Rising Intangible Capital, Shrinking Debt Capacity, and the US Corporate Savings Glut^{*}

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Abstract

This paper explores the connection between rising intangible capital and the secular upward trend in US corporate cash holdings. We calibrate a dynamic model with two productive assets, tangible and intangible capital, in which only tangible capital can serve as collateral. We highlight the following points: 1) a shift toward intangible capital shrinks firms' debt capacity and leads them to hold more cash; 2) the effect accounts for 3/4 of the observed trend in average cash ratios; 3) it also accounts for the upward trend of cash ratios in the cross-section of small and large firms and in the aggregate.

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1 Introduction

Public corporations in the U.S. underwent fundamental changes over the last decades. On the financial side, they steadily increased the cash holdings on their balance sheets, an issue that has attracted wide attention in the popular press, with commentators dubbing it the "corporate saving glut," expressing a concern that it might hamper growth of the US economy, and even raising calls to tax corporate savings. On the real side, their production technology is increasingly reliant on intangibles, with assets such as knowledge, brands, reputation, organizational, and information technology capital becoming in many respects a defining feature of the modern industrial corporation. Yet, despite recent progress on incorporating financing frictions into investment-based models in corporate finance (see, for example, Bolton, Chen, and Wang (2011)), these important trends have been mostly studied in isolation, and the extent to which they may be connected remains relatively unexplored.

In an attempt to fill the gap in the literature, this paper explores the connection between the secular trends in intangible capital and the cash holdings of U.S. corporations. A critical feature of intangible capital is that it cannot be easily verified or liquidated and, as such, cannot be pledged as collateral to raise debt financing. Under frictional capital markets, where external funds command substantial premiums, the rising importance of intangible capital as an input of production boosts firms' precautionary demand for cash in order to ensure that they have sufficient liquidity to exploit future investment opportunities. We build on q-theoretic models of internal financing (e.g., Bolton, Chen, and Wang (2011)) and formalize this intuition within a dynamic model featuring two distinct productive assets, physical and intangible capital. A motive for cash holdings arises in our model because of the interplay between real and financial frictions: when firms have growth options, they optimally hold cash since they anticipate having to make large (S,s)-type adjustments in capital and want to avoid raising costly external finance to fund investment. Since in the model only tangible capital can be pledged as collateral, a shift toward intangible capital shrinks the debt capacity of firms and leads them to hold more cash. Using a calibrated version of the model to quantify this mechanism, we show that the rise in intangible capital can account for about 3/4 of the increase

in average cash ratios in the data. Other forces that have been proposed in the literature, such as, for example, the increase in cash flow volatility, also played a role but are relatively weaker. The model can also account quantitatively for a broader set of cross-sectional and aggregate facts of the secular evolution of cash. Overall, our quantitative analysis indicates that the rise in intangible capital is an important force behind the long-run rise of the cash ratios of U.S. corporations.

Our focus on the rise in intangible capital builds on a large body of evidence spanning various literatures, including the economics of innovation, macroeconomics, and industrial organization, which shows that over the last few decades there has been a dramatic shift away from physical capital investments toward intangible capital. In the aggregate, investments in intangible capital by US firms have picked up substantially since the 1980s, especially investments in computerized information, private R&D, and organizational capital (Corrado, Hulten, and Sichel (2009), Corrado and Hulten (2010), and Lev (2001)). This well-documented shift in firms' mode of production is an economy-wide phenomenon, something that the literature has dubbed a general purpose technology (GPT) shock, or the third industrial revolution, in that it affected firms across the board, well beyond simply the high-tech sector (Jovanovic and Rousseau (2005)). This body of evidence broadly suggests that fundamental technological changes, or shocks, in the 1980s and 1990s have had a pervasive effect on public corporations.

We begin by detailing the stylized facts of the link between the rise in intangible capital and the secular trend in corporate cash holdings. The main measurement hurdle is that intangible assets are not reported on the firms' balance sheet and investments in intangibles are generally treated as expenses. We overcome this problem by constructing a comprehensive firm-level measure of intangible capital as the sum of three components: knowledge capital, which is constructed as the stock of assets from investments in R&D; organizational capital, the stock of assets from investments in the value of brand names and employee training; and information technology capital.¹ Intangible capital rose almost fivefold relative to book assets (net of cash) from about 20% in 1970 to about 90% in 2010. Over the same period, average cash ratios displayed a pronounced upward secular

¹Our measure is highly correlated with other proxies that have been used in the literature, such as the firm-level intangible capital measure of Peters and Taylor (2017) and the industry-level measure based on the BEA Fixed Assets data used in DellAriccia, Kadyrzhanova, Ratnovski, and Minoiu (2020), which supports its validity.

trend from about 9% in 1970 to more than 20% of book assets by 2010, which is in line with Bates, Kahle, and Stulz (2009). While both trends are broad-based, there are cross-sectional differences, as small firms experienced a more pronounced upward trend in cash ratios. Since the size distribution of cash is highly skewed, with the largest firms holding the bulk of aggregate cash, aggregate cash ratios also trended up, but less so than average cash ratios. Our battery of stylized facts indicates that there is a strong link between cash and intangible capital in the time-series and that there are cross-sectional differences between large and small firms, all of which we use to confront the model in our quantitative analysis.

In order to better understand the economic mechanism behind the link, we develop a dynamic model of firms' capital structure, cash management, and real investment decisions that is rich enough to capture our proposed mechanism but at the same time parsimonious enough to allow for calibration to confront the mechanism with the data. The model is cast in a standard infinitehorizon, discrete-time stochastic environment, where managers make value-maximizing investment and financing decisions under costly external financing frictions. The key innovation is that firms make capital accumulation decisions over two types of real assets, tangible and intangible capital, and cannot pledge intangible capital as collateral for debt financing. The model has two key ingredients: first, we allow for the interplay of real frictions, that arise because investment is partially irreversible and subject to fixed costs of adjustment, and financial frictions, that arise because debt financing is subject to a collateral constraint while equity financing involves dilution costs; second, intangible capital matters for financing and investment decisions because it cannot be pledged as collateral for borrowing. The financial side frictions, other than for the addition of the debt collateral constraint and imperfect pledgeability of intangible capital, share features of the dynamic corporate finance models with costly external finance such as, for example, Bolton, Chen, and Wang (2011). The real side frictions build on the unified theory of investment with non-convex adjustment costs and partial irreversibility of Abel and Eberly (1994), which make adjustments of the capital stock infrequent and lumpy, generating large financing needs. By explicitly modelling real and financing frictions, we are able to highlight and evaluate the shrinking debt capacity mechanism behind the link between intangible capital and corporate financial policies.

Using a tightly calibrated version of the model with the parameters chosen either from previous studies or to match empirical restrictions, we quantify the importance of intangible capital. In the first part of the analysis, we examine the ability of the model to account for the evolution over time of key financial ratios by comparing model-implied averages of these ratios to their empirical counterparts. We find the following main results. First, with a realistic combination of forces at work, the model can account for the full rise in average cash ratios that is observed in the data between the first and the second half of our sample period, which is an increase of 8.3%. Specifically, we allow for four main forces to be at work: changes in intangible capital, as well as volatility, equity issuance costs, and interest rates, all chosen to match the changes in their empirical counterparts. The quantitative performance of the model stands in sharp contrast to the polar case when firms use only tangible capital in their production technology. In this case, our model becomes similar to the traditional workhorse dynamic corporate finance benchmark and generates average cash ratios that are an order of magnitude smaller than their empirical counterparts. The intuition for this result is that intangible assets boost the precautionary demand for cash through a tightening of the collateral constraint, which leads firms with growth options to hold more cash in anticipation of (S,s)-type adjustments in capital to avoid raising costly external finance. The model provides a good fit not just for the magnitude of the increase in cash, but also for the levels and changes of the other key financial ratios, such as leverage and equity issuance.

Second, what are the main drivers of the rise in cash, and how much of the increase in cash can be attributed to the rise in intangible capital? We isolate the quantitative importance of intangible capital by "switching off" our proposed mechanism while allowing the other forces to still be at work. This quantitative counterfactual exercise gauges how much cash would have risen if firms had continued to rely on the same mix of tangible and intangible assets in the 1990s and 2000s as they did in the 1970s and 1980s. Strikingly, without our mechanism the model fails to generate a meaningful increase in average cash ratios and predicts that the average cash ratio would have increased by only 2.1%, roughly 1/4 of the overall increase both in the data and in the full model response. As such, this counterfactual implies that about 3/4 of the overall increase can be attributed to the rise in intangible capital, which corresponds to an increase of 6.2% in the average cash ratio. Switching off the alternative mechanisms, while still allowing intangible capital to rise, has a more subdued impact on the predicted change. For example, without the increase in cash flow volatility the model predicts that the average cash ratio would have increased by 6.9%, which is still a sizable increase. This counterfactual implies that less than 1/5 of the increase in cash ratios can be attributed to the increase in cash flow volatility. For equity issuance costs, despite their sizable impact on cash ratios, if anything they appear to have mitigated the upward trend because the data indicates that they have come down in recent times. In all, the results of the first part of our analysis indicate that intangible capital is a quantitatively important force behind the secular trend in corporate cash ratios, both relative to the data and to the alternative forces we considered.

In the second part of the analysis, we go beyond simple averages. We confront the model-implied size distribution of cash with its empirical counterpart to address two additional questions. First, does the model match the heterogeneity in cash holdings between small and large firms that we observe in the data? In the data, small firms have higher cash ratios than large firms. The model matches closely the magnitude of the cross-sectional differences between the cash ratios of firms at the opposite ends of the size distribution (bottom vs. top decile), which is 7.4% in the data and 7.1% in the model. It also fits well the highly skewed concentration of cash levels, with the model-implied share of aggregate cash held by the largest firms (top size decile) matching closely its empirical counterpart at about 70%. The intuition is that, as we show using model-implied estimates of the opportunity-cost of cash, even large firms hold cash to preserve financial flexibility because they want to save on the cost of external finance - i.e., they prefer not to issue equity - when growth opportunities arise. Second, how much of the cross-sectional differences in the evolution of cash ratios for firms at different points of the size distribution can our model explain? The model does a good job at accounting quantitatively for the bulk of the upward trend in cash ratios of firms at each point of the size distribution. For example, it fully explains the doubling of the cross-sectional spread between the cash ratios of small and large firms, which went from 4.7%to 9.5% in the data and from 4% to 7.4% in the model. And it generates a stronger upward trend in cash ratios for smaller firms and accounts for over 2/3 of the difference between the increase in cash ratios of small vs. large firms, which is about 4.8% in the data. Finally, these results are achieved with the cross-sectional concentration of cash levels staying stable, as it did in the data. As a result, our proposed mechanism also accounts for at least 3/4 of the increase in the aggregate cash ratio. This second set of results lend additional credibility to our proposed mechanism, as they show that it can account for the behavior not just of the average firm in the US corporate sector, but also of a large swath of different firms and of the sector as a whole.

We further probe the plausibility of the relation between cash and intangible capital using regression analysis. First, we confirm that the positive relation between cash and intangible capital also holds after controlling for a standard set of covariates that include cash flow volatility and firm size. The relation is robust to using the measure of intangibles by Peters and Taylor (2017), a measure based on BEA data from DellAriccia, Kadyrzhanova, Ratnovski, and Minoiu (2020), as well as another validity check that uses principal component analysis to extract a common latent intangible factor to aggregate the three sub-components of our measure instead of taking their sum, among several batteries of specification checks. The reduced-form estimates confirm the quantitative importance of intangible capital, as they imply that more than 40% of the predicted increase in cash can be attributed to the rise in intangible capital.

Second, to address potential omitted variable concerns we examine more saturated specifications that add controls for other covariates of cash that have been proposed in the recent literature, including industry competition (Morellec, Nikolov, and Zucchi (2014)), taxes (Faulkender, Hankins, and Petersen (2019)), interest rates (Azar, Kagy, and Schmalz (2016)), selection by young and newly listed entrants (Begenau and Palazzo (2019)), employee equity compensation (Sun and Xiaolan (2019)), and corporate profits (Chen, Karabarbounis, and Neiman (2017)). The estimates confirm that these alternatives are indeed significantly related to cash in the cross-section. However, the coefficient estimate on intangible capital remains stable even after adding these controls, suggesting that omitted variables are unlikely to be driving the result. Finally, while the reduced-form evidence does not rule out alternative mechanisms, additional evidence from the relation between cash and patent pledgeability following the work of Mann (2018) indicates that the collateral mechanism is economically significant, with the treatment effect of patent pledgeability on cash ratios estimated at about 2% to 3%.

We make two main contributions. First, we develop a calibratable model of liquidity management (see Froot, Scharfstein, and Stein (1993) for a model of corporate liquidity) and use it to establish the quantitative importance of a new mechanism, rising intangible capital, for the secular trend in cash.² In addition, we contribute to the classical literature on collateral (Shleifer and Vishny (1992), Hart and Moore (1994), Rampini and Viswanathan (2010)) by examining the connection with cash in a setting that is parsimonious enough to bring this class of models closer to the data. As such, ours is the first attempt to quantify the importance of the collateral mechanism for the secular changes in corporate liquidity.

A related contribution is that we also use the model to quantify the strength of other forces that have been set forth in the literature such as, for example, changes in cash flow volatility (see, for example, Bates, Kahle, and Stulz (2009)).³ The contribution here is that we provided complementary model-based estimates of the quantitative importance of these forces, which so far have been studied mainly in reduced form (see Graham and Leary (2018) for a comprehensive overview). As such, our calibrated model provides the first comprehensive quantitative assessment of key forces behind the secular evolution of corporate liquidity.

Second, we contribute to the small but growing literature on intangible assets in finance. Eisfeldt and Papanikolaou (2013) examine the link between one type of intangible asset, organization capital, and the cross-section of stock returns. Peters and Taylor (2017) show that intangible capital helps to improve the performance of standard q-theory, as investment is better explained by Tobin's q and less sensitive to cash flow in firms and years with more intangible capital, as also confirmed by Andrei, Moyen, and Mann (2019). Our contribution to this literature is to examine the relation between intangible capital and corporate financial policies. Our results indicate that there is an important connection between intangible capital and the balance sheet and liquidity management decisions of U.S. corporations. Thus, our work indicates that expanding the reach of the literature

²Other models of liquidity management in this literature include Riddick and Whited (2009), Bolton, Chen, and Wang (2011), Nikolov and Whited (2014), Gamba and Triantis (2008), Hugonnier, Malamud, and Morellec (2013), Begenau and Palazzo (2019), Morellec, Nikolov, and Zucchi (2014), Armenter and Hnatkovska (2017). There are also recent studies by Bolton, Chen, and Wang (2013), Eisfeldt and Muir (2016) and Warusawitharana and Whited (2015), which focus on the short-run fluctuation of cash associated with equity market timing.

³There is a large and established empirical literature that, starting with Opler, Pinkowitz, Stulz, and Williamson (1999), has highlighted several other determinants of cash, including taxes (Foley, Hartzell, Titman, and Twite (2007), Faulkender, Hankins, and Petersen (2019)), industry competition (Morellec, Nikolov, and Zucchi (2014)), interest rates (Azar, Kagy, and Schmalz (2016)), and agency issues (Dittmar and Mahrt-Smith (2007)). See Graham and Leary (2018) for a comprehensive overview.

beyond traditional firms and toward the financing decisions of innovative firms, which rely heavily on intangible assets, is a promising direction to improve our understanding of the balance sheets of U.S. firms and their evolution.

2 Intangible Capital and the Rise in Cash: Stylized Facts

The central message of our theory is that there is a link between the rise in intangible capital and the rise in corporate cash holdings. In this section, we construct a measure of intangible capital from micro data for a large sample of 18,535 US corporations over the 1970 to 2010 period.⁴ We use the measure to detail the stylized facts of the relation between intangible capital and corporate cash holdings. Specifically, we show that the relation holds in the time-series and take a first step toward examining cross-sectional differences in the evolution of cash among firms, especially with respect to size.

Although investments in intangible assets are expensed in the year in which they are incurred, the capital that is created by such investments is not reported on firm balance sheets.⁵ We overcome this hurdle by constructing a measure which is defined for each firm-year as the sum (divided by net book assets) of the capital accumulated through three types of intangible investments whose importance has been emphasized in the literature on the economics of innovation (Corrado, Hulten, and Sichel (2009) and Corrado and Hulten (2010)): knowledge capital, organizational capital, and informational capital.⁶

 $^{^{4}}$ The sample includes 176,877 firm-year observations from Compustat. As it is standard in the literature, we exclude financial firms (SIC codes 6000-6999), regulated utilities (SIC codes 4900-4999), and firms with missing or non-positive book value of assets and sales in a given year.

⁵The only exception is the (fair value of) intangibles assets that are acquired via mergers and acquisitions (M&As), which can be booked as assets and are included in the "intangibles" (item #33) in Compustat. Since this variable also includes goodwill and excess cost or premium of acquisition, which are unrelated to the economic definition of acquired intangible assets but rather measure over-payment in mergers, we opted for not including this variable in our baseline measure of intangible capital used in the main analysis. However, both our stylized facts and supporting evidence are robust to using an "augmented" version of the baseline measure that also includes the "intangibles" item 33 from Compustat. See Appendix C for additional details.

⁶Existing attempts at measuring intangible capital empirically have been mostly in macroeconomics and, thus, involve constructing aggregate measures of intangible capital for the US economy. For example, one approach is to construct a proxy using aggregate stock market or accounting data (Hall (2001) and McGrattan and Prescott (2007)). While these approaches measure intangibles as unexplained (by physical capital) residuals of stock market value or firm productivity, a more direct recent approach is to construct aggregate measures of the different components of intangible capital, which include the stock of assets created by R&D expenditures, brand equity, and human and organizational capital using NIPA accounts (Corrado, Hulten, and Sichel (2009) and Corrado and Hulten (2010)).

Knowledge capital is measured by capitalizing R&D expenditures using the perpetual inventory method with depreciation rate of 15% (Hall, Jaffe, and Trajtenberg (2000)). This is consistent with the new approach adopted by the Bureau of Economic Analysis (BEA) in 2013 for the National Income and Product Accounts (NIPA). Organizational capital is defined as capitalized Selling, General, and Administrative (SG&A) expenses with depreciation rate of 20% (Lev and Radhakrishnan (2005), Eisfeldt and Papanikolaou (2013)). These expenditures enhance the value of brand names and other knowledge embedded in firm-specific human capital and include employee training costs, payments to management and strategy consultants, and distribution systems. Since SG&A expenditures include other expenses unrelated to investments in organizational capitalities, we follow Corrado, Hulten, and Sichel (2009) and only weigh the stock of organizational capital by 0.2.⁷

Finally, informational capital is constructed by capitalizing expenditures on computerized information and software with a depreciation rate of 31% following BEA. Since these expenses are not reported at the firm level, we use the annual (2-SIC) industry level BEA Fixed Reproducible Tangible Wealth (FRTW) data. We then construct a multiple of this stock to tangible capital stock at the industry level and apply the multiple to each firm's tangible capital stock (PPE) to derive a firm-level stock.⁸ On average, our resulting estimate for the ratio of intangible to tangible capital over the 2000s is close to 1, which is comparable to the estimate in Corrado, Hulten, and Sichel (2009) based on aggregate NIPA accounts.

To further cross-validate our measure, we examined its correlation with other related proxies that have been used in the literature. The correlation between our measure and other measures is high. For example, the firm-level intangible capital measure of Peters and Taylor (2017) and our measure have a correlation of 0.98. An industry-level measure based on the BEA Fixed Assets data used in DellAriccia, Kadyrzhanova, Ratnovski, and Minoiu (2020) (see their Appendix for details) has a correlation of 0.51 with our overall measure and of 0.60 with our measure of knowledge capital, which is reassuring since the BEA measure is narrower than ours and mainly includes R&D expenditures by both publicly-traded and private firms in a given industry.

⁷We have explored alternative weights in a wide (+/-50%) range, which leave our results qualitatively unchanged. ⁸Our results are little changed if we exclude informational capital.

Figure 1 illustrates the time-series of intangible capital and cash by plotting annual averages across firms of their respective ratios to book value of assets (left and middle panels, respectively) over the last four decades. For reference, we also plot average net debt ratios (right panel) to illustrate the implications of the rise in cash for net-indebtedness. The intangible ratio rose fivefold from about 20% of book assets (net of cash) in 1970 to about 90% in 2000s. The share of cash on the balance sheets of U.S. corporations also displayed a pronounced upward trend, with cash ratio growing on average from 9% to 20% between the beginning and the end of our sample period. The secular trend in cash was steady and not concentrated in any particular decade. And it led to a downward trend in net-indebtedness of U.S. firms, with net-leverage going down on average from 20% to 6%.

Figures 2 and 3 take a first step toward exploring cross-sectional differences in the trends by plotting annual averages of cash and intangible capital by sub-groups of firms based on size (Panel a), industry (Panel b), and age (Panels c-d). Two clear patterns emerge: first, both trends are broadbased, with cash and intangible capital trending up robustly across all the sub-groups of different types of firms. The evidence that the trend in cash was broad-based is in line with previous papers on the secular trend in cash, including Chen, Karabarbounis, and Neiman (2017), who find that the rise in cash is predominantly a within-firm phenomenon, and Bates, Kahle, and Stulz (2009), who find that changes in standard firm characteristics have limited explanatory power for the trend. For intangible capital, the evidence suggests that the secular trend was an economy-wide shift in firms' mode of production that affected a broad swath of different types of firms, not just firms in high-tech sectors. As such, it is unlikely to be simply a manifestation of changes in other firm characteristics, an issue we address carefully later in Section 5 on supporting evidence. Second, there is systematic cross-sectional variation in the trends, which are relatively more pronounced for smaller firms and in high-tech sectors. On the other hand, there is little evidence of differential trends by firm age.⁹

⁹Appendix Figures A1-A4 further detail the trends and show that knowledge and organizational capital are behind the rise in intangible capital (Figure A1), which is not sensitive to the parametric assumptions behind our measure (Figure A2). We also show that the rise in cash is not sensitive to the choice of denominator for the cash ratio (Figure A3) and that the relation between cash and intangible capital is not just driven by young firms, as cash displays an upward sloping relation with intangible capital also for incumbent firms (Figure A4).

Finally, turning to the aggregate facts, Figure 4 shows that there was an upward trend also in aggregate cash ratios, though the trend for aggregate cash ratios was weaker than the trend for average cash ratios. This evidence is consistent with the cross-sectional fact about the stronger upward trend in the cash ratio of small firms. As shown in the bottom panels, the size distribution of cash holdings in levels is highly skewed, with the largest firms (top size decile) holding the bulk of aggregate cash. Even then, the fact that smaller firms experienced such a large increase in their cash ratios makes them an important factor behind the trend in aggregate cash. Thus, for our mechanism to be successful at matching the aggregate trends quantitatively, it is critical that it accounts not only for the average trends, but also for the cross-sectional differences between the cash trends of small vs. large firms.¹⁰

The stylized facts presented in this section indicate that there is a strong link between cash and intangible capital in the time-series and that there are interesting cross-sectional differences especially between large and small firms, both of which we use to confront the model in our quantitative analysis.

3 A Structural Model of Corporate Cash Management

This section develops a dynamic model of corporate cash management in which firms make optimal financing and liquidity decisions as well as decisions to invest in tangible and intangible capital in the presence of financial market frictions.

3.1 Technology

The firm combines two types of capital to produce output, tangible capital (K_T) and intangible capital (K_N) . In particular, the operating income of the firm is given by

$$\Pi(Z, K_T, K_N) = Z^{1-\gamma} \Phi(K_T, K_N)^{\gamma} - ZF^o$$
(1)

 $^{^{10}\}mathrm{See}$ Appendix D for additional cross-sectional stylized facts by industries and within-firm.

where Z is an idiosyncratic productivity shock that follows a geometric random walk,

$$\log Z' = \log Z + \log \eta', \ \log \eta \sim N(-0.5\sigma_z^2, \sigma_z^2),$$

and γ is the curvature of the profit function, which reflects either the degree of decreasing returns to scale (DRS) or the market power of the firm.¹¹ $\Phi(K_T, K_N)$ is a capital aggregator that combines the services of the two types of capital, and ZF^o is the fixed cost of operation, which, in order to keep the firm maximization problem stationary, is assumed to be proportional to the current technology level. The capital aggregator takes a general constant elasticity of substitution (CES) functional form:

$$\Phi(K_T, K_N) = \left[\theta\left(\frac{K_T}{\theta}\right)^{-\rho} + (1-\theta)\left(\frac{K_N}{1-\theta}\right)^{-\rho}\right]^{-1/\rho},\tag{2}$$

where the elasticity of substitution is given by $1/(1 + \rho)$.

To be able to assess the link between the illiquidity of capital assets and corporate liquidity demand, we follow Abel and Eberly (1994) and assume that the adjustment of both types of capital is costly and involves fixed costs (or so-called non-convex adjustment costs), F_i^K per unit of capital stock for i = T, N. We can then express the total adjustment costs of the capital stock as

$$G(K'_{T}, K'_{N}, K_{T}, K_{N}) = \sum_{i=T,N} G_{i}(K'_{i}, K_{i})$$
(3)

where the type-specific adjustment cost function for tangible and intangible capital is given by

$$G_i(K'_i, K_i) = [K'_i - (1 - \delta_i)K_i] + F_i^{\kappa}K_i, \text{ for } i = T, N$$
(4)

and δ_i denotes the type-specific depreciation rate of capital.

¹¹Throughout the paper, we will denote future variables by primes.

3.2 Financing Frictions

Firms have access to three sources of financing: (i) internal funds; (ii) debt; and (iii) outside equity. The debt and equity market frictions laid out below make capital structure decisions deviate from the Modigliani-Miller theorem and introduce non-trivial trade-offs in firm financing choices.

3.2.1 Debt Market Friction

We denote the outstanding debt of the firm by B and new issuance by B'. Since in our setting it is never optimal for the firm to issue debt and hold cash at the same time, we can use B to also denote the firm's liquid asset position, with B < 0 denoting firm's cash holdings. More generally, one can think of B as the net-debt position of the firm.¹²

It is well established in the literature that tangible assets support more debt (see Hart and Moore (1994), Shleifer and Vishny (1992) and Rampini and Viswanathan (2010) for theoretical arguments, and Sibilkov (2009) for empirical evidence). This is because intangible capital is difficult to verify in quality or in quantity. In fact, it often embodies the human capital of developers, which cannot be easily transferred to a third entity partially or entirely. As a consequence, intangible capital is rarely pledged as collateral in debt contracts. To capture this feature, we assume that the firm cannot commit to transfer the technology embodied in the intangible capital stock to creditors upon default.

As in Hart and Moore (1994), we also assume that the firm's output is observable, but not verifiable by a court. Hence, no debt contract can be written on the outcome of the firm's output. Under these circumstances, as shown by Kiyotaki and Moore (1997), the only possible form of debt contract is a risk-free debt contract collateralized by capital assets. We differ from Kiyotaki and Moore (1997) in that we introduce intangible capital in production and assume that only tangible

 $^{^{12}}$ In order to preserve tractability, we do not introduce additional frictions in the adjustment of the firm's financial accounts, such as issuance/refinancing costs for debt, which would make frequent refinancing of debt costly. These frictions would lead the firm to *simultaneously* hold debt and liquid assets, an issue that is beyond the scope of the paper, which is to explain secular, low frequency movements in cash.

capital assets constitute eligible collateral. The resulting contract for risk-free debt is subject to the following borrowing constraint:

$$B' \le \bar{B}(K'_T) \equiv \frac{(1 - \delta_T)K'_T}{1 + r(1 - \tau)},\tag{5}$$

where τ denotes the corporate tax rate and r is the risk-free rate. Note that the constraint is an occasionally binding one in our environment and that the collateral value does not depend on the realization of the shock at date t + 1.¹³ The assumption that intangible assets cannot be used as collateral is broadly factual. Using a large sample of syndicated loans to US corporations for which a detailed breakdown of types of collateral used is available, we have verified that contractual loan terms state that only assets that can be easily valued represent eligible collateral.¹⁴ Consistent with the legal definition of eligible collateral, only an extremely small minority of secured syndicated loans (about 3% of total loan value) have patents or brands used as collateral.For later reference, we define the financial slack of the firm as $\bar{B}(K'_T) - B'$. The literature has recognized other instruments that firms can use to preserve debt capacity, such as, for example, financial derivatives (Rampini and Viswanathan (2013)), and has examined a richer menu of borrowing instruments, such as leasing. Our marginal contribution is to highlight the role of cash and explore the time-series implications for its secular trend within a calibratable setting with adjustment costs and equity issuance.

3.2.2 Equity Market Friction

If there were no equity market frictions, the firm could undo debt market frictions at no cost by issuing new equity whenever necessary. Therefore, to create scope for active liquidity management

 $^{^{13}}$ Another closely related paper is Rampini and Viswanathan (2013) who recently developed a model of investment, capital structure and risk management in a setting where only tangible capital can be used as collateral. Our model differs from Rampini and Viswanathan (2013) in that it has a richer real side that allows for capital illiquidity. In addition, their financial side considers a state contingent contract based on the realized cash flow, while in our setting the debt contract cannot be contingent upon the realized cash flow. These features allow us to analyze how both real and financial frictions contribute to precautionary savings in a quantitative setting.

¹⁴Using an additional data source, Capital IQ, which covers a smaller cross-section of firms (about 1,000 per year) and a shorter time-series (2002-2010) but has detailed information on firm debt structure, we have verified that the median ratio of secured to total debt value is about 80%. We also find a similar pattern in the loan information from a 2011 extract of Loan Pricing Corporation's (LPC) Dealscan database, which consists of dollar-denominated private loans made by banks (e.g., commercial and investment) and nonbank lenders (e.g., insurance companies and pension funds) to U.S. corporations during the period 1981 to 2010, which includes about 90,000 loans. Most of the loans in this dataset are senior secured claims, features common to commercial loans. However, a detailed breakdown of collateral types is available for only 20,000 loans. Finally, median leverage and net leverage for firms with very little tangible capital are 2% (0%) and -15% (-16%) for the bottom decile (quintile) of tangibility, respectively.

policies, we assume that equity issuance, denoted by E, is costly. In particular, we assume that equity issuance costs take the following parametric form:

$$\varphi(E) \equiv \varphi_0 \sum_{i=T,N} K_i + \varphi_1 E,\tag{6}$$

The firm incurs a fixed cost of issuing new equity, φ_0 , which is proportional to its size measured by the book value of capital assets $\sum_{i=T,N} K_i$. It also faces a linear cost, φ_1 , that is proportional to the amount issued. This functional form is standard in the literature and facilitates comparison with Bolton, Chen, and Wang (2011), who show that fixed costs of equity issuance significantly strengthen firms' precautionary demand for cash.¹⁵

3.3 Value Maximization Problem

To ease presentation of the value maximization problem of the firm, we introduce three indicator variables: $\nu_T^K \in \{0, 1\}, \nu_N^K \in \{0, 1\}$, and $\nu^E \in \{0, 1\}$. These indicators denote the action/inaction status of the firm regarding the adjustment of tangible capital stock, the adjustment of intangible capital stock, and equity issuance, respectively. The action/inaction margin is a consequence of the presence of fixed costs of investment and equity issuance. We collect the status of these three decisions in a single element of the Cartesian product, $\nu \in \{(0,1) \times (0,1) \times (0,1)\} \equiv \mathbb{V}$. For instance, $\nu = (1,1,1)$ indicates a policy regime in which the firm makes non-zero adjustments for both tangible and intangible capital and its financial policy involves issuance of new shares. With this additional piece of notation in hand, we can define dividend payouts as

$$D(\nu) = (1-\tau)\Pi(Z, K_T, K_N) - \sum_{i=T,N} [\nu_i^K G_i(K_i', K_i) - \tau \delta_i K_i] - [1 + r(1-\tau)]B + B' + \nu^E E \quad (7)$$

We assume that the dividend payouts are subject to a nonnegativity constraint¹⁶.

 $^{^{15}}$ While (6) is exogenously imposed to the firm problem, such a cost can arise endogenously when outside investors face uncertainty about the value of capital in place and investment opportunity of the firm as shown by Myers and Majluf (1984). As is standard in the literature, our equity issuance costs are aimed at capturing in a parsimonious way the consequences of these underlying information frictions.

 $^{^{16}\}mathrm{For}$ simplicity, we abstract from dividend taxation.

The firm problem can be defined in recursive form as the maximization of the value of equity

$$W(K_{T}, K_{N}, B, Z) = \min_{\lambda, \mu} \max_{E, K_{T}', K_{N}', B', \nu} \left\{ (1+\lambda)D(\nu) - \nu^{E}[E + \varphi(E)] + \mu[\bar{B}(K_{T}') - B'] + \frac{1}{1+r} \int W(K_{T}', K_{N}', B', Z')Q(Z, dZ') \right\}.$$
(8)

Q(Z, dZ') is the transition function of Z, and λ and μ are the Lagrange multipliers associated with the nonnegativity constraint for dividends and the collateral constraint for debt financing, respectively. The term $1 + \lambda$ can be interpreted as the shadow value of internal funds.

The objective function and the constraint correspondences of problem (8) are jointly homogenous of degree 1 in $(K_T, K_N, B, K'_T, K'_N, B', Z)$. We can exploit this property to reduce the dimensionality of the problem and the computational burden involved in solving it numerically. More specifically, we can normalize the firm problem by the level of current technology such that $W(K_T, K_N, B, Z)/Z = W(K_T/Z, K_N/Z, B/Z, 1) \equiv w(k_T, k_N, b)$ where the normalized state variables are defined as $k_T \equiv K_T/Z$, $k_N \equiv K_N/Z$ and $b \equiv B/Z$. We also define a series of normalized policy variables: $e \equiv E/Z$, $\tilde{b}' \equiv B'/Z$, $\tilde{k}'_T \equiv K'_T/Z$, and $\tilde{k}'_N \equiv K'_N/Z$. It is straightforward to show that the problem given by (8) is equivalent to

$$w(k_{T}, k_{N}, b) = \min_{\lambda, \mu} \max_{e, \tilde{k}_{T}', \tilde{k}_{N}', \tilde{b}', \nu} \left\{ (1 + \lambda) d(\nu) - \nu^{E}[e + \varphi(e)] + \mu[\bar{b}(\tilde{k}_{T}') - \tilde{b}'] + \frac{1}{1 + r} \int \eta' w \left(\frac{\tilde{k}_{T}'}{\eta'}, \frac{\tilde{k}_{N}'}{\eta'}, \frac{\tilde{b}'}{\eta'} \right) dH(\eta') \right\},$$
(9)

where $w(k_T, k_N, b)$ is the normalized conditional value function and

$$d(\nu) = (1-\tau) \left[\Phi(k_T, k_N)^{\gamma} - F^o \right] - \sum_{i=T,N} \left[\nu_i^K g_i(\tilde{k}_i', k_i) - \tau \delta_i k_i \right] - \left[1 + r(1-\tau) \right] b + \tilde{b}' + \nu^E e.$$
(10)

The normalized adjustment costs, $g_i(\tilde{k}'_i, k_i)$, and debt capacity, $\bar{b}(\tilde{k}'_T)$, can be constructed in a straightforward manner because they are linear. Finally, $H(\cdot)$ denotes the lognormal cdf of η .

3.4 Properties of Capital Accumulation and Financial Policies

We now discuss some key qualitative properties of the optimal firm investment and financing policies, which we denote by $\tilde{k}'_T(k_T, k_N, b)$, $\tilde{k}'_N(k_T, k_N, b)$, and $\tilde{b}'(k_T, k_N, b)$. A detailed characterization of these efficiency conditions is provided in the Appendix.

Panel A of Figure 5 plots the tangible and intangible investment policy functions of the model against the tangible capital stock k_T and the intangible capital stock k_N , respectively. For each policy, the other two state variables are fixed to their median values from our stochastic simulation. All parameters are set to the calibrated values for the full sample in Table 1. The two graphs contrast two different levels of asset tangibility θ , higher for the thick black line and lower for the thin blue line.

The red lines are drawn to denote $(1 - \delta_i)k_i$. If \tilde{k}'_i coincides with the red line, the firm's capital stock k_i is in a region of inaction. The vertical black dotted lines delimit the inaction region for the case with high asset tangibility, while the vertical blue dashed-dotted lines delimit the inaction region for the case with low asset tangibility. If k_i is smaller than the lower bound of the inaction region or greater than its upper bound, the next-period capital stock jumps to its target. For example, the firm waits until its capital stock is sufficiently larger than its disinvestment target before making a downward capital adjustment. In both cases, the non-convex adjustment friction leads the firm to avoid frequent adjustments of its capital stock.

In both plots, the thin blue lines shows that, as technology shifts toward increased reliance on intangible capital, the target for tangible capital shrinks, while the one for intangible capital rises. This is because, even though we allow for substitution between the two types of capital in the short-run, a significant deviation from the long-run tangible capital ratio is costly in terms of firm profitability.

Panels B and C of Figure 5 illustrate the key properties of the firm's liquidity (cash) and financial (debt) policy. Again, all graphs contrast two different levels of asset tangibility θ , higher for the thick black line and lower for the thin blue line, and the vertical lines delimit the investment inaction

regions. Because in the model firms never optimally hold cash and debt simultaneously, cash is zero when debt is positive and vice versa, as a comparison of Panel B and Panel C highlights.

In Panel B, the thick black lines shows that, while some features of the policies depend on parameterizations, optimal cash holding decisions are tightly linked to the arrival of investment opportunities. In the absence of financing frictions, corporate saving would be unnecessary as outside funding could be tapped costlessly. When firms face costly external financing because of equity flotation costs and collateral constraints, corporate savings become valuable in anticipation of investment spending. Firms accumulate cash to the right of the divestment action boundary, where they face lower external financing needs to cover investment spending. Panel C shows that firms heavily borrow to finance investment after the investment boundary to the left of the inaction region. Importantly, while the tangible capital stock limits the firm's debt capacity, firms allocate this debt capacity to financing intangible investment as well. As a consequence, for small values of intangible capital, the stock of debt can exceed the current intangible capital stock. In addition, firms use debt financing to cover income shortfalls that are due to the presence of fixed operating costs, F_0 . This effect increases reliance on external debt towards the left of the inaction region.

Finally, the thin blue lines in Panel B indicate that corporate savings increase when the asset tangibility parameter, θ , decreases. As technological change increases the firm's reliance on intangible capital, its ability to pledge collateral for debt financing is limited, which strengthens the precautionary motive to hold cash. By converse, the tighter collateral constraint leads to less reliance on debt financing.

4 Quantitative Results

How much of the rise in cash can be accounted for by the rise in intangible capital? In this section, we use a calibration approach to confront the model with data and evaluate the quantitative importance of our proposed mechanism. We start by detailing the calibration and model fit. We then present the main result on the importance of intangible capital using a quantitative counterfactual

exercise. While the primary focus of the analysis is on sizing up how much of the secular trend in cash we can account for with our proposed mechanism, we also examine the ability of the model to account for a broader set of key corporate financing decisions, including leverage and equity issuance, as well as the contribution of other mechanisms that have been proposed in the literature, including changes in firm cash flow risk and interest rates. In the second part of the quantitative analysis, we turn to the model's implications for the cross-sectional size distribution of cash holdings and for the evolution of aggregate cash holdings in the U.S. corporate sector.

4.1 Calibration and Model Fit

Our baseline calibration is summarized in Table 1. The frequency of our calibration is annual. The model features 12 parameters, 8 of which are on the technology side and 4 on the financing side. Starting with the technology-side parameters, we set the elasticity of the profit function with respect to capital, γ , to 0.6, following previous studies (for instance, Hennessy and Whited (2007)). The asset tangibility parameter, θ , which determines the mix between tangible and intangible capital, is new to the literature and we set it to match the average mix of these two types of capital – the ratio of tangible to total capital – in the data. The depreciation rates of each type of capital can also be directly measured in the data and we choose them to fit the average depreciation rates for tangible and intangible capital in our sample, which is the standard approach. The resulting values of 0.12 and 0.19 for tangible and intangible capital, respectively, are comparable to those used in previous studies. For example, Gomes (2001) uses a depreciation rate of 0.145 and Riddick and Whited (2009) use 0.15 for tangible capital. Higher depreciation rates for intangible capital are supported by existing evidence (see, for example, Table 5 in Hall (2005), which uses micro data to estimate a depreciation rate for R&D of 0.19). The elasticity of substitution between the two types of capital, ρ is the only parameter for which we have limited guidance from either data or previous studies. We set it to 1, which implies a relatively high elasticity of 0.5 $(= 1/(1 + \rho))$, to show how far the baseline calibration can go toward accounting quantitatively for the rise in cash even when firms can substitute relatively easily away from intangible capital in their production needs. This is a conservative choice because firms will need less cash if they can use real hedging instead of financial hedging. That said, we ensure that the results are not driven by this particular parameter choice by performing an extensive set of sensitivity checks to varying the elasticity of substitution over a relatively wide range that includes even higher values than the baseline (see Appendix Table A2).

For the fixed cost of investment, $F_N^{\kappa} = F_T^{\kappa}$, we choose a value on the low end of the range, 0.005 of installed capital or, under our baseline calibration, 1.47% of sales. Using plant-level data for manufacturing. Cooper and Haltiwanger (2006) estimate a fixed adjustment cost of about 0.04 of installed capital (or about 20% of sales), which is at the high end of the range of existing estimates. Using the same plant-level data, Caballero and Engel (1999) estimate fixed adjustment costs of about 16% of sales. We use a lower value because investment is less lumpy at the firm-level. For example, the annual frequency of large investment spikes (defined as investment rates in excess of 20%) is about 19% at the plant-level (see Table 1 in Cooper and Haltiwanger (2006)), but it is only about only 4% at the firm-level for the median industry in our sample. We calibrate this parameter following Bloom (2009), which using firm-level data estimates fixed adjustment costs of 1.5% of sales, at about a tenth of the plant-level estimates. We perform sensitivity checks also on this parametric choice (see Appendix Table A2). The fixed cost of operation, F^{o} , is chosen to approximately match average profitability in our sample, which leads to a value of 0.069 of steady state capital. For the idiosyncratic volatility of the technology shock, we set the annual standard deviation, σ_z , to 0.35. This value is chosen to match its empirical counterpart. Specifically, we construct idiosyncratic profitability as the estimated residual from a regression of firm-level profitability on common factors, which we proxy for using average industry-level (4SIC) profitability in any given year. The standard deviation of the change in the estimated residual in our sample is 0.35. This value is in line with previous studies. DeAngelo, DeAngelo, and Whited (2011) estimate a value of 0.2853; Li, Whited, and Wu (2016) report estimates ranging from 0.394 to 0.458; Nikolov, Schmid, and Steri (2019) report a value of 0.283, which is similar to Riddick and Whited (2009).¹⁷

Turning to the 4 parameters on the financial side, the risk free rate is calibrated as 0.011, equal

¹⁷We have examined the sensitivity of our estimate to using different specifications to construct idiosyncratic volatility, including using coarser industry groups at the SIC3 or SIC2 level, or using the "market model" with the market factor proxied by average economy-wide profitability in any given year. These three alternatives lead to implied estimates for σ_Z of 0.35, 0.36, and 0.36, respectively.

to the average one-year (real) Treasury rate over the sample period, which is a standard approach in the literature. We set the fixed cost of equity issuance approximately to 1% of the capital stock, following Bolton, Chen, and Wang (2011). We then set the proportional equity issuance costs to approximately match average equity issuance in the data. The value we use for proportional costs (0.015) is also comparable to previous studies. For example, Gomes (2001) uses a value of 0.028. Using our calibrated values for the equity issuance costs and the asset tangibility moment, we can back out the implied average underwriting fees relative to the overall size of proceeds, which are equal to 5.78%.¹⁸ This value is closely aligned with the estimate of 5.38% for average underwriting costs of common stock offerings relative to overall size of proceeds in Altinkilic and Hansen (2000) and with the fee of 50,332 for the first million dollars of gross equity proceeds in Hennessy and Whited (2007). Finally, following Nikolov and Whited (2014), we set the corporate tax rate to 0.20, as an approximation of the statutory corporate tax rate relative to personal tax rates.

Table 2 summarizes overall model fit for the baseline parametrization by comparing the modelimplied moments, which are tabulated in the second column, with their empirical counterparts, tabulated in the first column.¹⁹ Overall, despite being quite parsimonious, the model is successful at matching quantitatively the core financing policies of US firms. As shown in Panel A, the model matches closely the magnitudes of our two main untargeted financial quantities of interest, the average cash- and debt-to-asset ratios, which are about 14% and over 20% in the data, respectively. The model also matches well the average size and frequency of equity issues. This close fit is achieved for an empirically plausible parametrization, because the model also reproduces the empirical counterparts of the targeted real moments, the average mix of tangible and intangible assets and profitability, on the real side. Panel B provides additional external validation of model

$$\frac{c}{E} = \frac{1}{1 + \varphi_1} \left(\frac{\varphi_0}{\frac{E}{K_T} \cdot tang} + \varphi_1 \right).$$

¹⁸In the model, underwriting fees c (in USD) are implicitly defined as $c = \varphi_0(K_T + K_N) + \varphi_1(E - c)$. Rearranging the previous equation and using estimates of tangibility conditional on issuance tang and the size of equity issuance relative to tangible capital $\frac{E}{K_T}$ one can back out $\frac{c}{E}$ as

¹⁹To compute the data moments, we trim all variables at 2.5%, which is a standard approach to ensure comparability with the modelimplied moments (see, for example, Hennessy and Whited (2007), which uses trimming at 2%). We have examined sensitivity to different cutoffs, including trimming at 2% and at 1% and winsorizing at 2.5%, at 2%, and at 1%. These five alternatives lead to data moments for our main financial variables of interest that are close to the baseline. For example, the mean cash ratio is 0.142, 0.146, 0.152, 0.153, and 0.154, respectively.

fit by considering higher-order non-target moments, such as the error variance of profits, the autocorrelation of cash, and the skewness of tangible and intangible investment. The model-implied magnitudes of these additional non-targeted moments are also close to the data. That said, the model slightly overestimates some of these higher-order moments, especially the skewness of investment, suggesting that allowing for a richer adjustment cost function with asymmetric adjustment costs between investment and disinvestment, or costly irreversibility, could be a potentially useful extension to further improve model fit.

Finally, the third column offers another yardstick to evaluate model fit. We tabulate modelimplied moments for the polar case when all parameters are set as in the baseline calibration except for θ , which is now set equal to one. In this polar case, our model is similar to the traditional workhorse dynamic corporate finance benchmark where firms use only tangible capital in their production technology. Strikingly, the average cash-to-assets ratio in this economy is an order of magnitude smaller than its empirical counterpart, at only about 2.1%. Intangible capital helps to improve model fit both on the real and financial sides. It helps to account for the fact that US firms are heavily reliant on intangible assets in their mode of production, but also turns out to be critical to account for why they rely on internal financing so much. As such, the comparison to the traditional benchmark provides a first indication that intangible capital is a quantitatively important force behind cash holdings.

4.2 Baseline Quantification of the Impact of Asset Tangibility on the Rise in Cash

Tables 3 and 4 report the parametrization and results of our main quantitative experiment. The experiment is designed to reproduce the magnitude of the technological transformation involving the shift of U.S. firms toward intangible capital in the data. Specifically, we choose the asset tangibility parameter, θ , so that the mix between the two types of capital matches its empirical counterpart in the first vs. second half of the sample. To capture the time-series trend over the four decades that span our sample period, we divide the sample into two sub-samples, one for the first half and the other for the second half of the overall 1970-2010 period. To focus on long-term variation behind

the trend rather than short-term year-to-year changes, we take the mid-point decade for each of the two sub-periods and compare model-implied moments to data moments averaged over the mid-point decade for each of the two sub-periods, the 1975-1985 decade, the "Early Period," vs. the 1995-2005 decade, the "Late Period." Finally, to allow for a broader set of forces beyond just intangible capital to be potentially at work, we also vary the financing and other key real-side parameters, including volatility, to match their empirical counterparts in each of the two sub-periods. Whenever possible, we calibrate the parameters for each sub-period following the same logic as in the baseline calibration. Since we do not have separate benchmark values for fixed equity issuance costs by sub-period, we observe that the equity issuance frequency in the late period is similar to the one in the full sample. Thus, we keep the fixed equity issuance parameter approximately at its baseline values for the late period, and increase it in the early period to approximately match the lower average frequency of equity issues in the data.

Table 4 reports the results of the main experiment. We address two main questions. First, how much of the rise in cash can our model explain? In the data, the average cash-to-assets ratio rose substantially, from 10% to 18.3%, which is an increase of 8.3%. – i.e., it almost doubled in the last period relative to the first. In our quantitative experiment, the model generates an increase in the average cash-to-asset-ratio that is strikingly close to the data, from 9.5% to 17.8%, which is also an increase of 8.3%. Thus, the model is able to fully account for the secular rise in corporate cash holdings. Importantly, the model can also account quantitatively for the evolution of other key financial and real policies of U.S. firms. For example, the model can account for roughly one third of the relatively small average decrease in leverage and for roughly two thirds of the increase in equity issuance proceeds. For the frequency of equity issues, the model, if anything, overshoots a bit the increase in the data. This result owes, at least in part, to the data moment understating the full frequency of equity issues in the recent period due to the well-documented rise in private placements and shelf registrations, which may have substituted for traditional public placement via secondary equity offerings (see, for example, Gomes and Phillips (2012)). Finally, the model provides a good fit not just for the magnitude of the change in cash-to-asset ratio, but also for the level of the cash ratio as well as of the other key financial ratios in each sub-period. As such, our

quantitative exercise is relatively disciplined, as it involves three untargeted moments (two levels and one change) for each financial ratio - cash, leverage, and equity issuance proceeds.

Second, what are the main drivers of the rise in cash, and how much of the increase in cash can be attributed to the rise in intangible capital? To isolate the quantitative contribution of intangible capital to the rise in cash, we use a simple counterfactual experiment in which we keep the asset tangibility parameter, θ , fixed at its value for the early period while all other parameters are otherwise allowed to vary as per Table 3. The thought experiment behind this counterfactual exercise is that we can leverage our structural model by "switching off" the intangible capital mechanism to gauge how much cash would have risen without the rise in intangible capital – i.e., if firms had continued to rely on the same mix of tangible and intangible assets in the 1990s and 2000s as they did in the 1970s and 1980s. The results are shown in the last column of Table 4. Without the rise in intangible capital the model predicts that the average cash-to-asset ratio would have increased by only 2.1%, which is roughly one quarter of the overall increase both in the data and in the full model response. The difference between this counterfactual increase and the full model response -i.e., 6.2% – is the increase in cash that can be specifically attributed to intangible capital.²⁰ Thus, the results of the quantitative counterfactual indicate that about three quarters of the increase in cash is due to the increase in intangible capital. Interestingly, the counterfactual also shows that our mechanism helps to account for the secular evolution of the other financial moments, because without the rise in intangible capital the model would counterfactually predict an increase, albeit small, in leverage and less of an increase in equity issuance.

In summary, the results of our main experiment and quantitative counterfactual indicate that the shift toward intangible capital can account for the bulk of the secular increase in the cash ratios of U.S. firms. As such, intangible capital is a quantitatively important force behind the secular trend in corporate cash holdings.

 $^{^{20}}$ Note that our counterfactual is conservative because it evaluates the quantitative effect of tangibility while allowing for realistic changes in the other forces that mitigate the effect (see next section for details). In fact, evaluating the counterfactual using the baseline values in Table 1 (instead of their values by sub-period in Table 3) gives an even larger effect of 0.129.

4.3 Sizing Up Alternative Mechanisms

In this section, we dig dipper into quantifying the relative importance of other forces. We do so by conducting three additional quantitative counterfactual exercises in which we now "switch off" some of the alternative mechanisms that have been proposed in the literature by fixing their respective parameters at their values for the early period. Table 5 reports the model-implied moments for each of the three counterfactuals. In the first column, we examine the quantitative importance of cash flow volatility (see, for example, Bates, Kahle, and Stulz (2009) and Bates, Chang, and Chi (2018)). Similar to what we did for the main counterfactual in 4, we now fix the profitability shock volatility parameter σ_z at its value for the early period, while all other parameters are otherwise allowed to vary as per Table 3. Without the increase in cash flow volatility the model predicts that the average cash-to-asset ratio would have increased by 6.9%, which is still a sizable secular increase in cash holdings. Thus, the results of this counterfactual imply that an increase of 1.4% in cash can be attributed to the increase in cash flow volatility, which is less than a fifth of the overall increase in cash. Our model-based estimate corroborates the reduced-form estimate in Bates, Kahle, and Stulz (2009), who attribute roughly a quarter of the increase in cash to volatility.

The second column reports model-implied moments of a counterfactual with respect to equity financing costs. Bolton, Chen, and Wang (2011) and Eisfeldt and Muir (2016), among others, have proposed that higher costs of external finance heighten the precautionary motive and lead firms to hold more cash. Notably, our calibrated parameters for both equity issuance costs, φ_0 and φ_1 , decrease in the later period (Table 3). As evident from the table, without the reduction in issuance costs the model generates an even larger increase in the average cash-to-asset ratio. This counterfactual indicates that the reduction in equity issuance costs contributed to a reduction the average cash ratio by 11.9%. In addition, without the reduction in issuance costs the model also overshoots by an order of magnitude the size of equity issuances in the late period, because higher fixed cost of issuance lead to larger offerings. In all, the results support the existing literature in that equity issuance costs are a quantitatively powerful driver of cash holdings. However, this force is unlikely to be an important driver of the secular trend in cash because the data indicates that equity issuance costs have come down since the 1970s. Finally, the last column considers the cost of carry, which is driven by the interest rate r in our model. Previous papers including Azar, Kagy, and Schmalz (2016) and Chen, Karabarbounis, and Neiman (2017) suggest that interest rates are a determinant of cash holdings because they affect firms' opportunity costs of holding cash. Gao, Whited, and Zhang (2018) points to a non-monotonic relationship between interest rates and corporate cash. In the data, real interest rates decreased a bit from 1.35% to 1.3%, as reported in Table 3. The results of our counterfactual indicate that without the small decline in interest rates the model predicts an increase in cash by 9.6%, which is slightly higher but little changed relative to the full response of 8.3%. Thus, the results indicate that a decrease by 1.3% in cash can be attributed to interest rates, suggesting that this force, while non-negligible quantitatively as a determinant of cash, is unlikely to be one of the main drivers of its secular trend.

In summary, the additional counterfactuals suggest that some of the determinants that have been previously considered in the literature, such as volatility and interest rates, are relatively weak, while others, such as equity issuance costs, do not help to account for the upward trend in cash because in the data they moved in such a way as to decrease, rather than increase, cash.

4.4 The Cross-Sectional Size Distribution of Cash and Aggregate Implications

So far, our analysis has focused on cross-sectional averages of cash ratios and how they evolved over time. In the second part of the quantitative analysis, we go beyond the standard metrics and confront the model with the empirical cross-sectional size distribution of cash ratios as well as aggregate cash levels. This part of the analysis addresses two additional questions. First, does the model match the heterogeneity in cash holdings between small and large firms that we observe in the data? Second, how much of the cross-sectional heterogeneity in the rise in cash for firms at different points of the size distribution can our model explain?

Table 6 examines the cross-sectional model fit for the baseline calibration by comparing modelimplied and data moments conditional on each decile of the firm size distribution. Specifically, we sort firms into size deciles both in the model and in the data and report two key distributional moments averaged within each size bin, namely the cash-to-asset ratios and the share of aggregate cash held by firms in each size bin. The first column shows that in the data, small firms have higher average cash-to-asset ratios than large firms, which is in line with previous findings in the literature (e.g. Almeida, Campello, and Weisbach (2004), Denis and Sibilkov (2009), Bates, Kahle, and Stulz (2009)). In addition, the third column shows that the size distribution of cash levels is highly skewed. with the bulk of the aggregate dollar amount of cash holdings being highly concentrated among large firms. The model provides a highly accurate quantitative match to both facts. Specifically, the model matches very closely the magnitudes of the cross-sectional differences between the cashto-asset ratios of small vs. large firms, which is 7.4% in the data and 7.1% in the model for the difference between firms in the bottom and those in the top size decile. Even for the intermediate points of the size distribution, the magnitude of the cross-sectional spread predicted by the model matches closely its empirical counterpart. For example, the difference between the cash-to-asset ratio of small (bottom decile) vs. mid-sized (median) firms is 2.2% in the data and 1.6% in the model, and that between mid-sized (median) vs. large (top decile) firms is 5.2% in the data and 5.5% in the model. Finally, the model also generates an accurate quantitative fit for the concentration of cash levels. The model-implied shares of aggregate cash held by firms in each size decile match closely their empirical counterparts. For example, the largest firms (top decile) hold about 71% of aggregate cash in the data and about 70% in the model.

To help interpret the cross-sectional results, the last column reports an estimate of the modelimplied average "value of cash" for firms in each size decile. The estimate is defined similar to Bolton, Chen, and Wang (2011) and Gamba and Triantis (2008) as the percentage gain in firm value from having the option to hold cash or, equivalently, the firm's willingness to pay for the option to hold cash. In the model, it is constructed using the baseline calibration and taking for any given firm the percentage difference between their value and the constrained value for the case when they are not allowed to hold cash, which we operationalize by adding a non-negativity constraint on net-debt to the firm optimization problem. The results show that cash increases firm value by about 5.3% more for small (bottom decile) relative to large (top decile) firms. That said, cash remains valuable even for the largest firms, at over 9.5%, which is the reason why the size distribution of cash is non-degenerate in the model and even large firms have sizable cash ratios. This result is in line with the standard intuition of costly external finance models, where the financial constraint status is not just a function of firm size but also of growth opportunities – i.e., the realization of the technology shock. In our model, even large firms may find themselves in the financially constrained region when faced with a good realization of the technology shock (see, for example, Figure 5 in Gomes (2001)). Given that the primary motive to hold cash is to preserve financial flexibility, even very large firms hold cash in our model because they prefer to save on costly external finance when growth opportunities arise, though they hold less cash than small firms because decreasing returns to scale reduce the value of growth opportunities for larger firms.

Next, we examine the evolution of the cross-sectional size distribution of cash and of aggregate cash ratios. To that end, we compute data and model-implied cross-sectional moments under the same parametrization we used for the main quantitative experiment in Section 4.2. We consider again two sets of cross-sectional moments, cash-to-asset ratios and the share of aggregate cash held by firms in each size decile. The results are reported in Table 7. Overall, the model explains a large fraction of several key changes in the size distribution of cash ratios. First, cash-to-asset ratios in the data roughly doubled for the median firm, going from 9.1% to 18.3%, which corresponds to a change of 9.2%. The model provides a close match to this trend, generating an increase of 8.7% for the median firm. Second, the cross-sectional difference between the cash ratios of small and large firms almost doubled both in the data and in the model, going from 4.7% to 9.5% and from 4% to 7.4%, respectively. Third, the upward trend in cash ratios was stronger for small firms, with a difference of about 4.8% between the increase in the cash-to-asset ratio of small (bottom decile) vs. large (top decile) firms in the data. The model accounts for a large fraction of the cross-sectional difference between the trend, generating a difference between the trend of firms in the bottom vs. top size deciles.

Finally, these results are achieved with the cross-sectional concentration of cash levels staying relatively stable, which is the case also in the data. As a result, our proposed mechanism is strong enough to account for the bulk of the increase in the aggregate, not just average, cash ratio. Specifically, as shown in the last three rows of Table 7, the aggregate cash ratio increased by 4.2% in the data. The increase in the aggregate cash ratio is smaller than the increase in the average ratio because it is driven disproportionately by large firms, which experienced a smaller increase in their cash ratios in the data. To take this important cross-sectional feature of the data into account, we repeat the main quantitative counterfactual with one modification: as in the analysis of the average cash ratio (Table 4), we keep the asset tangibility parameter fixed at its value for the early period while all other parameters are otherwise allowed to vary as per Table 3. The modification is that we now calculate the model-implied increase in the aggregate cash ratio counting in the numerator only the model-implied change in dollar cash of the largest firms - i.e., excluding the effect on smaller firms. If the effect in the model was just due to small firms, this counterfactual would predict no increase in the aggregate ratio. Thus, the modified counterfactual provides a lower bound on the aggregate effect by quantifying whether the model-implied increase in cash ratios for large firms is strong enough to account for the overall increase in the aggregate cash ratio. The results show that our mechanism is indeed strong also in the aggregate, with the counterfactual implying an increase in the aggregate cash ratio of at least 3.3% for the case when only the model-implied increase for the top 5% tail of the firm size distribution is counted in.

Overall, the second part of the analysis helps buttress our main conclusion that the rise in intangible capital is a quantitatively powerful mechanism by showing that it leads to a realistic size distribution of cash ratios and concentration of cash levels and can account for the magnitude of several key changes in the size distribution of cash ratios. In addition, the mechanism can account for a large fraction of the upward trend not only of average, but also of aggregate cash ratios.

5 Supporting Evidence

This section offers additional evidence in support of the relation between cash and intangible capital. We start by showing that the positive relation between cash and intangible capital we described in the stylized facts also holds in a regression setting, where we can control for other covariates of cash. To that end, we regress cash holdings on our firm-level measure of intangible capital, while controlling for a set of standard covariates of cash (e.g., Opler, Pinkowitz, Stulz, and Williamson (1999) and Bates, Kahle, and Stulz (2009)). We consider two main specifications, with and without firm fixed effects.²¹ The specification that controls for firm fixed effects ascertains whether intangible capital has incremental explanatory power over and above firm fixed effects, which are a well-established covariate of cash and other financial policies (e.g., Lemmon, Roberts, and Zender (2008)). We also examine more saturated specifications that add controls for other covariates of cash that have been proposed more recently in the literature. Finally, while the reduced-form evidence in this section does not rule out alternative interpretations, we explore the relation between cash and patent pledgeability following Mann (2018) to provide some corroborating evidence for the collateral mechanism at the core of our model.

The baseline estimates are reported in the top panel of Table 8 for the overall sample (Columns (1)-(2)) and for the subset of firms that report positive R&D (Columns (3)-(4)).²² The coefficient on intangible capital is robustly positive and significant across the two samples and both specifications with and without firm fixed effects.²³ In the baseline specification in Column (1), one standard deviation increase in intangible capital is associated with about 8.5% increase in the cash ratio, which is equal to about half the sample mean value of the cash ratio of 15%. Further supporting the quantitative importance of the relation, the coefficient estimates imply that more than 40% of the predicted increase in cash can be attributed to the rise in intangible capital.²⁴ Estimates are similar in magnitude for the specification that controls for firm fixed effects, suggesting that intangible capital has explanatory power over and above this previously-established covariate of cash, and are larger for firms with R&D, suggesting that the baseline result is not spuriously driven by differential

 $^{^{21}}$ All specifications include standard firm-level controls such as industry cash flow volatility, market-to-book ratio, firm size, cash flow, capital expenditures, (cash) acquisitions expenditures, and a dummy for whether the firm pays dividend in any given year, as well as year effects to control for aggregate factors. The sample for the panel regressions requires non-missing observations for all controls and includes 150,574 firm-year observations. We evaluate statistical significance using robust clustered standard errors adjusted for non-independence of observations within firms. See Appendix B for detailed variable definitions.

 $^{^{22}}$ To address the concern that the main estimates for the overall sample may pick up spurious differential responses to aggregate shocks by innovative vs. non-innovative firms.

 $^{^{23}}$ Table A3 reports the coefficient estimates for the control variables. Signs and statistical significance of the controls are generally in line with the findings of the previous literature, which include firms with higher and more volatile cash flows and those with higher market-to-book holding more cash. The coefficients on capital expenditures and acquisitions are negative and significant, consistent with firms using their cash holdings to pursue investment opportunities. The coefficient estimates on firm size and dividend payer status are sensitive to the inclusion of firm effects.

 $^{^{24}}$ This calculation is implemented similar to Bates, Kahle, and Stulz (2009) by taking the point estimates from the regression estimated over the 1970-1989 period and multiplying them by the difference in average value of intangible capital between the estimation (1970-1989) and the post-estimation (1990-2010) period.

shocks to innovative firms. The lower panels examine external validity of the results by re-running the baseline specification using either different sub-components of our intangible capital measure or alternative measures that have been used in the literature, in turn. Either set of validity checks leaves our baseline estimates little changed. In addition, the estimates are stable to excluding IT capital or using principal component analysis to extract a common latent intangible factor, which aggregates the three sub-components, as an alternative to taking their sum (see Table A4). And they remain strongly statistically and economically significant when we use alternative measures of intangible capital, including the measure of Peters and Taylor (2017) (Panel D of Table 8) and an industry-level measure based on the BEA data from DellAriccia, Kadyrzhanova, Ratnovski, and Minoiu (2020) (Table A4). This reduced-form empirical evidence indicates that intangible capital is an important attribute of cash holding firms, thus reinforcing the main conclusion from the quantitative analysis.²⁵

Next, we offer further reassurance that the relation between cash and intangible capital is not due to the omission of covariates that have been previously established in the literature. The concern is that our baseline controls do not include other important covariates of cash that have been proposed in the recent literature (see Graham and Leary (2018) for a comprehensive overview). If these covariates of cash are also correlated with intangible capital, their exclusion may lead us to find a spurious correlation in the baseline. To that end, Table 9 examines a more saturated specification that adds controls for the following covariates of cash, in turn: industry competition (Morellec, Nikolov, and Zucchi (2014)), corporate taxes that may lead multinationals to hold on to their profits abroad by holding cash (Faulkender, Hankins, and Petersen (2019)), the risk-free interest rate that determines the opportunity cost of money and, as such, of holding cash (Azar, Kagy, and Schmalz (2016)), selection due to young entrants (Begenau and Palazzo (2019)), employee equity compensation that may be used to substitute for cash by intangible capital-intensive firms (Sun and Xiaolan (2019)), and the rise in corporate profits (Chen, Karabarbounis, and Neiman

²⁵The relation between cash and intangible capital is also robust to three additional batteries of specification tests, which comprise alternative parametric assumptions to construct the intangible capital stock variable (Table A4), alternative definitions of the cash ratio, weighting observations by firm size (Table A5), an alternative definition of the market-to-book control to address potential measurement error issues with Tobin's Q (Table A5), alternative samples, and inclusion of additional controls to address potential omitted variables concerns related to changes in the industrial composition of the U.S. (Table A6 and Row 4 of Table A5). In Table A9 we also explore empirically the relation between intangible capital and equity issuance. See Appendix D for a detailed summary of these additional results, as well as of additional empirical analyses of the mechanism.
(2017)). The coefficient estimates for each of the additional controls are generally significant and the sign is in line with previous results in the literature, confirming that these alternative forces indeed matter for cash. For example, as shown in Columns (3) and (4), firms that face a higher repatriation tax penalty hold more cash, and the same holds for firms with higher corporate profits relative to value added (Columns (9) and (10)). However, the coefficient estimate on intangible capital remains remarkably stable across specifications with these controls, suggesting that omitted variables are unlikely to be driving the result. And the contribution of intangible capital to the rise in cash is generally much larger than that of the other covariates, which is in line with the evidence in Bates, Kahle, and Stulz (2009)) that standard firm and industry characteristics tend to have an economically small effect on the trend in cash.

In Appendix Table A_6 we further address potential confounds from selection by young entrants by showing that the cross-sectional relation between cash and intangible capital is robust to adding controls for IPO cohorts and excluding young entrants from the sample (see Appendix D for details). A recent literature (Begenau and Palazzo (2019) and Graham and Leary (2018)) examines whether the rise in cash is due to the extensive margin (i.e., changes in the composition of public firms) vs. the intensive margin (i.e., changes in the cash holdings of existing firms). Our model is agnostic about this question because the main implication that the rise in intangible capital should be accompanied by a rise in cash holds regardless of whether the rise in intangible capital is due to a change in the composition of public firms toward more intangible-capital intensive firms or an increase in the reliance on intangible capital by existing firms. That said, selection raises two interesting empirical questions: first, is the relation robust to controlling for other characteristics of IPO firms that may also be associated with higher cash? Second, what is the relative contribution of the extensive vs. intensive margins to the relation between cash and intangible capital? While beyond the scope of this paper, in Appendix Table A7 we offer some perspective on these questions based on the reduced-form cross-sectional approach of this section. Specifically, we re-run the baseline cross-sectional regression with additional controls for cash at IPO and intangible capital at IPO, in turn, an approach which is similar to Lemmon, Roberts, and Zender (2008).²⁶ The

 $^{^{26}}$ To mitigate multicollinearity issues, in this specification we exclude the IPO year from the intangible capital variable and include only post-IPO year values.

estimates in Columns 2 and 6 indicate that there is a positive relation between cash and cash at IPO, which is in line with the findings of the previous literature. However, even after controlling for cash at IPO, the relation between cash and intangible capital remains strongly statistically and economically significant, suggesting that the relation between cash and intangible capital is unlikely to be due to other factors associated with selection. Finally, the estimates from the specification that adds intangible capital at IPO show that there is a positive relation between this variable and cash (Columns 4 and 6 of Appendix Table A7), suggesting that both the extensive and intensive margins contribute to the cross-sectional relation between intangible capital and cash.

Finally, we provide supporting evidence for the collateral mechanism at the core of our model by exploring the relation between cash and patent usage as collateral. Mann (2018) shows that pledging patents as collateral to raise debt financing has become more common among patenting firms since the 2000s and that firms raise more debt after court decisions that strengthen creditor rights to patents in bankruptcy. We build on his work to examine two questions. First, does patents' use as collateral reduce cash holdings? Second, do state laws that increase the collateral value of patents also lead to a reduction in cash holdings? Both effects would be as predicted by our model in response to an increase in debt capacity, stemming from an increase in pledgeability of patents. The results are summarized in Table 10. In panel A, we replicate the cross-sectional analysis of Mann (2018) for cash by adding his main measure of a firm's reliance on patents as collateral - i.e., the number of pledged patents - to our baseline specification. The coefficient estimate on pledged patents is negative and significant, which is in line with our prediction. In panel B, we replicate his difference-in-differences analysis by adding a dummy that equals one for firms incorporated in Delaware after the 2002 passage of the Asset-Backed Securities Facilitation Act (ABSFA) that strengthened creditor rights with respect to patents in bankruptcy, thus increasing their collateral value.²⁷ The coefficient estimate on the treatment dummy is also negative and statistically significant for R&D firms, further supporting the link between cash and collateral at the core of our model. The coefficient estimate on our intangible capital measure remains stable relative to the baseline across these tests, indicating that the recent opening up of the market

²⁷Appendix Figure A7 shows diagnostics for the difference-in-differences (DD) analysis, showing that there are no significant differential pre-event trends between Delaware and non-Delaware firms. Note that the DD estimates are for the later part of the sample period.

for collateralizing patents has not reduced the importance of the "core" intangible assets that are included in our measure, such as knowledge from R&D and organizational capital from SGA, which remain mostly uncollateralizable.

While we caution that the reduced-form empirical analysis in this section does not rule out alternative mechanisms, the magnitude of the estimates in Table 10 indicates that collateral mechanism is economically significant. For example, the estimates in Column 1 of Panel A imply that one standard deviation increase in pledged patents is associated with about 6% decrease in the cash ratio, which is equal to about forty percent of the sample mean value of the cash ratio of 15% and about two thirds of the estimate on intangible capital. As for the difference-in-differences estimates, they imply that the treatment effect leads to up to about 2% to 3% decrease in the cash ratio, depending on the intensity of the treatment (Columns 1 and 3 of Panel B and Columns 2 and 5 of Appendix Table A8, respectively),²⁸ which correspond to about ten to twenty percent of the sample mean of the cash ratio and about twenty percent to one third of the estimate on intangible capital. In all, these results indicate that the collateral mechanism is economically significant.

Overall, the cross-sectional evidence indicates that intangible capital is an economically important covariate of cash holdings, thus helping to build confidence in the main takeaway of our model analysis.

6 Conclusion

There is a strong link between the rise in intangible capital and the rise in cash holdings of U.S. corporations over the last four decades. We used a model with two productive assets, tangible and intangible capital, to highlight this point. The economic mechanism at the heart of our results is shrinking debt capacity that arises from the imperfect pledgeability of intangible capital. Using a calibration approach to quantify the strength of the mechanism, we estimated that the rise in intangible capital can account for about 3/4 of the upward trend in average cash ratios as well as

 $^{^{28}}$ Note that the intensity of the treatment depends on whether firms have patents, because the Delaware law increased the pledgeability of patents. In line with this reasoning, the intensity of the treatment is higher for R&D active firms (Columns 3 and 4 of Table 10 and for firms with active patent applications pre-treatment (Appendix Table A8).

for a variety of important quantitative features of the evolution of cash ratios in the cross-section and in the aggregate. We conclude that intangible capital helps to make progress on providing a satisfactory analytic account of the evolution of the cash holdings of US corporations, which has proved challenging to date.

There are several caveats and venues along which our approach can be extended. On the empirical side, we took a step in the direction of constructing a firm-level measure of intangible capital, but clearly more can be done to measure assets that anecdotally are well known to matter for the modern public corporation but are not routinely reported by firms on their balance sheets, including brands, customer loyalty, and other reputational assets. In addition, the inputs that go into the construction of our intangible capital measure are readily available at the firm level for a wide cross-section of countries. Extending the analysis to an international setting could help to understand whether differences in the pace of technological progress across countries can account for differences in the secular evolution of their corporate balance sheets, which would be interesting given the growing evidence that cross-country differences in financial policies are large and do not seem to be easily explained by standard country characteristics. Finally, the reduced-form nature of our empirics helps to corroborate the relation between cash and intangible capital, but does not rule out alternative mechanisms. While beyond the scope of this paper, providing more direct causal evidence would help to better size up the importance of the collateral mechanism and constitutes a fruitful venue for future research. Related, clearly more work is needed to gauge the relative contribution of the extensive vs. intensive margins to the rise in intangible capital, which would be a valuable contribution to the recent literature on selection in corporate finance (Begenau and Palazzo (2019) and Graham and Leary (2018)).

A second set of extensions pertain to the model. While we kept the setup simple by design to allow for a disciplined calibration, it would be interesting to enrich our framework to allow for more heterogeneity across firms, say due to different types of corporate taxes, including subsidies to investment and R&D, or a richer structure of adjustment costs, which would likely further enhance the model cross-sectional fit and shed light on additional dimensions of heterogeneity in the evolution of cash, either across sectors or across firm characteristics beyond size. Related, while beyond the scope of our analysis, another interesting dimension along which our framework could be extended is to incorporate rents and make contact with the recent literature on increasing firm heterogeneity (see Van Reenen (2018) for an overview). Our results on the increase in the crosssectional differences between the cash ratios of small and large firms are broadly in line with this literature, which generally finds evidence of increasing differences among firms in terms of their sales, productivity and wages. Another recent literature has started to explore the interaction between intangible capital and rents on firm value (Crouzet and Eberly (2019)), which raises the intriguing possibility that there may be interaction effects between intangible capital and rents also on firm financing.

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A Efficiency Conditions of the Model

A.1 Payout/Issuance Policy

The necessary condition for equity issuance is given by the first order condition,

$$1 + \lambda = 1 + \varphi'(e) = 1 + \varphi_1 > 1. \tag{A.1}$$

This condition states that the firm issues new shares to finance its expenditures only if its value of internal funds exceeds 1. It also implies that the firm's shadow value of internal funds is bounded above by $1 + \varphi_1$ as it faces unlimited supply of external funds at the marginal price φ_1 . However, a direct consequence of the presence of fixed costs of equity finance is that the converse of this proposition is not true: $1 + \lambda > 1$ does not establish the optimality of $\nu^E = 1$. In other words, even when the firm's shadow value of internal funds exceeds 1, it may still be optimal to delay the issuance if the marginal improvement of the value of $w(k_T, k_N, b|\nu^E = 1)$ is not enough to justify it. The sufficient condition for equity finance is given by $w(k_T, k_N, b|\nu^E = 1) - w(k_T, k_N, b|\nu^E = 0) \ge 0$. In other words, the equity value must be improved sufficiently enough to compensate for the foregone fixed cost of issuance.

A.2 Cash/Debt Policy

To state the efficiency for net-debt position (b' = B'/Z), we define financial q as

$$q^{F}(\tilde{k}'_{T}, \tilde{k}'_{N}, \tilde{b}') \equiv -\frac{1}{1+r} \int w_{b} \left(\frac{\tilde{k}'_{T}}{\eta'}, \frac{\tilde{k}'_{N}}{\eta'}, \frac{\tilde{b}'}{\eta'}\right) dH(\eta').$$
(A.2)

The financial q measures the cost of issuing one more unit of debt (or equivalently reducing one more unit of liquid assets). The efficiency condition for \tilde{b}' requires the cost to be equated with the marginal benefit of additional cash inflow from the debt issuance, which should be measured by the shadow value of internal funds, $1 + \lambda$. However, this marginal benefit should be adjusted by the shadow cost of reducing the financial slack, i.e., μ , and hence, the efficiency condition is given by

$$1 + \lambda - \mu = q^F(\vec{k}'_T, \vec{k}'_N, \vec{b}').$$
(A.3)

When the firm does not issue debt and holds a strictly positive amount of cash, in which case the borrowing constraint becomes a slack ($\mu = 0$), this condition becomes identical to that of Bolton, Chen, and Wang (2011). In fact, $q^F(\tilde{k}'_T, \tilde{k}'_N, \tilde{b}')$ is what they call the marginal value of cash. Our framework generalizes their notion of value of liquidity by allowing debt issuance. Note that when the firm accumulates cash, the left and right sides of (A.3) interchange their roles: the left side measures the marginal cost of setting aside extra liquidity today for tomorrow's use and the right side measures the future benefit of a marginal unit of liquid asset tomorrow.

The Benveniste-Scheinkman's formula implies $w_B(k_T, k_N, b|\nu) = -(1+\lambda)[1+r(1-\tau)]$ regardless of ν . Hence, $w_B(k_T, k_N, b) = -(1+\lambda)[1+r(1-\tau)]$. We can then express the first order condition as

$$1 + \lambda - \mu = \frac{1 + r(1 - \tau)}{1 + r} \int (1 + \lambda') dH(\eta') \quad \text{if } \tilde{b}' \ge 0$$
(A.4)

and

$$1 + \lambda = \frac{1 + r(1 - \tau) - \kappa}{1 + r} \int (1 + \lambda') dH(\eta') \quad \text{if } \tilde{b}' < 0 \tag{A.5}$$

where we use the fact that the collateral constraint is slack, i.e., $\mu = 0$ when $\tilde{b}' < 0$.

Consider (A.4) first. Suppose that the firm issues new shares today. In this case $1 + \lambda = 1 + \varphi_1$. Since $1 + \lambda' \leq 1 + \varphi_1$, $1 + \lambda > \int (1 + \lambda') dH(\eta')$. Furthermore, $[1 + r(1 - \tau)]/[1 + r] < 1$. Hence, it must be the case that the collateral constraint binds, $\mu > 0$ to satisfy (A.4). This means that the firm never issues shares before using up its borrowing capacity.²⁹

Now consider (A.5). Again suppose that the firm issues new shares today. Since $1 + \lambda = 1 + \varphi_1 > \int (1 + \lambda') dH(\eta')$ under this assumption and $[1 + r(1 - \tau)]/[1 + r] < 1$, condition (A.5) cannot be satisfied. This means that the firm never simultaneously issues shares and accumulates liquid assets.

Finally, suppose that the firm does not issue new shares. Due to the presence of fixed costs of equity issuance, this case does not necessarily imply that $\lambda = 0$. Suppose, though, that the firm's liquidity conditions are indeed good enough that $\lambda = 0$ and, thus, the left hand side of (A.5) is equal to 1. This means that the firm pays out a strictly positive amount of dividends to shareholders.

 $^{^{29}\}mathrm{This}$ argument does not depend on the differential tax treatment of debt.

A.3 Investment Policy

To derive the efficiency conditions for tangible and intangible capital accumulation, we follow the approach of Abel and Eberly (1994), who characterize these conditions in a neo-classical setting with one type of real assets, i.e., tangible capital, and without financial frictions. We extend their analysis by incorporating the choice between two capital inputs that are different in their ability to back financial claims under frictional capital market condition.³⁰

We first derive the efficiency condition for tangible investment and then follow an analogous approach to derive its counterpart for intangible investment. As in Abel and Eberly (1994), we proceed as if $\nu_T^K = 1$ were optimal, and derive the efficiency condition that would be optimal under this assumption. To that end, we first define the marginal value of capital i as³¹:

$$q^{\kappa_i}(\tilde{k}'_r, \tilde{k}'_N, \tilde{b}') \equiv \frac{1}{1+r} \int w_{\kappa_i} \left(\frac{\tilde{k}'_T}{\eta'}, \frac{\tilde{k}'_N}{\eta'}, \frac{\tilde{b}'}{\eta'}\right) dH(\eta') \quad \text{for } i = N, T$$
(A.6)

where w_{K_i} denotes the first derivative of w with respect to \tilde{k}'_i/η' . Without non-convex adjustment frictions, the efficiency condition would simply require the marginal benefit of investment given by (A.6) to be equalized with the marginal cost of investment.

The marginal cost is given by the derivative of the adjustment cost (4) with respect to \tilde{k}'_i evaluated at the internal pricing term, i.e., at the shadow value of internal funds $1 + \lambda$. Hence the marginal cost can be expressed as $g_{i,1}(\tilde{k}'_i, k_i)(1 + \lambda)$. The marginal benefits consist of two elements: the shadow value of capital measured by the marginal Tobin's $q^{K_i}(\tilde{k}'_T, \tilde{k}'_N, \tilde{b}')$; and the marginal effect of increase in capital stock *i* on the debt capacity $\bar{b}(\tilde{k}'_T)$. This additional benefit has to be evaluated at the shadow value of the collateral constraint and be subtracted from the marginal cost. Hence,

$$q^{K_i}(\tilde{k}'_T, \tilde{k}'_N, \tilde{b}') = (1+\lambda)g_{i,1}(\tilde{k}'_i, k_i) - \mu \bar{b}(\tilde{k}'_T),$$

and the optimality condition requires \tilde{k}'_T to satisfy the following:

$$q^{\kappa_i}(\tilde{k}'_T, \tilde{k}'_N, \tilde{b}') = (1+\lambda) - \mu \frac{1-\delta_i}{1+r}.$$
(A.7)

A limiting case of (A.7) is the following. In the case with no financial frictions, i.e., when $\lambda = \mu = 0$ for all time, (A.7) is simplified into

$$q^{K_i}(\tilde{k}'_T, \tilde{k}'_N, \tilde{b}') = 1,$$
(A.8)

which implies that the firm should increase its investment until the marginal value of tangible capital falls to the level of its purchase price, which is normalized to one.

If there were no non-convex adjustment costs, this would be the necessary and sufficient condition for optimality. However, in the presence of non-convex adjustment costs, (A.7) is only a necessary condition for optimality. In other words, *given that the action is optimal*, investment has to satisfy (A.7). However, the converse is not necessarily true. The sufficient condition for the optimality of action requires

$$w(k_T, k_N, b|\nu_i^K = 1, \nu_j^K, \nu^E) - w(k_T, k_N, b|\nu_i^K = 0, \nu_j^K, \nu^E) \ge 0.$$
(A.9)

This last condition creates an inaction region since it requires a large enough gain from (dis)investment to warrant action.

The comparison of (A.7) and (A.8) shows how financial frictions affect real investment decisions. First, and most importantly, (A.7) differs from the neoclassical efficiency condition in that the equity market friction elevates the marginal cost of investment by a factor $1 + \lambda$. In this sense, today's liquidity problem, which is manifested by the shadow value of internal funds being strictly greater than one, raises the required return on equity. Second, because of the occasionally binding collateral constraint, investing in tangible capital benefits the firm not only by increasing future profits, but also by expanding its debt capacity, a benefit which is measured by the effective shadow value term μ . This implies that tangible capital commands liquidity premium. Conversely, more reliance on intangible technology implies that the firm has to compensate for the loss of liquidity service by holding more liquid financial assets.

³⁰See also Gilchrist, Sim, and Zakrajsek (2014) for a setting with both real and financial frictions, but without intangible capital and with unsecured rather than secured debt. More importantly, Gilchrist, Sim, and Zakrajsek (2014) does not allow corporate cash holdings.

³¹While $W_{k_T}(\mathbf{K}', B', Z')$ is discontinuous due to the non-convex adjustment costs, its integrated value $Q_T^K(\mathbf{K}', B', Z)$ is well defined nonetheless since the discontinuity occurs finite times.

B Details of Variable Definition

The variables used in the analysis are defined as follows:

- Cash ratio is defined as the ratio of cash and marketable securities (data item #1) to book assets (#6)
- Other cash measures (robustness): Cash to Net Book Assets is cash and marketable securities (#1) divided by book assets (#6) minus cash and marketable securities (#1); Cash to PP&E is cash and marketable securities (#1) divided by property, plant, and equipment (#8).
- Net-Leverage is the ratio of long-term debt (#9) plus debt in current liabilities (#34) minus cash and marketable securities (data item #1) to book assets (#6).
- Industry sigma (cash flow risk) is the standard deviation of industry cash flow to book assets. Standard deviation of cash flow to book assets is computed for every firm-year using data over the previous ten years. We then average these cash flow standard deviations over 2SIC industries and each year.
- Market-to-book ratio is the ratio of the book value of assets (#6) minus the book value of equity (#60) plus the market value of equity (#199*#25) to the book value of assets (#6).
- Firm size is the natural logarithm of book assets (#6) in 1990 dollars (using CPI).
- Cash flow is earnings after interest, dividends, and taxes before depreciation divided by book assets ((#13 #15 #16 #21) / #6).
- Capital expenditures is the ratio of capital expenditures (#128) to book assets (#6).
- Dividend is a dummy variable equal to one in years in which a firm pays a common dividend (#21). Otherwise, the dummy equals zero.
- Acquisitions is the ratio of acquisitions (#129) to book assets (#6).
- Net leverage is the ratio of long-term debt (#9) plus debt in current liabilities (#34) less cash (#1) to book assets (#6).
- R&D (flow) is the ratio of R&D expenditures (#46) to book assets (#6).
- High-tech industries are defined following Loughran and Ritter (2004) as SIC codes 3571, 3572, 3575, 3577, 3578, 3661, 3663, 3669, 3674, 3812, 3823, 3825, 3826, 3827, 3829, 3841, 3845, 4812, 4813, 4899, 7370, 7371, 7372, 7373, 7374, 7375, 7378, and 7379.
- Net equity issuance is sale of common and preferred stock (#108) minus purchase of common and preferred stock (#115) divided by book assets (#6). To exclude equity issuances, we set a cutoff equal 1% and 5% of assets for equity issuance.
- Industry Competition is defined as the Herfindhahl-Hirshmann index of sales of all firms in a given (SIC-3) industry-year. Firm sales are obtained using sales from Compustat (#12).
- Implied repatriation tax penalty follows Foley, Hartzell, Titman, and Twite (2007) and is defined as the maximum between zero and foreign pre-tax income (#273) times the marginal tax rate minus foreign taxes paid (#64).
- Foreign Income is defined as the ratio of foreign pre-tax income (#273) to book assets (#6).
- Broad-based equity compensation is defined as the ratio of reserved shares to market value of equity (#199*#25), where reserved shares are defined as follows: for pre-1983 years, we use common shares reserved for conversion total (#100) less preferred stocks and convertible debt (#39); for the subsequent years we use 1984–1995, we use common shares reserved for stock options conversion (#215).
- Cost of carry is based on Azar, Kagy, and Schmalz (2016) and is defined as 3-month Treasuries times the share of interest bearing to non-interest bearing (currency and checking account) assets in liquid asset portfolio of non-financial corporate sector. Data on Treasuries are downloaded from St Louis FRED and data on non-financial corporate sector's composition of assets are from the Flow of Funds.
- Labor share is defined as corporate labor share from NIPA (downloaded from Karabarbounis and Neiman (2013) country-level dataset)
- Firm age is defined as the number of years since the firm went public (first entry on CRSP, or Compustat for firms with no CRSP data).
- WW-Index is based on Whited and Wu (2006) and is as follows: WW-Index=-0.091*CashFlow -0.062*Dividend +0.021*Leverage -0.044*Size+0.102*Industry Growth -0.035*Growth, where Industry Growth is the 4-SIC industry sales growth, Growth is own-firm real sales growth, and the other variables are as defined above.
- Asset liquidation value is based on Berger, Ofek, and Swary (1996) and is the sum of 0.715*Receivables(#2), 0.547*Inventory(#3), and 0.535*Capital(#8).

- Industry asset redeployability index is based on Balasubramanian and Sivadasan (2009) and is the fraction of total capital expenditures in an industry accounted for by purchases of used (as opposed to new) capital, computed at 4-digit SIC level and constructed using hand-collected US Census Bureau data. Since these data are available only once every 5 years and not for more recent years, we compute a time-invariant index by averaging the available quinquennial indices at the 4-SIC level. This measure is only available for a restricted sample of manufacturing firms.
- Investment inaction, small investments, and investment spikes are defined at the firm level based on Cooper and Haltiwanger (2006) as those firm-year observations corresponding to |Capex/book assets| < 0.1, $|Capex/book assets| \geq .01$, and |Capex/book assets| > .2, respectively. Industry is 4-SIC. In each industry-year, we compute frequency as number of observations involving investment inaction (small investment) to total number of observations in the industry. This procedure results in a time-invariant cross-sectional ranking of 4-SIC industries.
- Time-series skewness and kurtosis of annual aggregate industry investment are based on Caballero (1999) and calculated as the skewness and kurtosis of average annual Capex (#128) to book assets (#6) ratios in each (4-SIC) industry. In every year, we calculate annual averages in each industry as industry-year means of individual firm-year Capex to book asset ratios. This procedure results in a time-invariant cross-sectional ranking of 4-SIC industries.
- Time-series standard deviation of aggregate industry operating costs is calculated after aggregating firm-level operating costs by taking annual means at the 4-SIC industry level. For each industry, the measure is the standard deviation of these annual industry means of operating costs. Operating costs are costs of good sold (#41). This measure gives a time-invariant cross-sectional ranking of 4-SIC industries.

C Details on Issues with Measuring Intangible Capital

Under the current accounting rules (worldwide), intangibles done in house are only expensed (hence reported R&D expenditures, Advertising expenditures, SG&A etc.), not booked as assets. For this reason, intangible assets are generally absent from firms' balance sheet, with the exception of the (fair value of) intangibles assets that are acquired via mergers and acquisitions (M&As), which can be booked as assets and are included in the "intangibles" (item #33) in Compustat. This variable also includes goodwill and excess cost or premium of acquisition, and these items have been extensively shown in the literature to be largely unrelated to the economic definition of acquired intangible assets but rather being closely related to over-payment in mergers. Due to these issues, we opt for not including this variable in our measure of intangible capital. In this appendix, we offer some additional details on these measurement issues.

The main measurement issue with the "intangible" variable in Compustat is that it includes goodwill and other merger items that do not have a connection with the economic definition of intangible capital and have been extensively shown in the literature to measure merger expenditures for acquiring companies. In particular, Compustat "Intangibles" (item 33) includes the following:

- excess of cost or premium of acquisitions
- goodwill (which is the difference between the actual price paid in a merger transaction and the accounting fair value of the total assets of the target company)
- (fair value of) intangible assets acquired in a merger (such as the patents, copyrights, etc.) of the target company.

Due to the inclusion of goodwill, the item picks up over-payment in mergers and acquisitions (M&As). In fact, there is extensive evidence in the accounting literature showing that goodwill is not really measuring assets, but liabilities for mergers involving over-payment. Ideally, one would fix the issue by subtracting goodwill and any other merger over-payment related items from the intangibles variable. Unfortunately, it is not possible to correct for the issue prior to 2000, since accounting rules did not require firms to disclose goodwill and other M&A-related intangibles separately prior to that year (for the specific M&A accounting rules, see FASB's promulgation of SFAS #141 and SFAS #142 (Goodwill and Other Intangible Assets, 2001)). Around the tech merger wave, a controversy ensued about goodwill accounting in M&As. As a result, there was a change in the accounting rules in 2000 and there is an "Intangibles - Other" variable in Compustat (item 352) that starts in 2000 and is net of goodwill, but still includes "excess of cost or premium of acquisitions," so it is still subject to the issue of over-payment in M&A transactions.

Based on these considerations, since item33 from Compustat also includes goodwill and excess cost or premium of acquisition, which are unrelated to the economic definition of acquired intangible assets but rather measure over-payment in mergers, we opted for not including this variable in our baseline measure of intangible capital used in the main analysis. However, we checked that both our stylized facts and supporting evidence are robust to using an "augmented" version of our baseline measure that also includes the "intangibles" item 33 from Compustat (Row [6] of Table A4).

D Additional Stylized Facts, Robustness Checks and Analysis of the Mechanism

Stylized Facts: Appendix Figure A5 shows that sectors where intangible capital rose the most are also those where cash went up the most. Panel (a) plots the distribution of average industry cash by decades for broad industry categories (12-Fama and French) sorted based on their respective sector-average intangible capital ratio in the 2000s. Clearly, the increase in cash was more dramatic in industries that became heavily reliant on intangible capital by the 2000s (e.g., by a factor of almost 40, from 0.13 to 5.07, in Healthcare), relative to those that didn't shift to intangible capital as much such as retail (Shops). Even more directly, panel (b) shows that the top-6 sectors (48-Fama and French) where intangible capital rose the most over the last two decades were exactly the top-6 sectors where cash rose the most. Panel (c) shows that the finding that cash ratios also rise in non-high tech sectors is not an artifact of classifying the "Business Services" sector as non-high tech: when we separate out "Business Services" from the non-high tech sectors, the remaining non high-tech sectors show almost a doubling of the cash ratios over our sample period. Finally, Appendix Figure A6 shows that there is a strong positive relation between cash and intangible capital also within-firm over time. We sort firms on the horizontal axis based on deciles of the distribution of annual changes in intangible capital and, for each decile-bin, plot the corresponding average annual change in cash on the vertical axis. Firms that experienced a decline in intangible capital also saw their cash ratios decline, while those for which intangible capital rose the most were those that experienced the largest rise in cash. In line with the evidence from the regressions that the relation between cash and intangible capital is robust to controlling for firm fixed effects, the slope of the relation between cash and intangible capital is roughly comparable between Figure A4 and Figure A6, at about 0.24 $(=\Delta Cash(10-1)/\Delta IK(10-1)=0.12/0.5)$ in Figure A6 vs. 0.17 $(=\Delta Cash(10-1)/\Delta IK(10-1)=0.5/3)$ in Figure A4.

Additional Robustness Checks: The relation between cash and intangible capital is robust to three batteries of tests, which comprise using alternative parametric assumptions to construct the intangible capital stock variable (Table A4), using alternative definitions of the cash ratio and the market-to-book control to address potential measurement error issues with Tobin's Q (Table A5), using alternative samples and including additional controls to address potential omitted variables concerns related to changes in the industrial composition of the U.S. (Table A6 and Row 4 of Table A5).³² The estimates are little changed when we vary the depreciation rate parameters for knowledge and organizational capital or the weight that is applied to SG&A expenditures to construct the stock of organizational capital (Rows 1-3 and 4-5 of Table A4, respectively), and remain large and significant for different definitions of the cash ratios and Tobin's Q adjusted for measurement error as per the approach of Erickson and Whited (2012) (Rows 1-2 and 3 of Table A5, respectively). The estimates also remain quite stable in sub-samples that exclude newly IPO'ed firms ("entrants" – Table A6, Rows 4-5) or high-tech sectors (Table A5, Row 4) or in specifications that add controls for firm profitability (Table A5, Row 5), as well as firm age and IPO cohort (Table A6, Rows 1-3), suggesting that entrants or high-tech firms are not driving our result. In line with recent evidence in Begenau and Palazzo (2019), age and IPO cohort controls are also significant. This evidence indicates that, while entrants or high-tech firms may have also contributed to the rise in cash, they are not driving our result. As such, selection and rising intangible capital are distinct and complementary mechanisms. Table A9 reports results for the relation between intangible capital and equity issuance. The evidence indicates that, consistent with our model and with what had been previously conjectured in the literature, there is a positive relation, which is stronger among R&D firms.

Additional Analysis of Mechanism: We use sample-split analysis to further examine whether the data support the main mechanism of the model. If firms with more intangible capital hold more cash because of financing frictions, the relation between intangible and cash should be stronger among firms for which external financing frictions are more severe. Table A10 shows evidence supporting this unique prediction of the model. We follow the standard approach in the literature (e.g., Hennessy and Whited (2007)) and in every year over the sample period we rank firms based on five ex-ante indicators of their financial constraint status, which include firm size, dividend payer status, the WW-Index by Whited and Wu (2006), a measure of asset liquidity by Berger, Ofek, and Swary (1996), and an index of industry asset redeployability by Balasubramanian and Sivadasan (2009). We assign to the financially constrained (unconstrained) groups those firms in the bottom (top) quartile of the annual distribution of each of these measures in turn, except for the financial constraints index, for which the ordering is reversed. Consistently across specifications and irrespective of which indicator of ex-ante financing status is chosen, we find that the economic significance of the coefficient on intangible capital is stronger in the sub-samples of firms that are more likely to face financial frictions. For example, the coefficient in Column (1) more than triples when we go from the top to the bottom quartile of the size distribution (Rows [1] and [2]). Further supporting our debt capacity mechanism, Appendix Table A9 shows that there is a positive relation between intangible capital and equity issuance, which is in line with the premise of our model that intangible capital leads firms to move away from debt to finance their growth opportunities.

Table A11 repeats the analysis for investment frictions. The basic insight of the vast literature on real options (e.g., Abel and Eberly (1994), Bertola and Caballero (1994)) is that fixed adjustment costs lead firms to make large, lumpy investments.

 $^{^{32}}$ In all the tests, we take the two full specifications, with and without firm fixed effects, as our starting point and report results for both the entire sample (Columns (1)-(2)) and for the sub-set of firms that report positive R&D (Columns (3)-(4)).

Thus, if intangible capital makes it more difficult to raise external finance, real frictions may lead firms with more intangible capital to accumulate even more cash to finance large investments. We split the sample between bottom and top quartiles of five proxies for investment frictions: (4-SIC) industry frequency of investment inaction and an indicator for whether there are investment spikes in the industry, which are both defined following Cooper and Haltiwanger (2006); the skewness and kurtosis of annual aggregate industry investment, both based on Caballero (1999); and the standard deviation of aggregate industry operating costs. The intuition underling these proxies is that, due to technological differences, the extent to which firms face fixed costs varies across industries. Thus, industries where fixed cost are higher are those where firms are more likely to adjust investment infrequently, and, conditional on adjusting, by a proportionally larger amount. In addition, in these industries fixed costs lead to a time-series distribution of aggregate investment that is sharply right-skewed and fat-tailed. We assign to the high (low) investment friction groups those firms in the top (bottom) quartile of the distribution of each of these measures in turn, except for the variability of operating costs, for which the ordering is reversed. For all specifications and indicators chosen, the coefficient on intangible capital is larger in the sub-samples of firms that are more likely to face investment frictions. Overall, the data support the unique economic mechanism at the heart of our model.

E Figures and Tables

Figure 1: INTANGIBLE CAPITAL, CASH HOLDINGS AND LEVERAGE

The figure depicts the long-run trend in the intangible capital ratio (relative to total assets net of cash) in Panel (a), the cash ratio (relative to total assets) in Panel (b), and the net debt ratio (relative to total assets) in Panel (c). The ratios are plotted as equal-weighted averages across all firms in the sample in each year. Total assets refer to the balance sheet book value of total assets. The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definition details are provided in Appendix B.



The figure depicts the long-run trend in the cash ratio in subsamples split by size (above and below median by total firm assets, Panel (a)), whether the firm is in a high tech industry as defined in (Loughran and Ritter 2004) (Panel (b)), and age (less than 5 years since IPO (Panel (c)) and less than 10 years since IPO (Panel (d)) vs all other firms). The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definitions are provided in Appendix B.



The figure depicts the long-run trend in the intangible capital ratio in subsamples split by size (above and below median by total firm assets, Panel (a)), whether the firm is in a high tech industry as defined in (Loughran and Ritter 2004) (Panel (b)), and age (less than 5 years since IPO (Panel (c)) and less than 10 years since IPO (Panel (d)) vs all other firms). The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definitions are provided in Appendix B.



Figure 4: CASH, AGGREGATE FACTS

The figure depicts the long-run trend in the aggregate cash ratio and aggregate cash holdings. Panel (a) plots the aggregate cash ratio, defined as the ratio of total cash holdings to total assets across all firms in each year. Panel (b) plots the long-run trend in the aggregate cash ratio in subsamples split by size (above and below median by total firm assets). Panel (c) plots the growth in annual aggregate cash holdings relative to 1970, defined as the sum of cash across all firms in the sample in each year normalized by the value of this sum in the beginning of sample (1970). Panel (d) plots the growth in annual aggregate cash holdings to 2010 with positive values for the sample. The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definitions are provided in Appendix B.



Figure 5: Optimal Policies

The figure depicts the optimal investment (Panel A), liquidity (Panel B), and leverage policies (Panel C) as a function of the tangible and intangible capital stocks K_T/Z and K_N/Z . The other state variables are set to their steady-state values. The thick black lines refer the case with high asset tangibility ($\theta = 0.7$), while the thin blue lines refer to the case with low asset tangibility ($\theta = 0.6$). The vertical black dotted lines delimit the inaction region for the case with high asset tangibility, while the vertical blue dashed-dotted lines delimit the inaction region for the case with low asset tangibility. All remaining parameters are set to the baseline values for the full sample as in Table 1.

Panel A: Investment Policy



The table reports the calibrated structural parameters. T the economy.	he frequency of the calibr	ation is annual. F^O is reported as a proportion of average tangible capital in
Description	Calibration	Target/Restriction
Techonological Parameters		
Curvature of profit function Asset tangibility	$\gamma = \begin{array}{c} 0.600\\ \theta = \end{array} 0.660$	Hennessy and Whited (2005, 2007) Average mix of tangible and intangible capital (data)
Depreciation of tangible capital Depreciation of intangible capital	$\delta_T = 0.120$ $\delta_N = 0.190$	Average depreciation of intangible capital (data) Average depreciation of intangible capital (data)
Elasticity of substitution between capital inputs Fixed cost of adjustment	p = 1.000 $F^K = 0.005$	High elasticity of substitution (=0.5) Bloom (2009)
Fixed cost of operation	$F^{0} = 0.085$	Average operating profits (data)
Volatility of technology shock	$\sigma_z = 0.350$	Idiosyncratic volatility of operating profits growth (data)
Financial Parameters		
Risk-free rate	r = 0.011	Average real interest (3-month treasury) rate (data)
Fixed cost of issuance	$\varphi_0 = 0.011$	Bolton, Chen, and Wang (2011), Altinkilic and Hansen (2000)
Linear cost of issuance Tax rate	$arphi_1=0.015 \ au=0.200$	Average equity issuance (data) Nikolov and Whited (2014)

Table 1: BASELINE CALIBRATION

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Table 2: Asset Tangibility and Cash Holdings: Baseline Quantitative Results

This table reports model-implied and data moments for the baseline calibration. The data moments in the first column are for a sample of nonfinancial, unregulated firms from the annual COMPUSTAT dataset, which we complement with information on equity issuance from SDC. The sample period is 1970 to 2010. The model-implied moments in the second column are calculated as averages of simulations of 1,000 firms and 100 time periods. To perform the simulation, we use 1,000 by 100 random draws from the lognormal distribution. The same set of random draws is applied to each economy. The expectation is approximated with 30 points Gauss-Hermite quadrature. The parameter values are as in Table 1. The third column reports model-implied moments for the case when firms use only tangible assets. All moments are self-explanatory, except for the Error Variance of Profits and Cash Autocorrelation, which are defined as the error variance and the slope coefficient from a first-order autoregression of idiosyncratic profit growth and the cash ratio, respectively. Details on model and data variable definitions are in Appendix Table A1.

	Data (1970-2010)	Model (Baseline)	$\begin{array}{c} \text{Model} \\ (\theta = 1) \end{array}$	_
	Panel A: Main Momen	nts		
Average Cash Ratio	0.140	0.151	0.020	
Average Leverage Ratio	0.239	0.211	0.251	
Average Equity Issuances	0.006	0.004	0.006	
Frequency of Equity Issuances	0.035	0.043	0.031	
Average Asset Tangibility	0.718	0.711	1.000	
Average Operating Profitability	0.151	0.151	0.145	
:	Panel B: Additional Mor	nents		
Error Variance of Profits	0.003	0.002	0.002	
Cash Autocorrelation	0.424	0.563	0.334	
Skewness of Tangible Investment	1.572	2.124	1.974	
Skewness of Intangible Investment	1.721	2.149	-	

Table 3: MAIN QUANTITATIVE COUNTERFACTUAL: CALIBRATION

This table reports the calibrated structural parameters for the main quantitative counterfactual, which involves a comparison between model-implied and data moments for the 1975-1985 decade ("Early Period") and the 1995-2005 decade ("Late Period").

	Calib	ration
Description	$\begin{array}{c} \text{Early} \\ (1975\text{-}1985) \end{array}$	Late (1995-2005)
Techonological Parameters		
Asset tangibility (θ)	0.710	0.620
Fixed cost of operation (F^O)	0.056	0.119
Volatility of technology shock (σ_z)	0.340	0.360
Financial Parameters		
Risk-free rate (r)	0.014	0.013
Fixed cost of issuance (φ_0)	0.022	0.011
Linear cost of issuance (φ_1)	0.020	0.014
Tax rate (τ)	0.250	0.200

unregulated firms from the annual COMPUST the second and fourth columns are calculated random draws from the lognormal distributio Gauss-Hermite quadrature. The parameter va cangibility parameter (θ) is kept constant at it Table A1.	TAT dataset, which w 1 as averages of simul on. The same set of alues are as in Table (ts calibrated value for	e complement with lations of 1,000 fir random draws is <i>i</i> 3. The fifth column the early period (h information on e ms and 100 time] applied to each ec n reports model-in (1975-1985). Detai	equity issuance fror periods. To perfor onomy. The expec nplied moments fo ils on model and da	a SDC. The model- m the simulation, a tation is approxim a counterfactual e ta variable definiti	implied moments in we use 1,000 by 100 ated with 30 points xercise in which the ons are in Appendix
		$\begin{array}{c} \text{Data} \\ (1975\text{-}1985) \end{array}$	$\begin{array}{c} Model \\ (1975-1985) \end{array}$	$\operatorname{Data}(1995-2005)$	$\begin{array}{c} Model \\ (1995-2005) \end{array}$	Counterfactual $(\theta \text{ Fixed})$
Average Cash Ratio Average Leverage Ratio Average Equity Issuances Frequency of Equity Issuances		$\begin{array}{c} 0.100\\ 0.256\\ 0.004\\ 0.029 \end{array}$	$\begin{array}{c} 0.095\\ 0.204\\ 0.003\\ 0.027\end{array}$	$\begin{array}{c} 0.183\\ 0.221\\ 0.007\\ 0.041 \end{array}$	$\begin{array}{c} 0.178\\ 0.191\\ 0.005\\ 0.064\end{array}$	$\begin{array}{c} 0.116\\ 0.210\\ 0.004\\ 0.055\end{array}$
Average Asset Tangibility Average Operating Profits		$0.754 \\ 0.168$	$0.754 \\ 0.164$	$0.677 \\ 0.133$	$0.672 \\ 0.133$	$0.751 \\ 0.133$
Change in Cash - Model (Late Change in Cash - Data (Late Change due to Intangible Cap. (Coun	e vs Early): 0.083 e vs Early): 0.083 iterfactual): 0.062					
Change in Leverage - Model(LateChange in Leverage - Data(LateChange due to Intangible Cap.(Count	e vs Early): -0.012 e vs Early): -0.035 terfactual): -0.019					
Change in Equity Issuance - Model (Late Change in Equity Issuance - Data (Late Change due to Intangible Cap. (Coun	e vs Early): 0.002 e vs Early): 0.003 hterfactual): 0.001					

Table 4: Asset Tangibility and the Rise in Cash Holdings: Results of Main Quantitative Counterfactual

This table reports model-implied and data moments for the main quantitative counterfactual, which involves a comparison of data and model-implied moments between the "Early Period" (1975-1985) and the "Late Period" (1995-2005). The data moments in the first and third columns are for a sample of nonfinancial,

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Table 5: Alternative Explanations for the Rise in Cash Holdings: Results of Additional Quantitative Counterfactuals

This table reports model-implied and data moments for additional quantitative counterfactuals. We consider three alternative explanations: Risk, Financing Costs, and Interest Rates. The data moments are for a sample of nonfinancial, unregulated firms from the annual COMPUSTAT dataset, which we complement with information on equity issuance from SDC. The data moments for the late period are reported in the third column of Table 4. The model-implied moments in each column are calculated as averages of simulations of 1,000 firms and 100 time periods. To perform the simulation, we use 1,000 by 100 random draws from the lognormal distribution. The same set of random draws is applied to each economy. The expectation is approximated with 30 points Gauss-Hermite quadrature. Each column reports model-implied moments for a counterfactual exercise in which, respectively, the profitability shock volatility (σ_z), the equity issuance costs (φ_0 and φ_1), and the riskfree rate (r) are kept constant at their calibrated value in the early period (1975-1985). All other parameter values are otherwise set as in Table 3. Details on model and data variable definitions are in Appendix Table A1.

	Counterfactual Volatility $(\sigma_z \text{ Fixed})$	Counterfactual Issuance Costs $(\varphi_0, \varphi_1 \text{ Fixed})$	Counterfactual Interest Rate (r Fixed)
Average Cash Ratio	0.164	0.297	0.191
Average Leverage Ratio	0.196	0.162	0.191
Average Equity Issuances	0.004	0.022	0.008
Frequency of Equity Issuances	0.057	0.035	0.065
Average Asset Tangibility	0.669	0.671	0.674
Average Operating Profits	0.132	0.133	0.133
Change in Cash - Data (Late vs Early):	0.070	0.203	0.096
Change due to Alternatives (Counterfactual):	0.014	-0.119	-0.013
Change in Leverage - Data (Late vs Early):	-0.007	-0.041	-0.012
Change due to Alternatives (Counterfactual):	-0.005	0.029	-0.000
Change in Equity Issuance - Data (Late vs Early):	0.002	0.019	0.006
Change due to Alternatives (Counterfactual):	0.000	-0.017	-0.004

Table 6: Asset Tangibility and Cash Holdings: Quantitative Analysis of the Cross-Sectional Implications

This table reports model-implied and data moments for the baseline quantitative analysis of the cross-sectional implications, which are calculated by sorting firms based on deciles of the firm size distribution. The data moments in the first and third columns are for a sample of nonfinancial, unregulated firms from the annual COMPUSTAT dataset between 1970 and 2010, which we complement with information on equity issuance from SDC. The model-implied moments in the second and fourth columns are calculated as averages of simulations of 1,000 firms and 100 time periods. To perform the simulation, we use 1,000 by 100 random draws from the lognormal distribution. The same set of random draws is applied to each economy. The expectation is approximated with 30 points Gauss-Hermite quadrature. The parameter values are as in Table 1. The fifth column reports model-implied moments for the value of cash, which are calculated similar to Bolton, Chen and Wang (2011) and Gamba and Triantis (2008) as the percentage gain in firm value from having the option to hold cash — i.e., as the percentage difference between firm value in the baseline and constrained value when not allowed to hold cash. Details on model and data variable definitions are in Appendix Table A1.

Size	Average Ca	sh Ratio	Aggreg. Cas	sh Shares	Value of Cash
Decile	Data (1970-2010)	Model Baseline	Data (1970-2010)	Model Baseline	Model Baseline
Small	0.154	0.173	0.002	0.000	14.868
2	0.147	0.165	0.004	0.000	14.239
3	0.144	0.162	0.007	0.001	14.006
4	0.134	0.159	0.011	0.003	13.791
5	0.132	0.157	0.016	0.007	13.743
6	0.124	0.157	0.026	0.017	13.618
7	0.117	0.156	0.039	0.035	13.549
8	0.105	0.152	0.062	0.071	13.176
9	0.094	0.131	0.127	0.127	11.300
Large	0.080	0.102	0.707	0.738	9.590

Cross-sectional Cash Spread (Small vs. Large) - Data: 0.074 Cross-sectional Cash Spread (Small vs. Large) - Model: 0.071

Table 7: CATIONS	Asset Tangibi	LITY AND THE R	ise in Cash Holi	dings: Quantita	tive Analysis oi	f the Cross-sec	tional and Age	REGATE IMPLI-
This table The data 1 with infor firms and applied to and data 1	r reports model-in noments in the fir mation on equity 100 time periods. each economy. T zariable definition	aplied and data mo st and third colum issuance from SDC . To perform the s he expectation is a s are in Appendix	ments for the quant ins are for a sample of C. The model-implied imulation, we use 1 upproximated with 3 Table A1.	f nonfine analysis of t f nonfinancial, unre, d moments in the se ,000 by 100 random 0 points Gauss-Herr	the rise in cash hold gulated firms from t scond and fourth co draws from the log n draws from the log mite quadrature. Tl	ing for firms in each he annual COMPUS lumns are calculate grormal distribution he parameter values	h decile of the firm STAT dataset, whic d as averages of sin a. The same set of s are as in Table 3.	size distribution. Ih we complement aulations of 1,000 random draws is Details on model
		Average	Cash Ratio			Aggreg. Ca	ash Shares	
Size	Data	Model	Data	Model	Data	Model	Data	Model
Decile	(1975-1985)	(1975 - 1985)	(1995-2005)	(1995-2005)	(1975-1985)	(1975-1985)	(1995-2005)	(1995-2005)
Small	0.116	0.106	0.181	0.201	0.002	0.000	0.001	0.000
2	0.108	0.103	0.188	0.191	0.004	0.001	0.003	0.000
റ	0.103	0.099	0.199	0.183	0.006	0.002	0.007	0.001
4	0.092	0.100	0.199	0.189	0.009	0.005	0.013	0.003
5	0.091	0.099	0.183	0.186	0.013	0.011	0.021	0.008
9	0.088	0.097	0.168	0.184	0.020	0.023	0.031	0.018
7	0.082	0.099	0.150	0.184	0.032	0.049	0.047	0.040
×	0.087	0.093	0.118	0.177	0.056	0.091	0.067	0.083
9	0.075	0.082	0.105	0.156	0.112	0.164	0.139	0.155
Large	0.069	0.066	0.086	0.127	0.746	0.656	0.670	0.691
Change	in Cash (Data -	Median Firm): C	0.092					
Unange	III Cash (Model	- INTEGLIAIL FIFILLJ:	100.0					
Change Change	in Cross-section in Cross-section.	al Cash Spread (] al Cash Spread (]	Data - Small vs. L Model - Small vs.	arge): 0.048 Large): 0.034				
Change Change Change	in Aggregate Cé in Aggregate Cé in Aggregate Ca	ash Ratio (Data): ash Ratio Due Int ash Ratio Due Int	0.042 angible Capital & angible Capital &	Top 5% Largest F Top 10% Largest	'irms (Counterfact Firms (Counterfac	ual): 0.033 tual): 0.039		

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Table 8: PANEL EVIDENCE ON INTANGIBLE CAPITAL AND FIRM FINANCING

This table reports estimates from panel regressions of the cash ratio on different measures of intangible capital for panel specifications with industry and firm fixed effects. In Panel A, intangible capital is the baseline IK measure defined as the sum of the stocks of past investments in firms' organizational capabilities and brand equity (organizational capital), technological knowledge (knowledge capital), and software and database development (IT capital) (see Section 2 for details). Panel B reports results from using only technological knowledge to measure intangibles. Panel C reports results from using only organizational capital to measure intangibles. Panel D reports results from adding the balance sheet Goodwill to the baseline measure, as in Peters and Taylor (2017). Reported coefficients in all panels are the change in the dependent variable associated with a one-standard deviation change in the corresponding measure of intangible capital. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the subsample of firms with positive R&D. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity (see Table A3 for the full set of coefficient estimates on controls). Firm fixed-effect regressions exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at the firm level. Predicted change in cash due to change in a intangible capital is obtained by taking the point estimates from the regression estimated over the 1970-1989 period and multiplying them by the difference in average value of intangible capital between the estimation (1970-1989) and the post-estimation 1990-2010 period. Detailed variable definitions are in Appendix B.

	Whole	Sample	R&D>	0 Firms				
	(1)	(2)	(2)	(4)				
	(1)	(2)	(3)	(4)				
Intangible Capital	Baseline 0.084*** (0.002)	IK measure 0.083*** (0.003)	0.099^{***} (0.002)	0.098^{***} (0.003)				
% Pred rise	42.50%		43 30%					
Pred rise	0.069		0.075					
Observations	155.255	97.052	78.341	54.295				
Adjusted R-squared	0.361	0.742	0.400	0.765				
	Only Ra	&D Capital						
Intangible Capital	0.083***	0.066***	0.103***	0.087***				
0	(0.002)	(0.003)	(0.002)	(0.003)				
Observations	150,574	96,136	77,052	53,858				
Adjusted R-squared	0.336	0.716	0.388	0.742				
Only Organizational Capital								
Intangible Capital	0.052^{***}	0.077^{***}	0.056^{***}	0.090^{***}				
	(0.002)	(0.002)	(0.002)	(0.003)				
Observations	$150,\!574$	96,136	77,052	53,858				
Adjusted R-squared	0.265	0.732	0.286	0.753				
Peter	s and Tay	lor (2017) me	easure					
Intangible Capital	0.080^{***}	0.076^{***}	0.096^{***}	0.090^{***}				
	(0.002)	(0.003)	(0.002)	(0.003)				
	150 551	00 190	77.059	59.05 0				
Observations	150,571	90,130	0.254	53,858				
Aujustea K-squared	0.318	0.720	0.334	0.747				
Firm Controls	Ves	Ves	Ves	Ves				
Year FE	Yes	Yes	Yes	Yes				
Industry FE	Yes	No	Yes	No				
Firm FE	No	Yes	No	Yes				

Table 9: PANEL EVIDENCE ON ALTERNATIVE CHANNELS

		$\mathop{\mathrm{Age}}_{(12)}$	0.089^{***} (0.003)						-0.009^{***} (0.003)		$95,741 \\ 0.733$	Yes Yes No Yes
		Firm (11)	0.092^{***} (0.002)						-0.027^{***} (0.001)	-1.4%	$131,102 \\ 0.364$	Yes Yes No
	ne in	$_{(10)}^{\mathrm{Share}}$	0.089^{***} (0.003)					-0.005***	(100.0)		92,306 0.733	Yes No No Yes
	Decli	Labor (9)	0.088^{***} (0.002)					-0.006***	(100.0)	2.1%	$144,108\\0.329$	Yes No Yes No
		f Carry (8)	0.089^{***} (0.003)				-0.006***	(100.0)			$95,741 \\ 0.731$	$\begin{array}{c} {\rm Yes} \\ {\rm N}_0 \\ {\rm N}_0 \end{array}$
ntrols for		Cost of (7)	0.088^{***} (0.002)				-0.003^{***}	(100.0)		11.2%	$150,574 \\ 0.331$	Yes No Yes No
X co	$\begin{array}{c c} X \ con \\ Broad-based \\ Equity \ Comp \\ (5) \ (6) \\ (0.003) \ (0.004) \\ (0.003) \ (0.004) \\ (0.001) \ (0.001) \\ (0.001) \ (0.001) \end{array}$						47,076 0.700	Yes Yes No Yes				
						-0.7%	$72,514 \\ 0.226$	Yes Yes No				
		ationals (4)	0.096^{***} (0.004)		0.001	(100.0)					49,218 0.777	Yes Yes No Yes
		Multin (3)	0.094^{***} (0.003)		0.004^{***}	(100.0)				0.5%	67,628 0.353	Yes Yes No
	stry	(2)	0.099^{***} (0.003)	0.001	(100.0)						$95,741 \\ 0.733$	Yes Yes No Yes
	Indu	$\begin{array}{c} \text{Compt} \\ (1) \end{array}$	0.097^{***} (0.002)	-0.008***	(100.0)					1.2%	$150,574 \\ 0.334$	Yes Yes No
			Intangible Capital	Х=ННІ	X=Foreign taxes	X=Stock Options	X=Cost of Carry	X=Labor Share	X=Firm Age	% due to X	Observations R-squared	Firm Controls Year FE Industry FE Firm FE

Table 10: Additional Panel Evidence on Patent Pledgeability

The table reports parameter estimates from panel regressions of the cash ratio on intangible capital and controls for the ability of a firm to pledge patents as collateral. Panel A shows results from including a firm's number of pledged patents as control. Panel B shows results from a difference-in-differences specification around the 2002 passage of the ABSFA law in Delaware as in Mann (2018), where we allow the effect of the law to vary by firms' intangible capital ratio. Reported coefficients are the change in the cash ratio associated with a one-standard deviation change in the explanatory variable. The sample in Panel A spans the entire sample period (1970 to 2010) while that in Panel B is limited to 8 years before and after the year of ABSFA passage. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the subsample of firms with positive R&D. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at the firm level. Variable definitions are in Appendix B.

	Whole	Sample	R&D Firms Only						
	(1)	(2)	(3)	(4)					
Panel A: Controlling for	pledged pa	atents							
Intangible Capital	0.089***	0.089***	0.092***	0.094***					
	(0.002)	(0.003)	(0.002)	(0.003)					
Pledged patents	-0.061***	-0.016***	-0.079***	-0.022***					
	(0.004)	(0.003)	(0.005)	(0.004)					
Observations	150,574	95,741	77.052	$53,\!645$					
R-squared	0.334	0.733	0.369	0.754					
Firm Controls	Yes	Yes	Yes	Yes					
Year FE	Yes	Yes	Yes	Yes					
Industry FE	Yes	No	Yes	No					
Firm FE	No	Yes	No	Yes					
Panel B: Difference-in-differences analysis									
Intangible Capital	0.085***	0.087***	0.093***	0.094***					
0	(0.003)	(0.003)	(0.003)	(0.003)					
Treated	-0.007	-0.001	-0.017***	-0.013*					
	(0.005)	(0.005)	(0.006)	(0.007)					
Intangible Capital*Treated		-0.006**		-0.003					
		(0.003)		(0.003)					
Observations	62,217	62,217	35,778	35,778					
R-squared	0.771	0.771	0.780	0.780					
Firm Controls	Yes	Yes	Yes	Yes					
Year FE	Yes	Yes	Yes	Yes					
Firm FE	Yes	Yes	Yes	Yes					

Online Appendix

Figure A1: RISE IN INTANGIBLE CAPITAL: BREAKDOWN BY COMPONENTS OF THE BASELINE IK MEASURE

The figure shows the long-run trend in the intangible capital ratio broken down into the three components of the baseline measure: the sum of the stocks of past investments in firms' organizational capabilities and brand equity (organizational capital), technological knowledge (knowledge capital), and software and database development (IT capital) (see Section 2 for details). Each stock is normalized by the book value of total assets net of cash. Each component is plotted as an equal-weighted average across all firms in the sample in each year. The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definition details are provided in Appendix B.



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Figure A2: RISE IN THE INTANGIBLE CAPITAL RATIO: ROBUSTNESS

The figure depicts the long-run trend in intangible capital for several alternative measures that vary key assumptions in constructing the baseline intangible capital measure. In Panel (a), past investments in organizational capital and knowledge capital are capitalized using depreciation rates of 10%, 20%, or 30% instead of the 15% in the baseline measure. In Panel (b), organizational capital is weighted 10% or 30% instead of the 20% in the baseline measure. Both panels show intangible capital computed using the described variations as well as the baseline measure (IK-main). See Section 2 for details on construction of the baseline measure.

(a) Varying the depreciation rate



(b) Varying the weights on organizational capital





The figure depicts the long-run trend in the cash ratio using alternative approaches to normalizing cash holdings. In Panel (a), cash holdings are normalized by the (balance sheet) total assets (as in Panel (b) of Figure 1) and by the sum of total assets and the baseline measure of intangible capital. In Panel (b), cash holdings are normalized by total assets less cash (net total assets) and by the sum of net total assets and the baseline measure of intangible capital. See Section 2 for details on construction of the baseline measure of intangible capital. Variable definition details are provided in Appendix B.





- 0661

- 366

2000

2005

2010-

985

975 -

970

-086

Figure A4: Cash against IK: By age

The figure presents the joint variation of cash and intangible capital ratios in subsamples of firms split by age (less than 5 years since IPO vs all other firms in Panel (a) and less than 10 years since IPO vs all other firms in Panel (b)). Within each age group, the sample is divided into deciles according to firm-level intangible capital ratio (horizontal axis). For each of these deciles, the plot depicts the average cash ratio for firms in that decile (vertical axis). Variable definition details are provided in Appendix B.



(b) Age II



4

Figure A5: Changes in Intangible Capital and Cash: Cross-Industry Variation

The figure depicts the joint evolution of industry-average cash and intangible capital ratios in our sample. Panel (a) plots the distribution of average cash ratios for broad industry sectors (Fama-French 12 industries) for each decade in our sample. Sectors are sorted by the sector-average intangible capital ratio in the 2000s and the bars show sector-average cash ratios in each decade. Panel (b) lists six finer(48)-category industries that exhibit the largest change in industry-average intangible capital and cash ratios between the first half and the second half of our sample (pre- and post-1990, respectively). The panel lists both the industry titles and the actual changes in intangible capital and cash. Panel (c) depicts the long-run trend the cash ratio in subsamples split by whether the firm is the "Business Services" sector (SIC codes 7000-7999), the high tech industries as defined in (Loughran and Ritter 2004) but excluding industries in the Business Services sector, and all remaining industries. Variable definition details are provided in Appendix B.

(a) Sector-average cash ratios, by decade



(b) Top Fama-French (48) industries by increase in intangible capital and cash

By increase in intangi	ble capital	By increase in cash		
	Change in IK	-	Change in Cash	
Pharmaceutical Products	1.22	Pharmaceutical Products	0.26	
Medical Eqpt	0.90	Medical Eqpt	0.15	
Computers	0.75	Electronic Eqpt	0.13	
Business Services	0.72	Computers	0.13	
Measuring & Control Eqpt	0.72	Business Services	0.12	
Electronic Eqpt	0.63	Measuring & Control Eqpt	0.12	





Figure A6: CHANGES IN INTANGIBLE CAPITAL AND CASH: WITHIN-FIRM VARIATION

The figure presents the within-firm joint variation of cash and intangible capital ratios. The sample is divided into deciles according to firm-level annual changes in the intangible capital ratio (horizontal axis). For each of these deciles, the plot depicts the average annual change in the cash ratio for firms in the decile (vertical axis). Variable definition details are provided in Appendix B.



Figure A7: Additional Evidence on Patent Pledgeability: Pre-trends

The figure depicts the evolution of cash ratios in treated and control firms in the 7-year (i.e., (-3,+3)) window around the passage of the ABSFA law in Delaware in 2002. The Treated sample consists of firms incorporated in Delaware at the date of the law's passage; the Control sample consists of all remaining firms. The sample excludes firms incorporated in states that enacted similar laws (Alabama, Texas, Louisiana, Virginia, South Dakota, Nevada, Ohio, and North Carolina; see Mann (2018) for details). Panel (a) plots the average annual within-firm cash ratio in each sample around the year of the ABSFA law adoption (2002). Panel (b) depicts the estimated effect of the law on cash for each year in the three-year window before and after the adoption, relative to the year of adoption (2002). Estimates are obtained from regressions identical to those in Column (3) of Panel B of Table 10, where the treatment dummy is interacted with each of the years in the event window. Vertical lines indicate two standard errors above and below each estimated coefficient.



(a) Average cash ratios around the event date




Table A1: VARIABLE DEFINITIONS - MODEL

This table details the mapping between model-based and data-based quantities. ik is defined as the sum of knowledge, organizational, and IT capital, as detailed in Section 2.

	Model	Data
Cash Debt Cash/Assets Debt/Assets Equity Issuance Indicator (<i>SEO</i>) Equity Issuances/Assets Asset Tangibility Operating Profits	$-\min(b, 0)$ $\max(b, 0)$ $\frac{Cash}{k_T+Cash}$ $\frac{Debt}{k_T+Cash}$ $\mathbb{1}_{\{e>0\}}$ $\frac{e}{k_T+Cash}$ $\frac{k_T+Cash}{k_T+k_N}$ $\Phi(k_T, k_N)^{\gamma} - F^0$	$\begin{array}{c} che\\ dltt + dlc\\ \frac{Cash}{at}\\ \frac{Debt}{at}\\ \\ \hline \\ \underbrace{1 \{ \text{SEO reported in SDC } \} \\ \underbrace{(sstk - prstkc) \cdot 1_{\{SEO=1\}}}_{at - che}\\ \frac{at - che}{ik + at - che}\\ oibdp + xrd + 0.2 \cdot sga \end{array}$

Table A2: Sensitivity Analysis to Parameter Values

This table reports model-implied average cash values for a series of counterfactual exercises in which the parameters ρ and F_i^K , i = T, N are both decreased and increased with respect to their baseline values of Table 1. Details on model and data variable definitions are in Appendix Table A1.

	Change in Cash - Model (Late vs Early)
Baseline	0.083
$ \rho = -0.50 $ $ \rho = 0.95 $ $ \rho = 1.05 $ $ \rho = 2.00 $	0.063 0.088 0.088 0.101
$\begin{split} F_T^K &= F_N^K = 0.001 \\ F_T^K &= F_N^K = 0.004 \\ F_T^K &= F_N^K = 0.006 \\ F_T^K &= F_N^K = 0.010 \end{split}$	$ \begin{array}{c} 0.080 \\ 0.076 \\ 0.089 \\ 0.096 \end{array} $

This table reports full estimates from panel regressions of the cash ratio on the baseline measure of intangible capital reported
in Panel A of Table 8. Reported coefficients in all panels are the change in cash ratio associated with a one-standard deviation
change in the explanatory variable. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the
subsample of firms with positive R&D. Year dummies are included in all regressions and are omitted for brevity). Firm fixed-
effect regressions exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at
the firm level. Detailed definitions of all variables are in Appendix B.

	Whole	Sample	R&D Fi	rms Only
	(1)	(2)	(3)	(4)
Intangible Capital	0.084***	0.083***	0.099***	0.098***
	(0.002)	(0.003)	(0.002)	(0.003)
Industry sigma	0.008***	0.001	0.013***	-0.000
v	(0.001)	(0.001)	(0.002)	(0.002)
Market-to-book	0.031***	0.012***	0.035^{***}	0.014***
	(0.001)	(0.001)	(0.002)	(0.001)
Firm size	-0.000	0.054***	0.016^{***}	0.092***
	(0.001)	(0.004)	(0.002)	(0.006)
Cashflow	0.019***	0.015^{***}	0.023***	0.020***
	(0.001)	(0.001)	(0.002)	(0.002)
Capex	-0.012***	-0.012***	-0.013***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
Dividend	-0.017***	0.014***	-0.042***	0.010***
	(0.002)	(0.002)	(0.004)	(0.003)
Acquisitions	-0.010***	-0.007***	-0.012***	-0.009***
	(0.000)	(0.000)	(0.001)	(0.000)
Observations	$150,\!574$	$96,\!136$	77,052	$53,\!858$
R-squared	0.333	0.732	0.367	0.754
Industry FE	Yes	No	Yes	No
$\mathbf{Firm} \ \mathbf{FE}$	No	Yes	No	Yes

Table A3: PANEL EVIDENCE ON INTANGIBLE CAPITAL AND CASH HOLDINGS: FULL RESULTS

Table A4: INTANGIBLE CAPITAL AND CORPORATE CASH HOLDINGS: ROBUSTNESS ANALYSIS

The table reports parameter estimates from panel regressions of the cash ratio on several alternative measures of intangible capital that vary key assumptions in constructing the baseline intangible capital measure. In Rows 1-3, past investments in organizational capital and knowledge capital are capitalized using depreciation rates of 10%, 20%, or 30% instead of the 15% in the baseline measure. In Rows 4-5, organizational capital is weighted 10% or 30% instead of the 20% in the baseline measure. In Row 6, we proxy for intangible capital with industry-level R&D capital estimates from the Bureau of Economic Analysis' (BEA) Fixed Assets data. In Row 7, IT capital is omitted from the baseline IK measure. In Row 8, we use the principal component analysis to extract a common factor component for the 3 components of the baseline IK measure and then use that as the summary IK measure. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the subsample of firms with positive R&D. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at the firm level. Detailed definitions of all variables are in Appendix B.

	Whole Sample		R&D	only
	(1)	(2)	(3)	(4)
[1] Depresiation Pate-100				
[1] Depreciation Rate=1070	0 075***	0.081***	0.086***	0 096***
	(0.002)	(0.001)	(0.002)	(0.003)
[2] Depreciation Rate= 20%	(0.00-)	(0.000)	(0.00-)	(01000)
	0.091***	0.086***	0.109***	0.100***
	(0.002)	(0.003)	(0.002)	(0.003)
[3] Depreciation Rate= 30%				
	0.101^{***}	0.090^{***}	0.123^{***}	0.104^{***}
	(0.002)	(0.003)	(0.002)	(0.003)
[4] SG&A Weight=10%	0 000****	0 000***	0 4 0 0 ***	
	0.088^{+++}	0.083***	0.103^{***}	0.097***
[] COLAW-:-1+ 2007	(0.002)	(0.003)	(0.002)	(0.003)
[5] SG&A weight=30%	0 000***	0 002***	0.005***	0 000***
	(0.000^{-10})	(0.003)	(0.095)	(0.098)
[6] BEA measure	(0.002)	(0.003)	(0.002)	(0.003)
	0.038***	0.019***	0.042***	0.011*
	(0.004)	(0.006)	(0.005)	(0.006)
[7] Excluding IT		× ,	()	× ,
	0.083^{***}	0.083***	0.098^{***}	0.098^{***}
	(0.002)	(0.003)	(0.002)	(0.003)
[8] Factor measure				
	0.076***	0.096***	0.086***	0.107***
	(0.002)	(0.003)	(0.002)	(0.004)

Table A5: Intangible Capital and Corporate Cash Holdings: Robustness Analysis

The table reports parameter estimates from panel regressions of the cash ratio on intangible capital using alternative approaches to normalizing cash holdings (Panel A) and alternative specifications (Panel B). In Panel A, cash holdings are normalized by the sum of total assets and the baseline measure of intangible capital (Row [1]) and by the sum of net total assets and the baseline measure of intangible capital (Row [2]). Row [3] of Panel B reports results from using the Erickson-Whited correction for mismeasurement in the average q, which is used as a controls in all regressions. Row [4] reports results from excluding firms in high tech industries as defined in (Loughran and Ritter 2004). Row [5] reports results from regressions that control for firm profitability, defined as the ratio of operating income to assets. Row [6] reports results from regressions that weigh observations by log of firm assets. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the subsample of firms with positive R&D. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at the firm level. Detailed definitions of all variables are in Appendix B.

		Whole	Sample	R&D	only
		(1)	(2)	(3)	(4)
Panal A. Including intensi	olo conital in cash	ratio dan	minator		
[1] $Cash/(Total Assets + IK)$	Intangible Capital	0.045***	0.046***	0.055***	0.058***
		(0.001)	(0.002)	(0.002)	(0.003)
	Observations	155.255	97.052	78.341	54.295
	R-squared	0.198	0.675	0.236	0.699
[2] Cash/(Net Assets + IK)	Intangible Capital	0.114***	0.123***	0.146***	0.159***
[] / ()	9	(0.004)	(0.006)	(0.006)	(0.008)
	Observations	155.255	97.052	78.341	54,295
	R-squared	0.166	0.649	0.201	0.683
[3] Erickson-Whited Q	Intangible Capital	0.076***	0.077***	0.095***	0.098***
[-]	9 I	(0.002)	(0.002)	(0.002)	(0.002)
	Observations	151,289	151,289	77,346	77,346
[4] Euclude high took contour	Intangible Capital	0.087***	0.081***	0.117***	0.099***
[4] Exclude high-tech sectors		(0.002)	(0.003)	(0.003)	(0.004)
	Observations	$124,\!546$	78,568	53,004	38,639
	R-squared	0.362	0.733	0.450	0.775
[5] Control for profitability	Intangible Capital	0.085***	0.084***	0.100***	0.099***
[5] Control for prontability		(0.002)	(0.003)	(0.002)	(0.003)
	Profitability	(0.029^{***})	(0.023^{***})	(0.039^{***})	(0.030^{***})
		150 554	00.100		FR 0 F 0
	Observations R-squared	$150,574 \\ 0.339$	96,136 0.736	77,052 0.373	53,858 0.758
		0.00	0.000***	0.000***	0.004***
[6] WLS	Intangible Capital	(0.067^{***})	(0.082^{***}) (0.003)	(0.083^{***})	(0.094^{***}) (0.004)
	Observations	150.571	96.134	77.049	53.856
		0.249	0.758	0.254	0.761
	Firm Controls	Yes	Yes	Yes	Yes
	Year FE	Yes	Yes	Yes	Yes
	Industry FE	Yes	No Voz	Yes	No
	FIRM FE	INO	res	INO	res

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Table A6: INTANGIBLE CAPITAL AND CORPORATE CASH HOLDINGS: ROLE OF FIRM AGE AND ENTRY

The table reports parameter estimates from panel regressions of the cash ratio on intangible capital and controls. Row [1] adds controls for firm entry decade cohort (1970s', 1980s, 1990s, and 2000s, respectively). Rows [2] and [3] add controls for five-year IPO cohorts and IPO year dummies, respectively. Rows [4] and [5] use the baseline specification of Table 8, but drop observations for each firm's initial 5 years (Row [4]) and 10 years (Row [5]) upon entry. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Columns (1) and (2) are for the entire sample, while Columns (3) and (4) are for the subsample of firms with positive R&D. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. Rows [1]-[3] regressions are not run with firm fixed effects as they would subsume entry period cohort dummies. p-values are in parentheses and are clustered at the firm level. Variable definitions are in Appendix B.

	Whole Sample		R&D Firms Onl	
	(1)	(2)	(3)	(4)
[1] Controlling for 10-year IPO cohorts				
Intangible Capital	0.084^{***}		0.098^{***}	
	(0.002)		(0.002)	
Cohort_1	-0.019***		-0.026***	
	(0.004)		(0.007)	
Cohort_2	0.011***		0.014***	
	(0.003)		(0.005)	
Cohort_3	0.033***		0.055^{***}	
	(0.003)		(0.005)	
Cohort_4	0.028		0.054	
	(0.032)		(0.044)	
Observations	150.574		77.052	
R-squared	0.337		0.376	
[2] Controlling for 5-year IPO cohorts				
Intangible Capital	0.08/***		0 008***	
Intaligible Capital	(0.004)		(0.030)	
	(0.002)		(0.002)	
Observations	150.574		77.052	
R-squared	0.337		0.376	
[3] Controlling for IPO year cohorts				
[5] Controlling for fr O year conorts	0.084***		0.008***	
Intaligible Capital	(0.004)		(0.098)	
	(0.002)		(0.002)	
Observations	150,574		77,052	
R-squared	0.337		0.374	
[4] Dropping young firms (less than 5 yo)				
Intangible Capital	0 086***	0 090***	0 100***	0 107***
intaligible capital	(0.002)	(0.004)	(0.003)	(0.005)
	(0.002)	(0.001)	(0.000)	(0.000)
Observations	$112,\!680$	$89,\!847$	57,955	50,751
R-squared	0.361	0.740	0.404	0.762
[5] Dropping young firms (less than 10 yo)				
Intangible Capital	0.092^{***}	0.089^{***}	0.109^{***}	0.105^{***}
S S S S S S S S S S S S S S S S S S S	(0.002)	(0.003)	(0.003)	(0.004)
	()	()	(- 000)	(
Observations	88,925	66,268	45,551	38,361
R-squared	0.339	0.736	0.374	0.750
Firm Controls	Vac	Vec	$\mathbf{V}_{\alpha\alpha}$	Vac
	Vec	Vec	Ies Vec	Vac
Ieal FE Industry: FE	res	res Na	res	res
Firm FE Electronic conviousilable at: http	res	 	1090 Mo	Ves

Table A7: INTANGIBLE CAPITAL AND CORPORATE CASH HOLDINGS: ROLE OF CASH AND IK AT IPO

The table reports parameter estimates from panel regressions of the cash ratio on intangible capital for firms that went public during the sample period (1970-2010), controlling for these firms' cash holdings and intangible capital at IPO. Columns (1)-(4) are for the entire sample, while Columns (5)-(8) are for the subsample of firms with positive R&D. Within each set, the first column presents results from the baseline specification of Table 8 but in the IPO firms sample only, for reference. The second and third columns add controls for each firm's IPO-year cash ratio and intangible capital ratio, respectively. The fourth column controls for both IPO-year cash ratio and intangible capital. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in the reported explanatory variable. Intangible capital at IPO is computed using the average of the first five post-IPO years. Year dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. Regressions that control for IK at IPO exclude first five post-IPO years. None of the specifications include firm fixed effects as they would subsume IPO-year variables. p-values are in parentheses and are clustered at the firm level. Variable definitions are in Appendix B.

	Whole Sample			R&D Firms Only				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intangible Capital	0.125^{***} (0.003)	0.092^{***} (0.003)	0.116^{***} (0.004)	0.114^{***} (0.004)	0.146^{***} (0.004)	0.109^{***} (0.003)	0.134^{***} (0.005)	0.132^{***} (0.005)
Cash at IPO	(0.000)	(0.000) (0.097^{***}) (0.002)	(0.001)	(0.001) 0.046^{***} (0.003)	(0.001)	(0.000) (0.111^{***}) (0.003)	(0.000)	(0.000) (0.049^{***}) (0.005)
IK at IPO		()	$\begin{array}{c} 0.037^{***} \\ (0.004) \end{array}$	0.015^{***} (0.005)		()	$\begin{array}{c} 0.044^{***} \\ (0.005) \end{array}$	0.021^{***} (0.006)
Observations	48,500	48,500	$20,\!653$	$20,\!653$	23,593	23,593	10,122	10,122
R-squared	0.440	0.556	0.502	0.530	0.417	0.543	0.495	0.521
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	No	No

Table A8: Additional Evidence on Patent Pledgeability: Sample Splits

The table reports parameter estimates from difference-in-differences specifications around the 2002 passage of the ABSFA law in Delaware in 2002, as in Panel B of Table 10 in subsamples split on whether the firms have an active patent application pre-treatment. Columns (1) and (4) report the baseline result from Panel B of Table 10 for the whole sample and for positive R&D firms, respectively, for reference. Firms are considered to have an active patent application if they apply for a patent in the preceding year. The sample is limited to 8 years before and after the year of ABSFA passage. Year and firm dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. p-values are in parentheses and are clustered at the firm level. Variable definitions are in Appendix B.

	Whole Sample				R&D only			
	All	Applied for	r patent	All	Applied for	r patent		
		in year t-1			in year t-1			
		Yes	No		Yes	No		
	(1)	(2)	(3)	(4)	(5)	(6)		
	0 00	0 001***	0 00	0.00.4***	0 000***	0 00 5444		
Intangible Capital	0.085***	0.091***	0.085***	0.094***	0.093***	0.095***		
	(0.003)	(0.005)	(0.003)	(0.003)	(0.005)	(0.004)		
Treated	-0.007	-0.027***	-0.001	-0.017***	-0.029***	-0.012		
	(0.005)	(0.009)	(0.005)	(0.006)	(0.009)	(0.008)		
Observations	62.217	11.387	49.959	32.923	10.528	21.634		
R-squared	0.771	0.856	0.764	0.782	0.853	0.775		
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes		
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes		

Table A9: INTANGIBLE CAPITAL AND EQUITY ISSUANCE

The table reports parameter estimates from panel regressions of the ratio of net equity issuance to assets on intangible capital and controls. Columns (1)-(3) are for the entire sample, while Columns (4)-(6) are for the subsample of firms with positive R&D. In each subsample, we run the regression for three variants of defining net equity issuance corresponding to cutoffs of 0% of net assets, 1% of net assets, and 5% of net assets. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Year and firm dummies as well as firm-level controls for standard determinants of financial policies are included in all regressions and are omitted for brevity. All regressions include firm fixed effects and therefore exclude firms with less than five consecutive years of data. p-values are in parentheses and are clustered at the firm level. Variable definitions are in Appendix B.

	Whole Sample			R&D Firms Only				
	Cutoff value (%Assets)			Cuto	Cutoff value (%Assets)			
	0%	1%	5%	0%	1%	5%		
	(1)	(2)	(3)	(4)	(5)	(6)		
					,	. ,		
Intangible Capital	0.003	0.011***	0.035***	0.006**	0.015***	0.044***		
	(0.002)	(0.004)	(0.008)	(0.002)	(0.005)	(0.010)		
Industry sigma	-0.000	-0.002	-0.002	-0.000	-0.000	0.001		
	(0.001)	(0.002)	(0.004)	(0.001)	(0.003)	(0.007)		
Market-to-book	0.023^{***}	0.027^{***}	0.032^{***}	0.027^{***}	0.028^{***}	0.031^{***}		
	(0.002)	(0.003)	(0.005)	(0.002)	(0.003)	(0.006)		
Firm size	0.010^{***}	0.007	0.029^{**}	0.018^{***}	0.016^{**}	0.048^{***}		
	(0.002)	(0.006)	(0.012)	(0.004)	(0.008)	(0.018)		
Cashflow	-0.019^{***}	-0.044***	-0.067***	-0.022***	-0.051^{***}	-0.074^{***}		
	(0.002)	(0.004)	(0.007)	(0.003)	(0.006)	(0.010)		
Capex	0.005^{***}	0.008^{***}	0.013^{***}	0.002^{**}	0.002	0.004		
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.004)		
Dividend	-0.013***	-0.032***	-0.066***	-0.014***	-0.036***	-0.085***		
	(0.001)	(0.003)	(0.007)	(0.002)	(0.005)	(0.011)		
Acquisitions	0.007^{***}	0.013^{***}	0.018^{***}	0.006^{***}	0.011^{***}	0.017^{***}		
	(0.000)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)		
Observations	89.603	30,192	11,777	49,674	18,453	7,181		
Adjusted R-squared	0.465	0.610	0.705	0.500	0.624	0.708		
0 1								
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes		
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes		

The table reports parameter estimates from panel regressions of the cash ratio on the baseline measure of intangible capital for several sub-sample splits based on ex-ante proxies for the severity of financial frictions faced by firms. Reported coefficients are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Controls are as in Table 8. The estimates of these controls are omitted from the table for brevity and are available upon request. Columns (1) and (2) report results for the whole sample, while Columns (3) and (4) are for the subsample of firms that report positive R&D. For each of the two samples, we report estimates for regressions with and without firm fixed effects. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. The sample is split between bottom and top quartiles of (year-prior) values of the following ex-ante proxies of financial frictions: firm size (Rows [1] to [2]), (Whited and Wu 2006) WW-Index (Rows [5] to [6]), (Berger, Ofek, and Swary 1996) asset liquidation value (Rows [7] to [8]), and (Balasubramanian and Sivadasan 2009) index of industry asset redeployability (Rows [9] to [10]), and by dividend payer status (Rows [3] to [4]). p-values clustered at the firm level are in parentheses. For detailed variable definitions, see Appendix B.

		Whole	Sample	R&D Fin	rms only
		(1)	(2)	(3)	(4)
By F	'irm Si	ze			
[1]	Q1	0.102	0.112	0.120	0.120
[*]	~C -	(0.000)	(0.000)	(0.000)	(0.000)
[2]	Q4	0.030	0.028	0.037	0.039
LJ	~	(0.000)	(0.000)	(0.000)	(0.000)
By D	lividen	d Paver S	tatus		
[3]	No	0 100	0.075	0 124	0.090
[U]	110	(0.000)	(0,000)	(0.000)	(0.000)
[4]	Ves	0.028	0.034	0.033	0.035
[1]	105	(0.000)	(0.000)	(0.000)	(0.000)
By V	VW-In	dex			
[5]	$\mathbf{Q4}$	0.104	0.090	0.126	0.107
		(0.000)	(0.000)	(0.000)	(0.000)
[6]	Q1	0.055	0.050	0.065	0.058
		(0.000)	(0.000)	(0.000)	(0.000)
By A	lsset L	iquidation	Value		
[7]	Q1	0.145	0.109	0.152	0.115
	•	(0.000)	(0.000)	(0.000)	(0.000)
[8]	Q4	0.051	0.049	0.059	0.054
	-	(0.000)	(0.000)	(0.000)	(0.000)
By D	egree	of Asset R	ledeplovabi	lity	
[9]	Q1	0.199	0.126	0.207	0.132
	v	(0.000)	(0.000)	(0.000)	(0.000)
[10]	Q4	0.062	0.048	0.084	0.059
L J	•	(0.000)	(0.000)	(0.000)	(0.000)

The table reports parameter estimates from panel regressions of the cash ratio on the baseline measure of intangible capital for several sub-sample splits based on ex-ante proxies for the severity of investment frictions faced by firms. Reported coefficient are the change in the dependent variable associated with a one-standard deviation change in intangible capital. Controls are as in Table 8. The estimates of these controls are omitted from the table for brevity and are available upon request. Columns (1) and (2) report results for the whole sample, while Columns (3) and (4) are for the subsample of firms that report positive R&D. For each of the two samples, we report estimates for regressions with and without firm fixed effects. Firm fixed-effect regressions exclude firms with less than five consecutive years of data. The sample is split between bottom and top quartiles of: (4-SIC) industry frequency of investment inaction - |Capex/book assets| < 01 (Rows [1] to [2]), and whether in the industry there are investment spikes - |Capex/book assets| > 2 (Rows [3] to [4]), all based on (Cooper and Haltiwanger 2006); time-series skewness (Rows [5] to [6]) and kurtosis (Rows [7] to [8]) of annual aggregate industry investment (Capex/book assets), based on (Caballero 1999); and the time-series standard deviation of aggregate industry operating costs (Rows [9] to [10]). p-values clustered at the firm level are in parentheses. For detailed variable definitions, see Appendix B.

Whale Group Deb DEiror Orla						
		whole	Sample	K&D FII	rms Only	
		(1)	(2)	(3)	(4)	
By I	ndustr	y Frequen	cy of Inves	tment Inact	ion	
[1]	Q1	0.024	0.031	0.030	0.036	
	-	(0.000)	(0.000)	(0.000)	(0.000)	
[2]	$\mathbf{Q4}$	0.137	0.112	0.162	0.133	
		(0.000)	(0.000)	(0.000)	(0.000)	
By I	nvestri	ent Spike	s in the In	dustry		
[3]	No	0.049	0.048	0.061	0.049	
[9]	110	(0.000)	(0.000)	(0.000)	(0.000)	
[4]	Yes	0.095	0.079	0.120	0.081	
[-]		(0.000)	(0.000)	(0.000)	(0.000)	
Ву Т	Time-S	eries Skew	vness of Inc	lustry Invest	tment	
[5]	Q1	0.044	0.043	0.060	0.047	
		(0.000)	(0.000)	(0.000)	(0.000)	
[6]	$\mathbf{Q4}$	0.100	0.079	0.145	0.104	
		(0.000)	(0.000)	(0.000)	(0.000)	
Bv T	ime-S	eries Kurt	osis of Ind	ustry Invest	ment	
[7]	Q1	0.048	0.046	0.065	0.051	
[,]	~0-	(0.000)	(0.000)	(0.000)	(0.000)	
[8]	Q4	0.092	0.078	0.133	0.093	
[0]	-0 -	(0.000)	(0.000)	(0.000)	(0.000)	
	~				. ,	
By T	'ime-S	eries Varia	ability of C	perating Co	osts	
[9]	Q4	0.038	0.040	0.054	0.050	
		(0.000)	(0.000)	(0.000)	(0.000)	
[10]	Q1	0.102	0.080	0.133	0.096	
		(0.000)	(0.000)	(0.000)	(0.000)	