control variablel. The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). $CashFlow$ is the ratio of operating income (item #18 + item#14) over lagged fixed capital stock. *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Dependent Variable	Independent Variables				R^2	Obs.
Investment	Q	$CashFlow$	$Tangibility$	$Q \times Tangibility$		
Financial Constraints Criteria						
1. Payout Policy						
Constrained Firms	0.0126	0.0011**	0.3265***	0.1787***	0.07	19,956
	(0.0322)	(0.0005)	(0.0545)	(0.0540)		
Unconstrained Firms	0.1097***	0.0006	0.1626***	–0.0795	0.02	17,103
	(0.0363)	(0.0014)	(0.0569)	(0.0608)		
2. Firm Size						
Constrained Firms	0.0082	0.0099*	0.4032***	0.1416**	0.05	13,141
	(0.0449)	(0.0060)	(0.0705)	(0.0748)		
Unconstrained Firms	0.1419***	0.0020	0.2671***	–0.1233**	0.05	17,105
	(0.0268)	(0.0024)	(0.0477)	(0.0473)		
3. Bond Ratings						
Constrained Firms	0.0334	0.0016*	0.2899***	0.0902**	0.05	41,230
	(0.0256)	(0.0009)	(0.0410)	(0.0431)		
Unconstrained Firms	0.1011*	0.0004	0.1881**	–0.0241	0.03	10,506
	(0.0542)	(0.0004)	(0.0844)	(0.0979)		
4. Comm. Paper Ratings						
Constrained Firms	0.0365	0.0017*	0.2695***	0.0867**	0.04	47,522
	(0.0245)	(0.0010)	(0.0394)	(0.0416)		
Unconstrained Firms	0.1674***	0.0005	0.2311***	–0.1485*	0.06	4,214
	(0.0478)	(0.0007)	(0.0728)	(0.0789)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 10. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Replacing Q with the Projection of Q on Industry Prices

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text), where conventional Q is replaced by the projection of Q on industry-level PPI (from the Bureau of Labor Statisticcs). This construct is denoted *ProjQ*. The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). All firm data are collected from COMPUSTAT's annual industrial tapes. The sample firms are from manufacturing industries (SICs 2000–3999). While for most industries the PPI series compilations start in the 1970's, for many it starts in the mid-1980's. All of the PPI series end in 2003. The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Dependent Variable	Independent Variables			R^2	Obs.
Investment	*ProjQ*	*Tangibility*	*ProjQ* ×*Tangibility*		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	0.9459***	0.0505	0.6176***	0.04	19,305
	(0.1409)	(0.1403)	(0.1756)		
Unconstrained Firms	0.3444***	0.0073	0.1187	0.00	14,869
	(0.1083)	(0.0817)	(0.1032)		
2. Firm Size					
Constrained Firms	0.6305***	0.2238	0.4859*	0.04	12,395
	(0.1980)	(0.2139)	(0.2612)		
Unconstrained Firms	0.5318***	0.0676	0.1167	0.02	14,979
	(0.0955)	(0.0695)	(0.0877)		
3. Bond Ratings					
Constrained Firms	0.4962***	0.1112	0.4109***	0.03	37,160
	(0.0910)	(0.0888)	(0.1101)		
Unconstrained Firms	0.4951***	0.0503	0.1307	0.01	9,348
	(0.1449)	(0.1141)	(0.1401)		
4. Comm. Paper Ratings					
Constrained Firms	0.4960***	0.1100	0.3717***	0.03	42,854
	(0.0848)	(0.0793)	(0.0987)		
Unconstrained Firms	0.4792***	0.0277	0.0606	0.02	3,654
	(0.1829)	(0.1223)	(0.1539)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 11. Investment Spending, Q, and Asset Tangibility: The Credit Multiplier Effect Replacing Investment Levels with Investment Growth Rates

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text), where investment level (*Investmet*) is replaced by investment growth rate ($Log(Capex_t/Capex_{t-1})$) as the left-hand side variable. The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, size, bond ratings, and commercial paper ratings (see text for details). *Capex* is item #128. Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). All firm data are collected from COMPUSTAT's annual industrial tapes. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Dependent Variable	Independent Variables			R^2	Obs.
$Log(Capex_t/Capex_{t-1})$	Q	*Tangibility*	$Q \times$ *Tangibility*		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	–0.0410	0.6789***	0.2950***	0.02	22,399
	(0.0724)	(0.1200)	(0.1104)		
Unconstrained Firms	0.1671***	0.5381***	–0.1681*	0.01	17,884
	(0.0611)	(0.1195)	(0.1022)		
2. Firm Size					
Constrained Firms	–0.2405**	0.6275***	0.5127***	0.01	15,170
	(0.0940)	(0.1532)	(0.1438)		
Unconstrained Firms	0.3375***	0.7926***	–0.4154***	0.01	17,913
	(0.0715)	(0.1272)	(0.1210)		
3. Bond Ratings					
Constrained Firms	–0.0342	0.6614***	0.2012**	0.01	45,038
	(0.0518)	(0.0898)	(0.0829)		
Unconstrained Firms	0.3722***	0.8368***	–0.4540**	0.01	11,050
	(0.1261)	(0.2088)	(0.2211)		
4. Comm. Paper Ratings					
Constrained Firms	–0.0065	0.6466***	0.1606**	0.01	51,696
	(0.0498)	(0.0850)	(0.0798)		
Unconstrained Firms	0.3127**	0.6251***	–0.3469	0.01	4,392
	(0.1332)	(0.2084)	(0.2227)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 12. Investment Spending, Q, and Asset Tangibility: Debt Capacity and the Credit Multiplier Effect

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier investment model (Eq. (17) in the text), where constrained firms are split into "high" and "low" debt capacity groups. In Panel A, firms are assigned into high and low debt capacity categories according to annual rankings of the residuals from a regression of firm leverage on asset tangibility. Low (high) residuals are associated with high (low) incremental debt capacity. In Panel B, annual rankings based on raw leverage are used. Accordingly, firms ranked at the bottom (top) of the leverage distribution are considered to have high (low). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). *Leverage* is computed as item #9 divided by item #6. All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Panel A: Debt capacity rankings based on the residuals from a regression of leverage on asset tangibility

Dependent Variable	Independent Variables			R^2	Obs.
Investment	Q	*Tangibility*	$Q \times$ *Tangibility*		
Financial Constraints Criteria					
1. Low Payout Firms					
High Debt Capacity	–0.0280	0.4258***	0.2443***	0.10	6,597
	(0.0418)	(0.0778)	(0.0719)		
Low Debt Capacity	0.0674	0.3860***	0.0341	0.03	8,002
	(0.0543)	(0.0941)	(0.0914)		
2. Small Firms					
High Debt Capacity	0.0103	0.5727***	0.1439***	0.08	5,945
	(0.0584)	(0.0988)	(0.0377)		
Low Debt Capacity	0.0354	0.5676***	0.0739	0.04	3,455
	(0.0635)	(0.1381)	(0.1167)		
3. Firms without Bond Ratings					
High Debt Capacity	0.0178	0.3544***	0.0903*	0.06	16,936
	(0.0311)	(0.0519)	(0.0517)		
Low Debt Capacity	0.0863	0.4581***	0.0320	0.04	9,806
	(0.0610)	(0.1031)	(0.1040)		
4. Firms without CP Ratings					
High Debt Capacity	0.0178	0.3544***	0.0903*	0.06	16,936
	(0.0311)	(0.0519)	(0.0517)		
Low Debt Capacity	0.0919*	0.3522***	0.0107	0.03	14,784
	(0.0492)	(0.0819)	(0.0848)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 12. – Continued

Panel B: Debt capacity rankings based on the distribution of leverage

Dependent Variable	Independent Variables			R^2	Obs.
Investment	Q	*Tangibility*	$Q \times Tangibility$		
Financial Constraints Criteria					
1. Low Payout Firms					
High Debt Capacity	0.4092***	–0.4615**	0.4497***	0.07	5,380
	(0.2857)	(0.2215)	(0.2811)		
Low Debt Capacity	0.6424***	0.1367	0.2384	0.02	7,569
	(0.1829)	(0.1768)	(0.2145)		
2. Small Firms					
High Debt Capacity	0.5042	0.0051	0.7951**	0.04	4,800
	(0.3178)	(0.3053)	(0.3762)		
Low Debt Capacity	0.7933**	0.3840	0.1874	0.03	3,376
	(0.3151)	(0.3367)	(0.4030)		
3. Firms without Bond Ratings					
High Debt Capacity	0.6233***	–0.0507	0.7382***	0.04	11,202
	(0.1767)	(0.1751)	(0.2174)		
Low Debt Capacity	0.7606***	0.4667**	–0.0400	0.02	8,211
	(0.2017)	(0.2285)	(0.2753)		
4. Firms without CP Ratings					
High Debt Capacity	0.6527***	–0.0681	0.7555***	0.06	16,936
	(0.1724)	(0.1619)	(0.2022)		
Low Debt Capacity	0.6620***	0.2577	0.0488	0.02	12,115
	(0.1564)	(0.1571)	(0.1901)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.

Table 13. Debt Taking, Q, and Asset Tangibility: The Credit Multiplier Effect on Debt Policy

This table displays OLS-FE (firm- and year-fixed effects) estimation results of the credit multiplier debt model (Eq. (18) in the text). The dependent variable is *DebtIssuance*, defined as the change in long- (Δitem #9) and short-term debt (Δitem #34) over lagged total assets. The estimations use pre-determined firm selection into "financially constrained" and "financially unconstrained" categories. Constraint category assignments use ex-ante criteria based on firm dividend payout, asset size, bond ratings, and commercial paper ratings (see text for details). *Investment* is the ratio of fixed capital expenditures (item #128) over lagged fixed capital stock (item #8). Q is computed as the market value of assets divided by the book value of assets, or (item #6 + (item #24 × item #25) – item #60 – item #74) / (item #6). *Tangibility* is an annual, firm-level proxy for expected value of assets in liquidation (the computation follows Berger et al. (1996)). All firm data are collected from COMPUSTAT's annual industrial tapes over the 1971–2005 period. The sample firms are from manufacturing industries (SICs 2000–3999). The estimations correct the error structure for heteroskedasticity and clustering using the White-Huber estimator. Robust standard errors reported in parentheses.

Dependent Variable	Independent Variables			R^2	Obs.
DebtIssuance	Q	*Tangibility*	$Q \times Tangibility$		
Financial Constraints Criteria					
1. Payout Policy					
Constrained Firms	–0.0523**	0.1342***	0.0701**	0.01	22,714
	(0.0229)	(0.0349)	(0.0326)		
Unconstrained Firms	–0.0017	0.0587**	–0.0022	0.00	18,108
	(0.0236)	(0.0286)	(0.0369)		
2. Firm Size					
Constrained Firms	–0.0595**	0.1217***	0.0778**	0.01	15,432
	(0.0285)	(0.0335)	(0.0394)		
Unconstrained Firms	–0.0057	0.1227***	0.0041	0.00	18,130
	(0.0234)	(0.0397)	(0.0377)		
3. Bond Ratings					
Constrained Firms	–0.0399*	0.1060***	0.0501**	0.01	45,644
	(0.0224)	(0.0269)	(0.0224)		
Unconstrained Firms	0.1049	–0.0219	0.2082	0.01	11,181
	(0.0925)	(0.1501)	(0.1664)		
4. Comm. Paper Ratings					
Constrained Firms	–0.0434**	0.1049***	0.0598***	0.01	52,381
	(0.0219)	(0.0273)	(0.0222)		
Unconstrained Firms	0.0878	0.2740*	–0.1646	0.01	4,444
	(0.1070)	(0.1604)	(0.1829)		

Notes: ***, **, and * indicate statistical significance at the 1-, 5-, and 10-percent (two-tail) test levels, respectively.