Discount Rates: Measurement and Implications for Investment*

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Abstract

Standard models in macro-finance imply that asset prices have large effects on firm investment. A key transmission channel operates through firms' discount rates: high asset prices may lower firms' cost of capital, which in turn may induce firms to reduce their discount rates and raise investment. We construct a new global database of corporate discount rates based on manual entry from earnings calls. Discount rates reflect time variation in the cost of capital in financial markets, but the relation is not one-for-one, leading to a time-varying wedge between discount rates and cost of capital. Discount rates are negatively related to investment, even after controlling for the cost of capital, with a magnitude close to that predicted by theory. Adjusting Tobin's Q for the discount rate wedge increases explanatory power over investment and lowers the implied adjustment costs by an order of magnitude. The adjusted Q largely accounts for "missing investment" relative to low interest rates in recent decades. We explore the drivers of discount rate wedges and find that risk, organizational frictions, and market power all play a role.

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Discount rates play a crucial role in firms' investment decisions. By setting their discount rates, firms determine how much they value future cash flows generated by investment projects. If discount rates increase, firms value future payoffs more and therefore invest more. Theory suggests that the effect of discount rates on investment is large. A standard Q-model, for instance, predicts that a drop in the discount rate of 1 percentage point raises firm investment by 30 percent.[1]

Despite the importance of discount rates, there exists little evidence about how discount rates change over time and how they affect investment, mainly because discount rates are hard to measure. A typical assumption in macroeconomics and finance is that firms use the cost of capital from financial markets as discount rate. This assumption implies that investment responds sharply to financial markets. In practice, however, firms' choice of discount rate need not equal the cost of capital. The corporate finance literature has outlined conceptually why the two might differ and surveys show that the levels of discount rates often exceed the cost of capital (Poterba and Summers 1995, Jagannathan et al. 2016, Graham 2021).[2] Moreover, even if firms use their perceived cost of capital as discount rate, their estimate is likely to differ from the actual cost of capital on financial markets, which is difficult to estimate.

In this paper, we construct a new dataset on discount rates and the perceived cost of capital that covers 2,400 firms, including some of the world's largest corporations. We show that firms partially incorporate changes in the cost of capital into discount rates, but the relation is weaker than in standard models. Discount rates are negatively related to future investment, both at the firm and country level, with a magnitude close to that predicted by Q-theory. The effect of discount rates on investment is stronger than the effect of cost of capital and robust to controlling for Tobin's Q. The behavior of discount rates across firms and over time sheds light on several investment puzzles, such as the low sensitivity of investment to capital costs, the weak relationship between investment and Tobin's Q, and the origins of low US investment rates in recent decades.

We measure discount rates using corporate conference calls. The majority of listed corporations hold conference calls every quarter, so that managers can inform financial analysts, investors, and other observers about the firm's operations. On these calls, managers sometimes disclose their discount rate and their perceived cost of capital as a way of providing

[1]This model is calibrated using the adjustment cost specification in Philippon (2009) and the observed values of Tobin's Q and the financial cost of capital in the United States since 2000.

[2]We follow the literature in using the terms discount rate, hurdle rate, and required internal rate of return interchangeably, as explained in Section 2.1.

transparency to the capital budgeting process. We collect transcripts for all conference calls between 2002 and 2021 and identify 55,000 paragraphs where managers discuss their cost of capital or discount rates. We read through each of these paragraphs with a team of research assistants and manually extracted relevant information.

The product of this data collection effort is a large global database of firms' perceived cost of capital and discount rates matched to investment rates. The database contains observations for roughly 2,400 firms across 20 countries. A unique feature of our data is that we can study variation in discount rates and investment across time within firms and countries. We observe the cost of capital and discount rates for 19 sequential years across multiple countries, giving rise to a country-level panel; and we observe many firms multiple times, giving rise to a firm-level panel. This panel variation is new to the literature and key to understanding how discount rates and the cost of capital relate to one another and to investment.

We start analyzing the new dataset by relating firms' perceived cost of capital, reported by managers, to the cost of capital on financial markets. The cost of capital is the weighted average cost of debt and equity. Firms can directly observe the contemporaneous cost of debt through bond yields and interest rates. It is thus not surprising that the average cost of debt in a given country is closely associated with the cost of debt perceived by firms. However, to calculate the cost of equity, firms need to estimate expected stock returns, which is not straightforward (Jagannathan et al. 2017). MBA students are often taught simplified approaches, for example to assume a constant equity risk premium, which would lead to mistakes in the perceived cost of equity (Cochrane 2011). Nonetheless, we find that firms' perceived cost of equity tracks a financially sophisticated measure of the cost of equity (CAPE), albeit one that assumes stronger returns growth than historically observed. This result implies that firms dynamically update their cost of capital using expected stock returns, in line with standard finance theory. This finding is important, because it implies that fluctuations on financial markets influence the cost of capital despite them rarely issuing equity.

We next study how discount rates relate to the cost of capital. We confirm the existing finding that discount rates are substantially higher than the cost of capital, on average twice as large. More importantly, we find that changes in the cost of capital are incorporated into discount rates, but the relation is significantly below the one-for-one mapping implied by theory. This pattern gives rise to a time-varying wedge between discount rates and the cost of capital. For the US, this wedge has expanded dramatically over the last two decades as

the cost of capital has decreased while discount rates have been relatively stable. We will later explain how this wedge is important for our understanding of the link between financial markets and investment, but before doing so, we address the relation between discount rates and investment.

We find that time variation in discount rates is strongly negatively related to investment, both at the firm and country level. Average discount rates and aggregate investment in the US in the past two decades strongly comove, raising the possibility that a large fraction of fluctuations in investment may be explained by variation in discount rates. At the firm-level, we find that a one percentage point increase in the discount rate lowers the investment rate by -0.9 points. This estimate is robust to controlling for firm and year fixed effects, Tobin's Q, the cost of capital, and other firm observables. We show that the magnitude is consistent with a simple Q-model where firms use our measured discount rates in investment decisions.

An important feature of our regressions is that we do not use the cost of capital to estimate the relation between investment and discount rates. The cost of capital is based on asset prices, which are driven by the state of the aggregate economy. We should therefore expect the cost of capital to be related to investment, even if the cost of capital does not influence investment through discount rates. This link between asset prices and the cost of capital makes it difficult to conclude that discount rates impact investment using variation based solely on the cost of capital.[3] In contrast, by regressing investment on discount rates and controlling for cost of capital, we use variation in discount rates that is orthogonal to the cost of capital. While this approach does not remove all endogeneity concerns, it breaks the mechanical link between the cost of capital and the state of the economy.

We next turn to the implications of discount rate wedges for our understanding of the link between financial markets and investment. As mentioned above, discount rates differ substantially from the cost of capital, which means that firms and financial market use different discount rates and therefore value investments differently. This difference is important for our understanding of Q-theory, which measures the shadow value of capital on financial markets using Tobin's Q. The presence of discount rate wedges implies that Tobin's Q is a misleading measure of firms' internal shadow value of capital. We therefore introduce an "adjusted Q," which recalculates Tobin's Q using observed discount rate wedges. This

[3]There is a large literature in macro finance that models how interest rates and expected stock returns respond to the state of the economy (Cochrane 2005). A sudden drop in investment is, for instance, usually associated with an increase in the volatility of the stochastic discount factor and thus in the cost of capital. Similarly, a drop in long-run growth rates of technology (which influences investment) is likely to impact interest rates through precautionary savings motives.

adjusted Q represents the shadow value of an additional unit of capital in the eyes of the firm. We find that adjusted Q predicts investment substantially better than Tobin's Q in the cross-section of US firms. Adjusted Q produces greater R^2 and slope coefficients that are an order of magnitude higher than for Tobin's Q. The high slope coefficients means that adjusted Q implies much more reasonable adjustment costs than Tobin's Q.

Discount rate wedges also inform the debate about "missing investment" in the 21st century, i.e., low US investment rates despite near-zero interest rates and high equity valuations. Gutiérrez and Philippon (2017) show that the growing value of Tobin's Q in the 21st century, combined with modest investment rates, implies cumulative investment shortfalls exceeding 10% of the capital stock. We find that the wedge between discount rates and cost of capital continually widened in this period, which means Tobin's Q has become an increasingly misleading measure of the shadow value of capital for firms. When instead considering the relation between investment and adjusted Q, we find cumulative investment shortfalls close to zero. Adjusted Q stays close to 1 throughout our sample, as Q-theory would predict. This finding does not imply that there is no missing investment relative to the standard benchmark. What it does imply, however, is that discount rate wedges are large enough to account for a large part of the missing investment. As such, understanding the drivers of discount rate wedges is likely a fruitful avenue for our understanding of low investment rates.

We explore the drivers of discount rate wedges in the final part of the paper. We find evidence that firms with higher risk, organizational, and financial constraints set greater discount rates, conditional on the cost of capital. These results are consistent with manager statements on earnings calls as well as theories about firm's agency costs or managerial frictions (Jagannathan et al. 2016). While these results address the high average level of discount rates, they do not explain why the wedge between discount rates and cost of capital has diverged in recent years. We find that the wedge has mostly increased for firms with high market power. This suggests that competitive forces have an important disciplining role in the determination of discount rates. In competitive markets, firms struggle to generate profits if they use high discount rate wedges, while firms with market power can let wedges grow without such pressures.

Related Literature

Discount rates have long been thought to play a prominent role in understanding investment dynamics (e.g., Jorgenson 1963, Tobin 1969, Cochrane 1991, Gilchrist and Zakrajsek 2012, Hall 2017, van Binsbergen and Opp 2019). We provide the first dataset that links firm-level

discount rates and perceived cost of capital to investment. We present evidence in favor of the view that discount rates change with the cost of capital and influence investment. But we also document substantial discount rate wedges that impact the relationship between discount rates, investment, and pricing on financial markets.

An important object in macroeconomics and finance is the elasticity of firm investment with respect to the cost of capital. This elasticity crucially determines how a range of shocks, including monetary policy, financial markets, and tax policy, affect the real economy. We show that the presence of discount rate wedges significantly lowers the investment elasticity. The dampening impact of wedges may help to explain why existing models without wedges produce excessively large investment elasticities, why macroeconomic models need to assume sizable adjustment costs to produce empirically plausible elasticities (Christiano et al. 2005, Khan and Thomas 2008, Bachmann et al. 2013, House 2014, Koby and Wolf 2020, Winberry 2021), and why firms report low sensitivity to hypothetical interest rate changes in a survey (Sharpe and Suarez 2020). The elasticity predicted by a Q-model adjusted for discount rate wedges is close to estimates based on tax reforms (Hassett and Hubbard 2002, House and Shapiro 2008, Zwick and Mahon 2017) and bond prices (Gilchrist and Zakrajšek 2007, Gilchrist and Zakrajsek 2012).

We also add to the debate about why Tobin's Q (Brainard and Tobin 1968, Tobin 1969) fails to explain investment dynamics under standard assumptions (Summers 1981, Bond and Van Reenen 2007, Philippon 2009). We find that firms' choice of discount rates can explain a significant part of the failure of Tobin's Q. We present evidence that this choice is partially driven by financial frictions, consistent with (Gomes 2001, Hennessy et al. 2007). Our findings leave open the possibility that other factors also play a role, including mismeasured in Q (Erickson and Whited 2000, Cummins et al. 2006), mismeasured intangible investment (Hall 2001, McGrattan and Prescott 2005, Eisfeldt and Papanikolaou 2013, Crouzet and Eberly 2021) and non-convex adjustment costs (Abel and Eberly 1994, Caballero and Engel 1999, Hall 2004).

Investment by US businesses in recent decades has been low, despite high equity valuations and falling interest rates (Summers 2014, Gutiérrez and Philippon 2017, Alexander and Eberly 2018). We find that a large share of low investment is accounted for by the divergence between financial and corporate discount rates. Our findings suggest that market power and firm-level risk partially drive "missing investment," consistent with recent work by Bloom (2009), Baker et al. (2016), Philippon (2019), and De Loecker et al. (2020).[4]

[4]The presence of a time-varying wedge between the cost of capital and discount rates is also relevant for

Existing evidence on firm discount rates comes from surveys. Summers (1986) reports discount rates for 95 firms in 1986, Poterba and Summers (1995) for 160 firms in 1990, and Meier and Tarhan (2007) and Jagannathan et al. (2016) for roughly 100 firms in 2003. The influential Duke CFO Survey provides broad insights into the practice of corporate governance (Graham and Harvey 2001). The survey has asked firms about their discount rates on five occasions between 2011 and 2019 (Graham 2022); around 130 observations of discount rates and 330 estimates of the perceived cost of capital are linked to financial data for listed firms. Our new dataset contains panel data on discount rates, the perceived cost of capital, and investment for 2,400 listed firms. This allows us to conduct dynamic within-firm analyses and to shed light on investment puzzles.

A unique feature of our new data is that we can directly observe how firm-level changes in the financial cost of equity transmit into firms' perceived cost of equity and ultimately discount rates. These data are important as the true cost of equity is hard to infer using asset pricing models[5] (Fama and French 1997, Pástor and Stambaugh 1999) and it unclear how firms estimate the cost of equity and incorporate it into discount rates.[6] Previous research documents that discount rates are related to both the perceived and financial cost of capital (Jagannathan et al. (2016), Gormsen (2021)) in the cross section; our data allow us to further address the time-series dynamics of this relation.

1 Theory

This section models the relation between firm investment and discount rates. The model is closely related to the standard Q-model but differs in that it allows for a wedge between the discount rates used by firms and the cost of capital on financial markets. Standard theory often assume that firms use the financial cost of capital as discount rate because doing so maximizes shareholder value. In practice, however, firms add wedges on top of the cost of capital to obtain their discount rates. There are many reasons why firms might add such

the debate about rising "factorless income" (Karabarbounis and Neiman 2019, Rognlie 2019). Similar to Caballero et al. (2017) and Farhi and Gourio (2018), we find that risk has altered the returns to corporate investment. However, we emphasize that risk can influence investment through higher discount rate wedges set by firms rather than through higher risk premia on financial markets.

[5] An alternative to financial factor models is to estimates the implied cost of equity from stock prices and expected cash flows (Gebhardt et al. 2001, Easton 2004).

[6] Graham and Harvey (2001) survey managers about methods used to estimate the cost of equity and discount rates, while Gormsen (2021) estimates which equity risk factors are correlated with discount rates in the cross-section of firms.

wedges, for example to approximate optimal solutions to complex maximization problems (McDonald 2000) or as a result of agency issues (see Section 5). For the purpose of the model, we treat discount rate wedges as exogenous and later discipline the model by measuring them in the data.

The firm chooses the optimal investment level I_t by maximizing the discounted value of future profits net of investment costs. The firm's discount rate is given by $r + x$, where $r \in \mathbb{R}^+$ is the cost of capital on financial markets and $x \in \mathbb{R}^+$ is a wedge between the cost of capital and the discount rate. We model the investment problem as

$$V_t(x, k_t) = \max_{I_t} \quad \sum_{t=0}^{\infty} \frac{\Pi_t(k_t) - I_t - \Phi(I_t, k_t)}{(1 + r + x)^t} \tag{1}$$

$$\text{s.t.} \qquad k_{t+1} = I_t + (1 - \delta)k_t \tag{2}$$

where $\Pi_t(k_t)$ is profits earned at time $t + 1$ net of labor cost using k_t units of capital and the optimal units of labor, I_t is investment at time t, δ is the depreciation rate of capital, and $V_t(x, k_t)$ is the value of the firm at time k, calculated using the discount rate $r + x$. The function $\Phi(I_t, k_t)$ captures adjustment costs, which are assumed to be quadratic in net investment:

$$\Phi(I_t, k_t) = \frac{\phi}{2}\left(\frac{I_t}{k_t} - \delta\right)^2 k_t,$$

where $\phi \in \mathbb{R}^+$ governs the magnitude of adjustment costs.

Solving the model as a constrained optimization problem (see Appendix for derivations) gives the following expression for optimal investment,

$$\frac{I_t}{k_t} - \delta = \frac{1}{\phi}(q_t - 1). \tag{3}$$

Here, q_t is the lagrange multiplier from the maximization problem in (2), capturing the marginal value of an additional unit of capital:

$$q_t = \frac{\delta V_t(x, k_t)}{\delta k_{t+1}}.$$

Taken together, the above expressions tell us that firms should expand capital whenever the marginal value of an additional unit of capital, q_t, exceeds 1. The pace at which they should do so depends on the adjustment cost ϕ.

The marginal value of capital q_t is not observable without additional assumption. The

literature usually follows Hayashi (1982) and assumes that the production function and the cost function are both homogeneous of degree one. In this case, the marginal value of capital equals the average value of capital, denoted Q_t,

$$q_t = \frac{\delta V_t(x, k_t)}{\delta k_{t+1}} = \frac{V_t(x, k_t)}{k_{t+1}} = Q_t. \tag{4}$$

Based on these assumptions, we can thus measure q_t as the value of total capital relative to its replacement value. We emphasize that $V_t(x, k_t)$ is calculated using $r + x$ as the discount rate. If $x = 0$, such that the firms uses the cost of capital as the discount rate, we can estimate this value on financial markets using Tobin's Q. However, when $x \neq 0$, one must make a correction to Tobin's Q to obtain the marginal value of capital in the eyes of the firm, q_t, as summarized in the next proposition.

Proposition 1 (Adjusted Q). *Assume that the production and investment cost functions are homogeneous of degree one. The shadow cost of capital can then be approximated as:*

$$q_t \sim Q_t^{\text{Tobin}} \times \frac{1}{x \times \text{Dur} + 1} \tag{5}$$

where Dur is the duration of the firm's future cash flows as defined in the Appendix. Proof is in the Appendix.

Proposition 1 shows that we can approximate marginal q as Tobin's Q times an adjustment. If the discount rate wedge x is equal to 0, such that firms use their cost of capital as their discount rate, the adjustment term is one and q is equal to Tobin's Q. Intuitively, firms and financial markets use the same discount rates in this case and therefore agree on the value of the profits produced by capital. However, when $x > 0$, as is the case empirically, we must adjust Q downwards because the firm uses a higher discount rate than the market, leading the firm to put a lower value on capital than the market does. The strength of the adjustment naturally depends on how much x deviates from 0, but it also depends on the duration of the cash flows. Indeed, it is well known that the impact of the discount rate on the value of an asset depends on the duration of the assets cash flows, which is calculated as the weighted time to maturity of the future cash flows. The longer the duration (i.e., the further into the future the average cash flows are earned), the larger the effect of discount rates on the value of the asset. For this reason, the effect of discount rate wedges increases

in the duration of the firm's cash flows.[7]

We next address the relation between investment and changes in discount rates. We do so by making a partial equilibrium statement about changes in discount rates that are unrelated to changes in future expected profits and adjustment costs. The proposition follows from inserting Proposition 1 into (3) and taking the derivative with respect to the discount rate.

Proposition 2 (Investment and Discount Rates). *Assume changes in the cost of capital do not influence expected future profits. At the steady-state, we observe the following relation between investment and a shock to* $x + r$*:*

$$\frac{\Delta\left(\frac{I_t}{k_t} - \delta\right)}{\Delta(x+r)} \sim \frac{1}{\phi} \times \frac{\text{Dur}}{x \times \text{Dur} + 1}. \tag{6}$$

Proposition 2 shows that investment decreases when r increases. The increase in the discount rate decreases the value of the future profits produced by capital, decreasing the marginal value of capital and thereby the incentive to invest. The strength of the effect again depends on the duration of the cash flows. In the absence of discount rate wedges, the denominator is equal to 1 and the effect is given by the duration divided by the adjustment costs, with the effect of discount rates on investment again being stronger the longer the duration. However, if $x > 0$ the denominator is bigger than 1 and the effect of discount rates becomes muted. The reason is that $x > 0$ effectively shortens the duration of $V_t(x, k_t)$), thereby decreasing the sensitivity of investment to discount rates.

In conclusion, the above model shows that optimal investment is directly related to the discount rate. If this discount rate is equal to the cost of capital, there is a strong relation between optimal investment and the market value of the firms asset, as known since Tobin (1969). If there is a wedge between the cost of capital and the discount rate, this wedge influences the relation between investment and financial markets.

[7] To better understand this result, imagine that an additional unit of capital will only create value in the next period, such that duration is 1. In this case, discount rates matter little (cash flows are not discounted many times) and x will therefore not influence the adjustment much. Conversely, imagine that an additional unit of capital creates value even in the very distant future, such that the cash flow duration is long (Dur is high). In this case, discount rates have a large impact on present value (the cash flows are now discounted many times) and x will therefore have a large impact on the adjustment.

2 Measurement

The previous section suggests that investment depends crucially on the discount rate, which itself may be influenced by the perceived cost of capital. These capital budgeting rates are part of firms' internal calculations and not observed in publicly available reports and datasets. One contribution of this paper is to jointly measure listed corporations' perceived costs of equity, debt, and capital, discount rates, and investment in one new database.

2.1 Intuitive Interpretation of Capital Budgeting Rates

It is useful to give an intuitive definition of perceived cost of capital and discount rates, so we can identify them in managers' speech. The perceived cost of capital is the weighted average cost of equity and debt, as calculated by the firm. It is given by r in the theory of equation 2 and in practice is calculated as

$$r_t = \omega_t \times (1 - \tau) \times r_t^{\text{debt}} + (1 - \omega_t) \times r_t^{\text{equity}} \tag{7}$$

where r_t^{debt} and r_t^{equity} are the cost of debt and equity for firm i at time t, τ is the tax rate, and ω_t is the leverage ratio defined as the market value of debt relative to the market value of debt plus equity.

The discount rate is the rate at which the firm values future cash flows and which enters the net present value (NPV) calculation of its projects. It is represented by $r + x$ in the theory section. While the discount rate determines how much the firm values future cash flows, it can also be thought of as the lowest return the firm is willing to accept on its investments. Indeed, the optimizing firm invests in projects where the NPV is above zero. The expected rate of return on a project exactly equals the discount rate if the NPV is zero and exceeds the discount rate if the NPV is positive. Rather than using the term discount rate, firms often discuss a minimum internal rate of return (IRR) that they are willing to accept, also known as hurdle rate. For our analysis, the terms discount rate, minimum IRR, and hurdle rate all capture the same concept.[8]

[8] In line with standard theory, finance textbooks recommend that firms should use net present value to make investment decisions. In practice, around 80 percent of firms follow this recommendation, according to surveys presented in Trahan and Gitman (1995), Graham and Harvey (2001), and Graham (2022). The second most common decision method involves comparing a project's IRR to the minimum required IRR, which produces the same decision as the net present value method for any given project and in the standard theory presented in equation 2 (Jagannathan et al. 2016). The two methods may rank mutually exclusive projects differently and thus lead to different project choices. Since we are concerned with total investment

2.2 Measuring Capital Budgeting Rates

We measure capital budgeting rates at the firm level using corporate earnings conference calls. The majority of listed corporations hold conference calls every quarter, so that managers can inform financial analysts, investors, and other observers about the firm's strategy.

We download all transcripts of conference calls for the period January 2002 to September 2021 available on the Thomson One database. We identify all paragraphs that contain at least one keyword related to capital budgeting as well as one of the words "percent," "percentage," or "%".[9] It is difficult to train an automatic text reading algorithm to identify the relevant objects, as context and background are of the essence. Instead, we trained a team of research assistants to manually extract the relevant variables from the text.

To measure financing costs, we use paragraphs where managers state their perceived, contemporaneous costs of equity, debt, and capital. These figures come from firms' internal calculations, potentially relying on financial asset prices and interest rates. We are careful not to record previous or speculative costs. We also consider abbreviations, such as WACC, and synonyms, such as required return on equity and debt rate, as long as the managers clearly relate them to financing costs.

There are three ways in which we identify discount rates. First, managers often state the required IRR for future investment projects. We only interpret an IRR as discount rate if it clearly refers to a required minimum rate as part of an investment rule. We separately record realized IRRs, when managers talk about current performance, and expected IRRs, when managers predict future performance without setting an explicit investment rule. Second, we interpret hurdle rates as discount rates if they are calculated on the basis of an IRR. Finally, managers sometimes define a discount rate based on a hurdle premium or fudge factor, which are added to the cost of capital. In addition to the capital budgeting figures, we record a range of other financial variables based on managers' statements on the conference calls, including required, expected, and realized returns on assets, on invested capital, and on equity.

We generally restrict the data collection to figures representative for the firm overall. For example, if the manager of a mining company refers to the cost of debt from a particular

and not choices between individual projects, the ranking is not key for our analysis.

[9]The keywords are capital asset pricing model, cost of capital, cost of debt, cost of equity, discount rate, expect a return, expected rate of return, expected return, fudge factor, hurdle rate, internal rate of return, opportunity cost of capital, require a return, required rate of return, required return, return on assets, return on invested capital, return on net assets, weighted average cost of capital, weighted cost of capital. We also include abbreviations of the keywords in the search, for example, IRR.

bond issuance and the expected return on assets from an individual mine, we do not record these figures. A handful of firms mention multiple discount rates in the same paragraph, for example varying by country. We record the rate that represents most of the firm's operations.

Overall, the team read over 55,000 distinct paragraphs over the span of roughly 20 months. To ensure high quality and consistency across research assistants, we had weekly team meetings where we discussed specific paragraphs. Most paragraphs were read by two separate research assistants to ensure consistent entries across research assistants. All outlier observations (in levels and changes) for discount rates were checked by hand by the authors.

2.3 Measuring Financial Data

We amend the data from conference calls with additional databases. Firm-level accounting data are from Compustat XpressFeed, stock prices from the Center for Research in Security Prices tape, and the implied volatility of stock returns from OptionMetrics. We focus our analysis on countries appearing in the MSCI Developed World Index.

We also construct the cost of capital on financial markets. We calculate the cost of debt using interest expenses in Compustat. The cost of equity is more complicated, as it is the firm's long-run expected stock return. We first estimate long-run expected stock returns at the country level, as explained below, and then calculate the cost of equity using the CAPM model. We obtain marginal tax rates from Valueline for US firms and assume a tax rate of 30% for non-US firms or firms that are not in Valueline.

We calculate long-run expected stock returns at the country level using two different methods. For the US, we use the earnings yield based on the CAPE measure from Robert Shiller. In the Gordon growth model, the yield is equal to the long-run expected stock return minus the long-run expected growth rate. We calculate expected stock returns by assuming a long-run real growth rate of 2% (which is the average growth rate for the 20^{th} century) and a long-run inflation rate of 2%. Outside the US, it is more complicated to calculate the earnings yield as we do not observe the CAPE.[10] Instead, we calculate expected stock returns using the out-of-sample methods in Campbell and Thompson (2008), focusing on the book-to-market, earnings-to-price, and dividend-to-price measures as described in that paper. Our final measure of expected stock returns averages across the three.[11]

[10] The CAPE measure is based on prices relative to average earnings over the last 10 years. Calculating average earnings over such long periods requires well-defined indexes that are stable in terms of constituents and composition, such as the S&P 500, but such stable stock indexes are not always available in foreign countries.

[11] As input to these, we estimate average return on equity and average payout ratios in the given countries.

2.4 Summary Statistics

The new dataset measures capital budgeting rates for a diverse set of listed firms. Market value in the data ranges from 291 million USD at the 5th percentile to 51,536 at the 95th (Table 1, panel A). The data include some of the world's largest corporations, including AT&T, Bank of America, Disney, Exxon, Home Depot, Intel, JPMorgan Chase, Mastercard, Nestle, Novartis, UnitedHealth, and Visa. The total market value of firms in the data was 31.1 trillion USD in 2019, which covers 42 percent of aggregate market value in advanced economies.

The dataset reveals roughly 8,300 capital budgeting rates (including perceived costs of equity, debt, and capital and discount rates) for roughly 2,400 unique firms. The average perceived cost of equity is 10.5%, cost of debt is 4.6%, cost of capital is 8.9%, and discount rate is 15.8% (nominal values in Table 1). The perceived cost of capital is distributed fairly symmetrically, while discount rates are more dispersed (Figure 1).

We study whether firms with observed capital budgeting rates are similar to other firms in Compustat between 2002 and 2021. We regress an indicator for whether we observe a capital budgeting rate for a firm-year observation on a set of firm-level regressors (1, panel B). The regressors are the firm's percentile rank, relative to other firms in its country in the same year, in the distribution of return on equity, market value, and book-to-market ratio. The coefficients on all regressors are generally small and statistically insignificant. For instance, the first coefficient in column 1 suggests that a one percentage point increase in the return rank is associated with a 0.001 percentage point change in the probability that a capital budgeting rate is observed. Note also that future returns do not predict inclusion, suggesting that firms are not more likely to discuss discount rates in response to changes in expected profitability. Taken together, these result imply that the new dataset contains firms with similar characteristics as other listed firms.

3 The Cost of Capital, Discount Rates, and Investment

In this section, we explore how firms' perceived cost of capital and discount rates are determined and how they relate to investment. Figure 2 uses the new dataset to plot raw averages of firms' perceived cost of debt, perceived cost of capital, and discount rates in the

This differs from Campbell and Thompson (2008), who use rolling ten-year average in their US application. As discussed above, we refrain from calculating ten-year averages outside the US due to data limitations.

US by year. The figure shows that both the cost of debt and the cost of capital have trended downward since 2002. Discount rates exceed the cost of capital and are more stable.

The figure raises a number of questions. Is the trend in perceived cost of capital consistent with developments on financial markets? Are changes in the cost of capital incorporated into discount rates? And how do discount rates affect investment? We address these questions in turn. We begin by providing macro evidence at the level of countries before turning to more fine-grained firm-level analyses.

3.1 The Perceived Cost of Capital and Financial Markets

We start by studying how the cost of equity and the cost of debt is reflected in firms' perceived cost of capital, using data at the country-year level. We measure the cost of equity on financial markets as the long-run expected stock return in a country at a given time, estimated as explained in Section 2.3. We measure the cost of debt as firms' average perceived cost of debt at a given time, as the perceived cost of debt closely follows realized interest rates. We weight regressions by the number of observations in each country at a given point in time.[12]

Table 2 shows the results of regressions of the cost of capital on the cost of debt and expected stock returns. The cost of capital is strongly related to expected stock returns, particularly once we include country fixed effects in columns 2 and 3. The coefficient on expected stock returns is around 0.5 with country fixed effects, which is only slightly below what we would expect given that firms use roughly 2/3 equity financing. The coefficient on the cost of debt is just below 0.3 with country fixed effects in column 2. There is little variation in the cost of debt once we control for country and year fixed effects in column 3, rendering an imprecise estimate in that specification.

It is ex ante unclear whether firms correctly incorporate variation in expected stock returns into their perceived cost of equity. Expected stock returns are difficult to estimate, making financial economist disagree on what expected stock returns are and whether they are even predictable (Stambaugh 1999, Welch and Goyal 2008, Campbell and Thompson 2008, Campbell and Yogo 2006). On top of that, MBA students are often taught to assume a constant equity risk premium of 6%, which would lead them to incorrectly vary their perceived cost of equity over time (Cochrane 2011).

[12]The weight for country i at time t is the number of observations in country i at time t relative to all observations at time t.

To illustrate the range of potential estimates for the cost of equity, Figure 3 plots US firms' perceived cost of equity along with three alternative estimates of long-run expected stock returns. The green line simulates the estimate of an MBA student assuming a constant equity risk premium of 6%. The two red lines use more sophisticated estimates based on the CAPE measure maintained by Robert Shiller. One of these is our baseline estimate of expected returns in the US, namely the earnings yield plus a nominal growth rate of 4% (the historical average, see Section 2.3). The other estimate is the earnings yield plus a bullish expected growth rate of 6%. The three methods lead to substantially different estimates of the cost of equity. The perceived cost of equity reported by firms is most closely aligned with the estimate based on CAPE and a high growth rate.

Overall, the results suggest that firms incorporate variation in expected stock returns into their cost of equity and thereby cost of capital. As an example of this behavior, this section ends with a quote from the CFO of IAG (the parent company of British Airways and Iberian) who on a conference call in 2014 shares his thoughts about their perceived cost of equity. The quote suggests that IAG increased their cost of equity in response to the sovereign debt crisis in Europe in 2011 and subsequently lowered the premium as the crisis resolved:

2014-11-07, IAG, Enrique Dupuy, CFO: *"... we are still keeping a cost of capital of 10% and this is getting very conservative. We had to make a fine tuning exercise through the crisis in Spain and Europe a couple of years ago ... and we increased the figure to this 10% level. But I think the assumptions are now behind ... the 15% cost of equity, it appears to have a big, big premium there. Maybe those figures could be brought down slightly so 10%, we are keeping it there as a reference. We may be having to change it through '15 and beyond.* [edited for ease of understanding]"

3.2 Discount Rates and the Perceived Cost of Capital

We next study how discount rates are related to the perceived cost of capital across countries and across time. To this end, Table 3 reports regressions of discount rates on the contemporaneous cost of capital, both averaged at the country-year level. We find a slope coefficient of 0.83 in a specification without controls, which suggests that countries with higher perceived cost of capital also have higher discount rates. The coefficient is significant at the 1% level. To illustrate this result, Figure 4 plots the average discount rate and perceived cost of

capital for the ten countries with most observations. The relation is close to linear, with the exception of Australia, for which discount rates appear low relative to the cost of capital. Discount rates lie well above the cost of capital in all countries.

The second column in Table 3 includes country fixed effects and thereby explores whether time variation in the perceived cost of capital is incorporated into discount rates. The slope coefficient remains significant but drops to 0.39, implying that a 1 percentage point increase in the cost of capital raises discount rates by 0.39 percentage points. In the third column, we include country and year fixed effects. The slope coefficient is 0.32 and statistically significant at the 10% level. Taken together, these results suggest that firms incorporate changes in the perceived cost of capital into discount rates, but that they do so less than one-for-one.[13] The following quote from a Fortune 500 CFO offers an example of such behavior:

2014-09-17, Spectra Energy, John Patrick Reddy, CFO: *"Well, one thing I'd just offer is that we didn't lower our hurdle rates in conjunction [with the past decrease in interest rates]. We lowered them somewhat but not just all the way down with long-term rates at 2.5%. We didn't take our hurdle rates down to 5%, for example. We are still looking at returns of, say 10%, on average for our projects."*

The partial pass-through of the cost of capital gives rise to discount rate wedges (represented by x in Section 1). Figure 5 shows that the average wedge in the US varies over time. We estimate the average wedge in each year using firm-level panel regressions that control for firm fixed effects. The wedge is around 8 percentage points on average and has trended upward throughout the sample, with some variation around the global financial crisis. We document in Section 4 that the existence and behavior of this wedge has important implications for the link between investment and financial markets. Section 5 explores the mechanisms driving the wedge.

3.3 Aggregate Investment and Discount Rates

Aggregate net investment in the US is positively correlated with the average discount rate reported by firms in the previous year, as shown in Figure 6. The raw correlation between the two series is -0.67. This pattern suggests that discount rates comove with investment,

[13] In Section 5.2, we conduct a similar exercise at the firm level. Firm-level point estimates are slightly higher, around 0.6, but confirm the conclusion of partial pass-through. There is likely some measurement error in the country-year averages, which could explain the slightly different point estimates.

as predicted by standard theory.

We analyze this relation in more detail using data at the country-year level in Table 4. We regress aggregate net investment on the average discount rate in the country and year. Aggregate net investment is measured in Compustat as total capital expenditure net of depreciation divided by the lagged net value of property, plant, and equipment. The coefficient on discount rates is statistically significant and implies that a percentage point increase in discount rates is associated with a -0.27 percentage point change in investment, conditional on country fixed effects. The coefficient remains the same when we add year fixed effects in column 2. The within-R^2 is 12% when including year fixed effects, consistent with discount rates potentially playing an important role in aggregate investment fluctuations.

The association between discount rates and aggregate investment is robust to controlling for the financial cost of capital in columns 3 and 4. This suggests that the importance of discount rates is not only driven by the relationship between discount rates and financial markets.[14] The results are also robust to controlling for Tobin's Q in columns 5 and 6, which is a sufficient statistic for investment in a standard model without discount rate wedges.

3.4 Firm-Level Investment and Discount Rates

We next study the relation between discount rates and investment at the firm level. Firm-level data allow us to explore more variation in discount rates and to control for common shocks more comprehensively.[15]

Table 5 reports regressions of firm-level net investment, measured in Compustat, on firm-level discount rates. All regressions include firm fixed effects, so estimates are driven by within-firm variation in discount rates and investment. Across a range of specifications, we find slope coefficients around -0.9. This estimate is well above the country-level estimate, potentially reflecting general equilibrium effects. The estimate is stable when we add year fixed effects in column 2. Controlling for the financial cost of capital does not affect the coefficient in columns 3 and 4. Further augmenting the regression with measures of profitability, such as return on equity and Tobin's Q, raises the point estimate slightly in columns 5 and 6.

The size of the coefficients is close to what we could expect from Proposition 2, which

[14]The relation between the cost of capital and investment is highly dependent on whether or not we include time-fixed effects, potentially because the cost of capital is driven by many variables that also affect investment, such as shocks to future productivity.

[15]We explore the drivers of firm-level discount rates in Section 5.

says that

$$\frac{\Delta\left(\frac{I_t}{k_t}-\delta\right)}{\Delta x+r}\sim\frac{1}{\phi}\times\frac{\text{Dur}}{x\times\text{Dur}+1}.$$

Assuming[16] $\phi=10$ and a cash-flow duration of 30 years, as is approximately the case for an unlevered firm (Gormsen and Lazarus 2019, Van Binsbergen 2020), the observed average discount rate wedge of 8 percentage points implies that the effect of discount rates on net investment is

$$\frac{\Delta\left(\frac{I_t}{k_t}-\delta\right)}{\Delta(x+r)}\sim\frac{1}{10}\times\frac{30}{0.08\times30+1}\sim-0.88.$$

This value is close to our empirical estimate of -0.9. We caution, however, that our empirical estimate has a causal interpretation only if we believe that discount rates are orthogonal to unobserved investment opportunities and profitability.

4 Implications of Discount Rate Wedges

The previous section documents substantial wedges between corporate discount rates and the cost of capital. In this section, we study the implications of these wedges for our understanding of the relation between investment and financial markets.

4.1 Investment Sensitivities with Discount Rate Wedges

The presence of discount rate wedges reduces the expected strength of the relation between investment and the cost of capital. Two channels are at play. To understand these two channels, note that we can approximate the effect of the cost of capital on net investment (following Proposition 2) as

$$\frac{\Delta\left(\frac{I_t}{k_t}-\delta\right)}{\Delta r}=\frac{\Delta\left(\frac{I_t}{k_t}-\delta\right)}{\Delta(x+r)}\frac{\Delta(x+r)}{\Delta r}\sim\left(1+\frac{\Delta x}{\Delta r}\right)\times\frac{1}{\phi}\times\frac{\text{Dur}}{x\times\text{Dur}+1}. \tag{8}$$

[16]The assumption $\phi=10$ is based on Philippon (2009), who discusses various estimates used in the literature. In the upcoming test of Q models in Section 4.2, we find $\phi>10$ when using Tobin's Q but $\phi<10$ when using adjusted Q.

Consider first the case where changes in cost of capital are passed one-for-one into discount rates $\left(\text{i.e., } \frac{\Delta(x+r)}{\Delta r} = 1\right)$. In this case, a positive discount rate wedge ($x > 0$) lowers the impact of any discount rate variation through the adjustment introduced in Proposition 2. Indeed, a higher wedge causes a shorter cash flow duration, which lower the sensitivity to discount rate movements. We refer to this as the duration channel.

The second channel is related to the term $\frac{\Delta(x+r)}{\Delta r}$. This term is generally smaller than one in the data. For the cost of capital, the estimate is around 0.6, as shown in Table 9 and Section 5.2). For the cost of debt (i.e., interest rates), the estimate is around 0.3, as shown in Table 2. We refer to this diminished transmission as the stickiness channel.

Figure 7 shows the effect of the cost of capital on investment rates under different assumptions. The existence of discount rate wedges substantially dampens the effect. This happens mostly through the first of the two channels discussed above, namely the duration channel: going form a model without discount rate wedges to a model with discount rate wedges and $\frac{\Delta(x+r)}{\Delta r} = 1$ lowers the effect from -3 to -1. Further incorporating the stickiness channel lowers the number to -0.6.

4.2 Adjusted Q

Positive discount rate wedges imply that firms and financial markets use distinct discount rates. As such, we cannot directly use financial market data to infer discount rates and thus investment incentives of firms. This insight is important for Q theory, which measures the value of an additional unit of capital on financial markets. In the presence of discount rate wedges, one has to adjust Tobin's Q for these.

Proposition 1 shows how to adjust Tobin's Q for discount rate wedges. To calculate adjusted Q, we need to know the discount rates used by firms, the cost of capital, and the duration of cash flows. We observe the first two from conference calls and calculate the duration of cash flows using the Gordon Growth model, in which the duration of cash flows is given by the earnings yield (see Appendix). We calculate the earnings yield by the inverse of the CAPE ratio.

Figure 8 plots adjusted Q along with Tobin's Q. The adjustment for discount rate wedges has a substantial impact, as adjusted Q is well below Tobin's Q. Adjusted Q is lower because firms put a lower value on the cash flows produced by capital than the market does (i.e., firms use higher discount rates). Adjusted Q hovers around 1 across time, as we expect from theory, and it is substantially less volatile than Tobin's Q. In addition, adjusted Q and

Tobin's Q trend downwards throughout the sample, something we will address in more detail in the next section.

We test the ability of adjusted Q to explain investment in the cross-section of US stocks. To ease comparison with previous studies, we measure Tobin's Q using data on total Q from Peters and Taylor (2017) (these are only available for US firms and until 2016). To implement the analysis for as many firms as possible, we assume that the discount rate wedge for any firm is equal to the average observed discount rate wedge in the given year in the US. The impact of this common discount rate wedge is still heterogeneous across firms because of differences in cash flow duration. To limit the number of new variables we introduce, and to put adjusted Q and Tobin's Q on a more level playing field, we proxy for duration using total Q, as explained in Appendix 7.1.

As shown in Table 6, adjusted Q performs substantially better than Tobin's Q in traditional investment regressions. Consistent with previous findings, the slope coefficient on Tobin's Q is only 0.02, which implies high adjustment costs. For instance, a net investment of 10% would cost around 25% of the value of the firm's capital stock in adjustment costs. The slope coefficient on adjusted Q, in contrast, is almost an order of magnitude larger, suggesting more reasonable adjustment costs. The implied adjustment cost of a net investment of 10% is now a more reasonable 2.5% of the capital stock. In addition to the high slope coefficients, adjusted Q also produces a higher R^2 than Tobin's Q, further emphasizing the value of adjusting Q for discount rate wedges.

4.3 Adjusted Q and "Missing Investment"

The left-hand plot in Figure 9 shows net investment by decade along with Tobin's Q. The figure reveals that net investment in recent decades has been fairly low relative to the time-series, which is surprising given the high values of Q. This divergence between investment and Q has lead to a debate about what Gutiérrez and Philippon (2017) refer to as "missing investment" (i.e., low investment despite high equity valuations and low interest rates).

Discount rate wedges help us to understand missing investment. To see this, consider the right-hand plot in Figure 9, which shows adjusted Q along with net investment. (We calculate adjusted Q pre-2002 by assuming that discount rates are 4 percent higher than the cost of capital.) Adjusted Q is much smaller than Tobin's Q and, importantly, it decreases rather than increases during the 21st century. Further, the figure shows that net investment in the 2010s is quite close to what we would expect based on adjusted Q. We also note that

adjusted Q is much more strongly related to net investment than Tobin's Q. The relation breaks down during the dot-com boom at the turn of the century. A potential reason is that high equity valuations of the 1990s were likely driven by growth options (Pástor and Veronesi 2006), which are potentially unlinked to current operations and not informative for investment, as argued by Philippon (2009).

To more formally address missing investment, Figure 10 plots cumulative investment shortfalls (relative to the capital stock) obtained from Tobin's Q and adjusted Q. For both types of Q, we fit an investment regressions in the pre-2003 sample and calculate investment residuals relative to the estimated parameters. The figure shows that investment was lackluster relative to Tobin's Q throughout the sample. In contrast, the residuals for adjusted Q hover around zero throughout the sample. By 2020, the difference between the two estimates is almost 20 percent of the capital stock. This implies that the cumulative investment shortfall relative to Tobin's Q is 20 percent larger than the shortfall predicted by adjusted Q.

The analysis above suggests that the wedge between discount rates and the cost of capital is sizable enough to account for a large part of missing investment in the 21st century. As such, the investment behavior of firms is consistent with standard investment models, given that they use discount rates that deviate from the cost of capital.

5 Exploring Variation in Discount Rates

The analysis above documents that firms' discount rates have important implications for our understanding of the link between investment and financial markets. In this section, we explore the drivers of discount rates across firms and time.

We take three steps. We first study which firm-level observables, apart from the financial cost of capital, can cross-sectionally explain the level of discount rates. We then show that changes in the financial cost of capital are not fully incorporated into discount rates. Finally, we analyze how market power has affected changes in discount rates since 2002.

5.1 Cross-Sectional Drivers of Discount Rates

We test a number of explanations for why firms might use discount rates that differ from the cost of capital. We broadly categorize these explanations into two categories: risk and organizational constraints.

5.1.1 Risk and Uncertainty

2016-11-10, Halyard Health Inc., Steve Voskuil, CFO: *"...So that's kind of how we come to the 9% [hurdle rate]. We start with the capital markets' rates and look at our capital structure, and then we add a little bit to that to reflect risk in the portfolio and execution."*

In the above conference call from Halyard Health,[17] the CFO explains how the company uses the cost of capital as the benchmark for their discount rate and adds a wedge to reflect risk. Such behavior is common. The 2021 AFP Survey of capital budgeting practices finds that close to half of respondents increase discount rates in the face of increased uncertainty. Motivated by such evidence, we study the association between discount rates and risk.

We find a strong relation between discount rates and risk, as shown in Table 7. In all specifications, we control for the firm's financial cost of capital, since we are interested in drivers of discount rates beyond the cost of capital. We measure risk using the implied volatility of firm equity, estimated using options written on the equity.[18] Discount rates load positively on implied volatility in columns 1 and 2. The point estimate implies that a one percent increase in implied volatility leads to a 22 basis point increase in the discount rate. This is a large magnitude given the that the panel-wise standard deviation of the implied volatility is 12%. The R^2 is around 20%, mainly driven by the implied volatility, further underscoring the importance of risk.

We find that idiosyncratic volatility is more important than systematic volatility. In column 3, we separate volatility into overall volatility and idiosyncratic volatility (relative to the market). Discount rates load positively on the idiosyncratic volatility but negatively on overall volatility (once controlling for idiosyncratic volatility). These results are consistent with Jagannathan et al. (2016) and Décaire (2021) who find that discount rates are higher for firms for which most volatility is idiosyncratic.

Why might risk lead to higher discount rates? The risk of a representative project should already be reflected in a firm's cost of capital – if the firm is riskier, investors will require a higher return. From an investor's point of view, it is therefore unclear why one would require a premium on top of the cost of capital. However, from a manager's point of view, the situation is different. The manager is often highly overexposed to the firm, as a resolution to the classical agency problem arising from separation of ownership and

[17] Halyard Health, formerly known as Kimberly-Clark Health Care, was a global producer of medical supplies. Most of Halyard Health is now part of the Fortune 500 company Owens & Minor Inc.

[18] We focus on options with 365 days to maturity.

control. This overexposure means that the risk-return trade-off different is different for the manager than for the investor. In particular, while idiosyncratic risk does not influence the required return of the well-diversified investor, it does influence the required return from the manager because the idiosyncratic risk is non-diversifiable to her. As such, adding a premium to discount rates could potentially lead to an increase in the manager's private utility (Jagannathan et al. 2016).

Managers of riskier firms may also set higher discount rates because their future cost of capital (Ingersoll Jr. and Ross 1992) or cash flows (McDonald and Siegel 1986) are more uncertain. In these cases, a firm's optimal investment strategy can often be approximated by setting a higher discount rate (McDonald 2000).

Finally, managers might be disproportionately averse to the possibility that realized returns are below the cost of capital. Indeed, a project with an IRR close to the cost of capital is expected to earn the cost of capital, but it might end up earning slightly more or slightly less. A project that earns less than its cost of capital might raise uncomfortable questions from investors. By choosing a discount rate above the cost of capital, the manager reduces the risk of such a scenario. While such behavior might appear inconsistent with a full-information rational equilibrium, the following quote from the Fortune 500 company Kinder Morgan is a real-life illustration for such behavior:[19]

2013-05-23, Kinder Morgan, Kim Dang, CFO: *"We do not do projects close to our cost of capital so we are not going to go – our cost of capital is 9%, we are not going to go out and do a project in 9.5% or 10% because there are just too many potential for changes in what you expect to happen and what actually happens that can result in that project not being as good. Now it could be much better but we're not going to take the risk that we have a project come in at or below our cost of capital."*

5.1.2 Organizational and Financial Constraints

Theory suggests that organizational and financial frictions can raise discount rates. For instance, firms with high leverage may forego projects with positive NPV due to debt overhang (Myers 1977), while managers in firms with many positive NPV projects may not have the available resources or expertise to pursue every project (Jagannathan and Meier 2002).

Consistent with theory, the Kinder Morgan CFO explains that financial considerations

[19]Kinder Morgan is number 262 on the Fortune 500 list, has 11,000 employees, and a market cap of around $40 bn.

affect the discount rate in the following quote. In particular, the CFO needs to decrease leverage and does not want to issue equity (because she considers it underpriced). She therefore hopes to finance investments only out of retained earnings, which limits the amount of available capital and forces her to raise the discount rate:

2016-10-19, Kinder Morgan, Kim Dang, CFO: *"So in my mind, what we are constrained by, we do want to improve the balance sheet, and that is a goal that we have. But what we're doing is we are living within our cash flow, meaning that we want to be able to fund our CapEx and our dividend from our cash flow. And so that is the constraint, and so, because we have a limited amount of capital, that is why we have the hurdle rate set at 15% IRR for projects. I fully anticipate that over time, as the CapEx comes down, and also as the balance sheet improves, that we would relax that standard. I don't know exactly what that number is going to be today, but it would be something less than the 15%. It probably won't be back at the 8% that we previously used for a hurdle rate, but we will have to make the assessment, when that time comes."*

We find that highly levered firms tend to have higher discount rates, conditional on the cost of capital, consistent with a role for financial constraints (8, column 1). Cash holdings and positive growth forecasts are associated with more investment opportunities and have been used to proxy for organizational constraints (Opler et al. 1999, Simutin 2010, Asvanunt et al. 2011, Jagannathan et al. 2016). Accordingly, we show that firms with high cash-to-assets ratios and high growth forecasts (measured by expected long-term growth from the Institutional Brokers' Estimate System) have larger discount rates, supporting the view that organizational constraints also play a role (columns 2 and 3).

5.2 Firm-level Changes in Discount Rates and the Perceived Cost of Capital

We have so far argued that risk, financial, and organizational constraints are associated with greater discount rates, even conditional on the cost of capital. An open question is how firms' discount rates move over time with the cost of capital. If the wedge between discount rates and cost of capital is constant over time, shocks to cost of capital would be dynamically incorporated into discount rates.

We find that the firm-level relation between discount rates and the cost of capital is

strong, with a slope coefficient of roughly 0.6 (Table 9). The effect is relatively stable across specifications without controls and with firm and year fixed effects. This implies that the average firm raises its discount rate by 0.6 percentage points when its perceived cost of capital changes by 1. The slope is statistically different from 0 and from 1. As such, the results imply that firms incorporate changes in the cost of capital in their discount rates, although the effect is less than the one-for-one incorporation that is often assumed in standard models.

The firm-level analysis requires that we observe both the discount rate and the perceived cost of capital in the same quarter for the same firm. This requirement lowers the number of observations. To ensure that results are robust, we additionally study the relation between cost of capital and required return on invested capital/equity, which we also extract from conference calls. These metrics are not to be understood as discount rates, but they are likely correlated with discount rates. Consistent with this idea, we find that the required return on invested capital/equity is positively related to the cost of capital, both with and without firm and year fixed effects.

5.3 Competition and Discount Rate Wedges

As shown in Figure 5, the average discount rate wedge has increased over the last two decades as the cost of capital has decreased. Are there differences by firm type in the evolution of the wedge? What economic forces lead firms to lower discount rates along with the cost of capital?

One hypothesis emphasizes the role of product market competition. In perfectly competitive markets, all firms must earn the same return. If one firm lowers the required rate of return based on a decrease in the cost of capital, other firms also have to lower their required return in order to compete in the same product market. If firms fail to do so, they will not be able to find positive NPV projects to invest in. Market pressures may thus force firms to lower their discount rates with the cost of capital or, at least, ensure that firms with low discount rates become relatively larger over time. In contrast, firms with high market power do not face the same pressure. These firms may keep discount rates unchanged even as the cost of capital falls (e.g., due to build-ups of organizational frictions, managerial risk aversion, or myopia) without losing market share. Under this hypothesis, firms with less market power increase discount rate wedges by less when the cost of capital falls.

To test the competition hypothesis, we divide the sample into two subgroups based on

firms' market power at the beginning of our sample.[20] We estimate the average discount rate in a year separately for each group as well as the average cost of capital across all firms, in both cases controlling for firm fixed effects to isolate variation over time. We then calculate the average annual discount rate wedge for each group by subtracting the average cost of capital from the average discount rate.[21]

Figure 11 show the resulting discount rate wedges. The increase in wedges takes place largely among firms with high market power. There are upticks in both groups around the financial crisis and the Covid crisis, possibly driven by a general increase in risk in these periods. Overall, however, the data are consistent with the view that competitive pressures force firms to maintain stable discount rate wedges. This finding is consistent with Philippon (2019) who argues that increases in market power have driven down corporate investment in the last decades.

6 Conclusion

This paper presents a new dataset on firms' discount rates and perceived cost of capital. The data allow us to study how firms incorporate financial market movements into their perceived cost of capital; how firms set their discount rates based on cost of capital and a range of other factors, including risk, financial, and organizational constraints; and how firm investment comoves with discount rates. We focus on the dynamics of discount rates and firm investment, as our data allow us to study within-firm variation over 19 years.

While corporate discount rates have always played an important role in macroeconomic and financial theories, a lack of data has made it difficult to empirically evaluate the impact of discount rates. Using the new data, we show that accounting for empirically grounded discount rates affects our understanding of several economic puzzles. For instance, once we incorporate discount rates into standard models, the elasticity of investment with respect to the cost of capital is relatively low; an adjusted Q-theory explains a larger share of investment fluctuations; and low investment in the US can be partially traced to managerial choices about discount rates. These findings suggest that future research into the drivers of discount rates is a promising avenue to understand investment fluctuations.

[20] We measure market power as the average markup between 2000 and 2002 in De Loecker et al. (2020).

[21] We estimate the cost of capital using the pooled sample to ensure that the results are not driven by differences in the cost of capital across the two subgroups. Estimating the cost of capital separately for each subgroup does not influence the findings.

7 Appendix

7.1 Theory

7.1.1 Proof of Proposition 1

We know from (4) that

$$q_t = \frac{\delta V_t(x, k_t)}{\delta k_{t+1}} = \frac{V_t(x, k_t)}{k_{t+1}} = Q_t.$$

To estimate Q, we must calculate $V_t(x, k_t)$. Note that $V_t(x, k_t)$ is the value of the future profits produced by capital, calculated using $x + r$ as the discount rate. If we set $x = 0$, we get the value of these profits calculated using the cost of capital as the discount rates, $V_t(1, k_t)$, which is the value of the firms in the financial markets. We can approximate both using the Gordon growth model

$$V_t(1, k_t) \sim \frac{CF_{t+1}}{r - g}$$
$$V_t(x, k_t) \sim \frac{CF_{t+1}}{x + r - g}$$

where g is the long-run growth rate of free cash flows and CF_{t+1} is the free cash flow next period. Both of these variables are unobserved.

We can calculate the value of $V_t(x, k_t)$ as

$$V_t(x, k_t) = V_t(1, k_t)\frac{r - g}{x + r - g} = V_t(1, k_t)\frac{1}{x \times \text{Dur} + 1} \tag{9}$$

where Dur is the weighted average of the firms future cash flows, which in the Gordon growth model is given by:

$$\text{Dur} = \frac{1}{r - g}$$

(Gormsen and Lazarus 2019).

We can then calculate Q by inserting (9) into (4) and using that

$$Q^{\text{Tobin}} = \frac{V_t(1, k_t)}{k_{t+1}}.$$

Alternative formulation without duration

We can replace Dur in 5 with Tobin's Q and return on equity. Under the assumption

that the firm is fully equity financed,

$$\frac{1}{\text{Dur}} = r - g = \frac{E}{P} = \frac{B}{M}\text{ROE} = \frac{\text{ROE}}{Q^{\text{Tobin}}}$$

such that

$$Q_t = Q^{\text{Tobin}}\frac{V_t(x, k_t)}{V_t(1, k_t)} = Q^{\text{Tobin}}\frac{\text{ROE}}{x \times Q^{\text{Tobin}} + \text{ROE}}. \tag{10}$$

In the cross-sectional implementation of adjusted Q, we use the above expression and assume a constant ROE across firms. We do so to ensure that the only additional information that is incorporated in the adjusted-Q relative to Tobin's Q is the discount rate wedge (which makes comparison of the two measures easier).

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Table 1
Summary Statistics on Corporate Discount Rates from Earnings Calls

This table reports summary statistics of metrics extracted from the earnings calls. The sample is 2005 to 2021.

Panel A: Summary statistics

VARIABLES	(1) N	(2) mean	(3) p5	(4) p95
Perceived cost of debt	3,929	4.56	1.75	8.40
Perceived cost of equity	257	10.5	5.32	15.5
Perceived cost of capital	1,805	8.88	6	12.2
Discount rate	2,277	15.8	8	30
Investment rate (net of depreciation)	3,922	-4.40	-37.2	13.7
Market cap in million USD	3,695	13,973	299	52,506
Return on equity	3,384	0.11	-0.033	0.26

Panel B: Representativeness

VARIABLES	(1) Cost of capital	(2) Cost of capital	(3) Discount Rate	(4) Discount Rate
Return on equity (rank)	0.00048		-0.00065	
	(0.00099)		(0.00091)	
Future return on equity (rank)		0.00058		-0.00082
		(0.0011)		(0.0010)
Market value (rank)	-0.00016	0.00047	-0.0030	-0.0024
	(0.0023)	(0.0020)	(0.0039)	(0.0036)
Book-to-market (rank)	0.000047	-0.00058	0.00060	0.00017
	(0.0012)	(0.0016)	(0.0012)	(0.0015)
Investment rate (rank)	0.0019		0.0041*	
	(0.0013)		(0.0020)	
Future investment rate (rank)		0.0019		0.0042*
		(0.0013)		(0.0021)
Observations	276,950	258,786	276,950	258,786
FE	Year	Year	Year	Year
Cluster	Country/year	Country/year	Country/year	Country/year

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2
The Perceived Cost of Capital at the Country Level

This table reports results of panel regressions of the country-year level average perceived cost of capital in a country on the cost of debt (as obtained in conference calls) and the long-run expected stock return in the same country at the same time:

$$\text{Cost of capital}_t^i = \beta_0 + \beta_1 \text{Cost of debt}_t^i + \beta_2 E[r_t^{\text{Equity}} | \text{Asset prices}_t] + \varepsilon_t^i$$

where i denotes country and t denotes calendar years. Long-run expected stock returns are measured using CAPE in the US and Campbell and Thompson (2008) outside the US, as explained in the text. The sample covers 10 countries and runs from 2005 to 2020. Standard errors are double-clustered by year and country. Regressions are weighted by the number of observations on cost of capital in the country as explained in the text. The left- and right-hand side variables are measured in percentage points.

	(1)	(2)	(3)
VARIABLES	Cost of capital	Cost of capital	Cost of capital
Expected stock returns	0.22*	0.46***	0.49*
	(0.11)	(0.10)	(0.23)
Perceived cost of debt	0.38*	0.26*	0.077
	(0.17)	(0.13)	(0.073)
Constant	5.29***	3.97***	4.67*
	(1.24)	(0.90)	(2.17)
Observations	128	128	127
R-squared	0.289	0.561	0.703
FE	None	Country	Country/Year
Cluster	Country/year	Country/year	Country/year
Within R^2	0.29	0.37	0.083

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3
Discount Rates and the Cost of Capital at the Country Level

This table reports results of panel regressions of the country-year level average discount rates on the perceived cost of capital. The sample covers 10 countries and runs from 2005 to 2021. Standard errors are double-clustered by year and country. Regressions are weighted by the number of observations on discount rates in the country as explained in the text. The left- and right-hand side variables are measured in percentage points.

	(1)	(2)	(3)
		Discount rate	
Perceived cost of capital	0.83***	0.39***	0.32*
	(0.12)	(0.032)	(0.16)
Constant	8.47***	12.4***	13.0***
	(1.45)	(0.0095)	(1.50)
Observations	117	117	117
R-squared	0.132	0.523	0.606
FE	None	Country	Country/Year
Cluster	Country/year	Country/year	Country/year
Within R^2	0.13	0.046	0.021

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4
Investment and Corporate Discount Rates at the Country Level

This table reports results of panel regressions of the country-year level investment rates on the ex ante discount rates. The sample covers 10 countries and runs from 2005 to 2020. Standard errors are double-clustered by year and country. We consider net investment measured as $I_t = (\text{CAPEX}^i_{t+1} - \text{Depreciation}^i_{t+1})/\text{PPEN}^i_t$, excluding firms in the financial sector. Right hand side variables are all measured at time t, as detailed in the text. Regressions are weighted by the number of observations on discount rates in the country as explained in the text. Investment rates, discount rates, and the cost of capital are measured in percentage points. Fin. cost of capital is the financial cost of capital estimated using the cost of debt and expected stock returns.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NetInvest	NetInvest	NetInvest	NetInvest	NetInvest	NetInvest
Discount rate	-0.26**	-0.27**	-0.33**	-0.29**	-0.34**	-0.21**
	(0.092)	(0.12)	(0.14)	(0.11)	(0.11)	(0.067)
Fin. cost of capital			1.32**	-1.61		
			(0.53)	(0.95)		
Tobin's Q					-2.15**	3.68***
					(0.74)	(0.86)
Observations	111	111	111	111	111	111
R-squared	0.082	0.817	0.180	0.832	0.176	0.891
FE	Country	Country/year	Country	Country/year	Country	Country/year
Cluster	Country/year	Country/year	Country/year	Country/year	Country/year	Country/year
Within R^2	0.027	0.12	0.13	0.19	0.13	0.48

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5
Investment and Corporate Discount Rates: Firm-Level Evidence

This table reports results of panel regressions of the firm-level investment rate on discount rates. We consider net investment measured as $I_t = (\text{CAPEX}^i_{t+1} - \text{Depreciation}^i_{t+1})/\text{PPEN}^i_t$. Right hand side variables are all measured at time t, as detailed in the text. Tobin's Q is measured as the book-to-market value of debt and equity. Standard errors are double-clustered by firm and date. The left- and right-hand side variables are measured in percentage points. Sample is 2002 to 2021 and excludes firms in the financial sector. Fin. cost of capital is the financial cost of capital estimated using the WACC and the CAPM.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NI	NI	NI	NI	NI	NI
Discount rate	-0.86***	-0.79***	-0.91***	-0.88***	-0.98***	-0.93**
	(0.30)	(0.26)	(0.26)	(0.26)	(0.31)	(0.34)
Fin. cost of Capital			0.21	0.12	0.56	0.55
			(0.33)	(0.34)	(0.36)	(0.44)
ROE					0.073	0.072
					(0.092)	(0.089)
Market cap					-2.41	-1.58
					(1.48)	(2.39)
Tobin's Q					2.00***	1.87**
					(0.54)	(0.67)
Observations	928	928	834	834	586	586
R-squared	0.799	0.819	0.804	0.823	0.851	0.864
FE	Firm	Firm/year	Firm	Firm/year	Firm	Firm/year
Cluster	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year
Within R^2	0.037	0.033	0.044	0.041	0.094	0.088

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6
Tobin's Q versus Adjusted Q

This table reports results of panel regressions of the firm-level investment rate on Tobin's Q and adjusted Q. We measure Tobin's Q as Total Q using data from Peters and Taylor (2017). We consider net investment measured as $I = (\text{CAPEX}^i_{t+1} - \text{Depreciation}^i_{t+1})/\text{PPEN}^i_t$. Right hand side variables are all measured at time t, as detailed in the text. Sample is 2002 to 2016.

	Net Investment					
Adjusted Q	22.5***		20.2***		17.2***	15.0***
	(1.41)		(1.31)		(1.42)	(1.26)
Tobin's Q		2.27***		2.09***	1.24***	1.21***
		(0.20)		(0.15)	(0.18)	(0.17)
Constant	-20.5***	-11.9***	-19.2***	-11.6***	-19.3***	-18.0***
	(0.91)	(0.69)	(0.74)	(0.21)	(0.89)	(0.66)
Observations	58,935	69,840	58,935	69,840	58,581	58,581
R-squared	0.526	0.491	0.531	0.498	0.529	0.533
FE	Firm	Firm	Firm/year	Firm/year	Firm	Firm/year
Cluster	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year
Within R^2	0.041	0.027	0.030	0.022	0.045	0.034

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7
Discount Rates and Firm-Level Risk

This table reports results of regressions of firm-level discount rates on measures of firm-level riskiness. Option-implied volatility is the at-the-money implied volatility on options written on the firm's equity as measured at time t. Realized volatility is the realized volatility on the firms equity over the past 5 years. Realized idiosyncratic volatility is the realized volatility on the firms equity over the last five years measured in excess of the part explained by exposure to the market portfolio. The regressions include the financial cost of capital on the right hand side, which is suppressed for simplicity. All volatilities are annualized. The left- and right-hand side variables are measured in percentage points. Sample is 2002 to 2021. Standard errors are double-clustered by firm and year.

	(1)	(2)	(3)
VARIABLES	Discount rate	Discount rate	Discount rate
Option-implied volatility	0.18***	0.22***	0.22***
	(0.024)	(0.025)	(0.042)
Realized volatility			-0.20**
			(0.078)
Realized idiosyncratic vol.			0.21**
			(0.081)
Observations	989	989	871
R-squared	0.176	0.250	0.265
FE	None	Year	Year
Cluster	Firm/year	Firm/year	Firm/year

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8
Discount Rates and Organizational Constraints

This table reports results of panel regressions of discount rates on measures of organizational constraints. Leverage and cash-to-assets are measured using Compustat data. Expected growth is the long-run expected growth rate from IBES data. The regressions include the financial cost of capital on the right hand side, which is suppressed for simplicity. The left- and right-hand side variables are measured in percentage points. Sample is 2002 to 2021. Standard errors are double-clustered by firm and year.

	(1)	(2)	(3)
VARIABLES	Discount rate	Discount rate	Discount rate
Leverage	0.067***		
	(0.020)		
Cash-to-assets		0.035**	
		(0.016)	
Expected growth			0.037***
			(0.0096)
Observations	1,728	1,394	793
R-squared	0.048	0.019	0.030
FE	None	None	None
Cluster	Firm/year	Firm/year	Firm/year

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9
Dynamic Updating of Discount Rates from Changes in Cost of Capital

This table reports results of panel regressions of discount rates on cost of capital from the same firm. Regressions in column (1) to (3) use our baseline measure of discount rates as the dependent variable. The regressions in (4) to (6) uses the required return on equity/invested capital as the dependent variable. Standard errors are double-clustered by firm and year. The left- and right-hand side variables are measured in percentage points. Sample is 2002 to 2021.

	(1)	(2)	(3)	(4)	(5)	(6)
	Discount rate			Required return on equity/invested capital		
Perceived cost of capital	0.72***	0.61***	0.56***	0.67***	0.54*	0.50*
	(0.11)	(0.16)	(0.13)	(0.16)	(0.27)	(0.25)
Constant	5.70***	6.44***	6.89***	6.58***	7.35***	7.69***
	(1.02)	(1.42)	(1.20)	(1.38)	(2.23)	(2.12)
Observations	266	142	136	263	163	153
Within R^2	0.19	0.68	0.52	0.12	0.12	0.064
FE	None	Firm	Firm/year	None	Firm	Firm/year
Cluster	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year	Firm/year

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1
Histograms of Cost of Capital and Hurdle Rates

This figure plots histograms for the perceived cost of capital and hurdle rates.

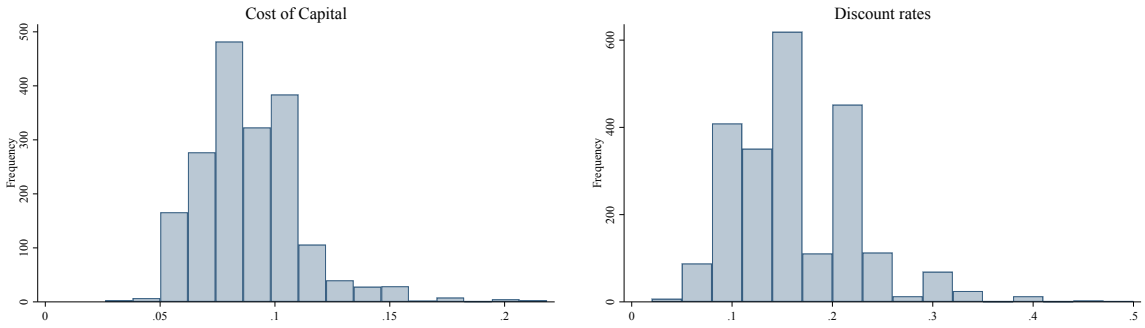


Figure 2
The Time Series of Corporate Discount Rates

This figure plots the average discount rate, perceived cost of capital, and perceived cost of debt for different years in the US.

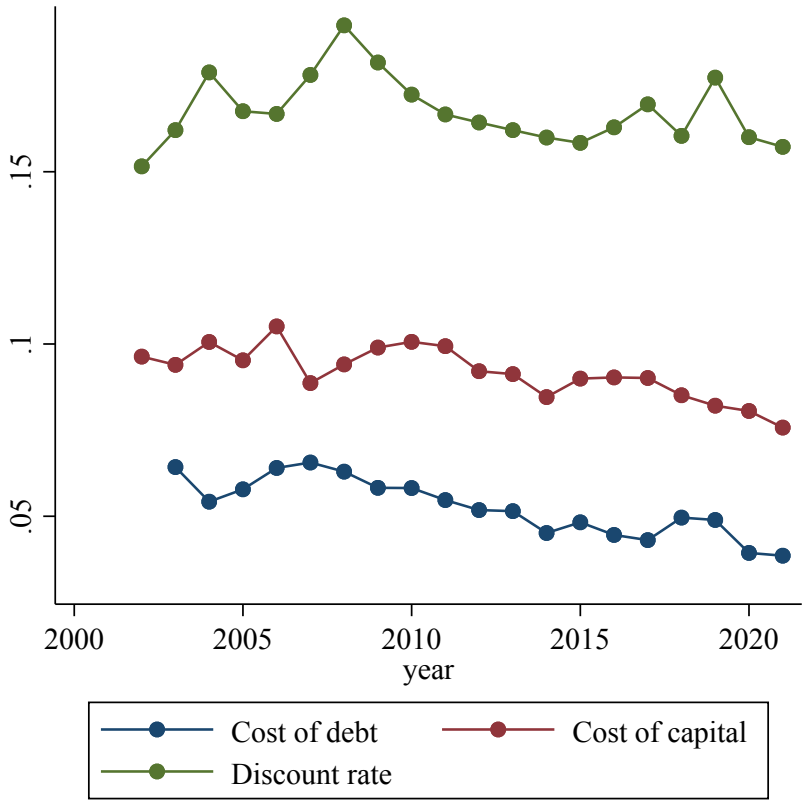


Figure 3
The Perceived Cost of Equity

This figure plots the perceived cost of equity along with three different estimates of expected stock returns. The perceived cost of equity is the average perceived cost of equity from conference calls in a given year, estimated using firm-fixed effects. The "standard MBA class" measure is calculated as the risk-free rate plus the long-run market risk premium of 6%, as in the example by Cochrane (2011). The measure 'Shiller + historical growth" is the earnings yield from CAPE + a nominal growth rate of 4%. The measure 'Shiller + high expected growth" is the earnings yield from CAPE + a nominal growth rate of 6%. Panel A plots expected stock returns/cost of equity and Panel B plots expected stock returns/cost of equity measured in excess of the risk-free interest rate.

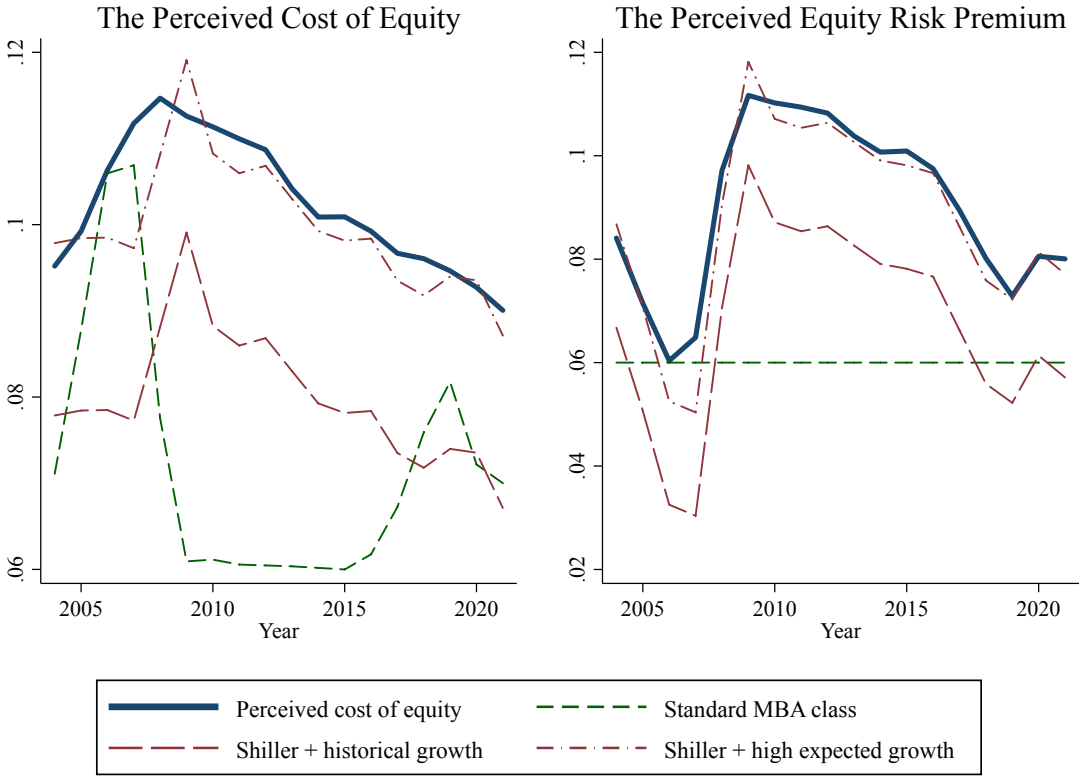


Figure 4
Discount Rates and Cost of Capital in Different Countries

This figure plots the average discount rates and perceived cost of capital in the different countries in our sample. Data are from 2002 to 2021.

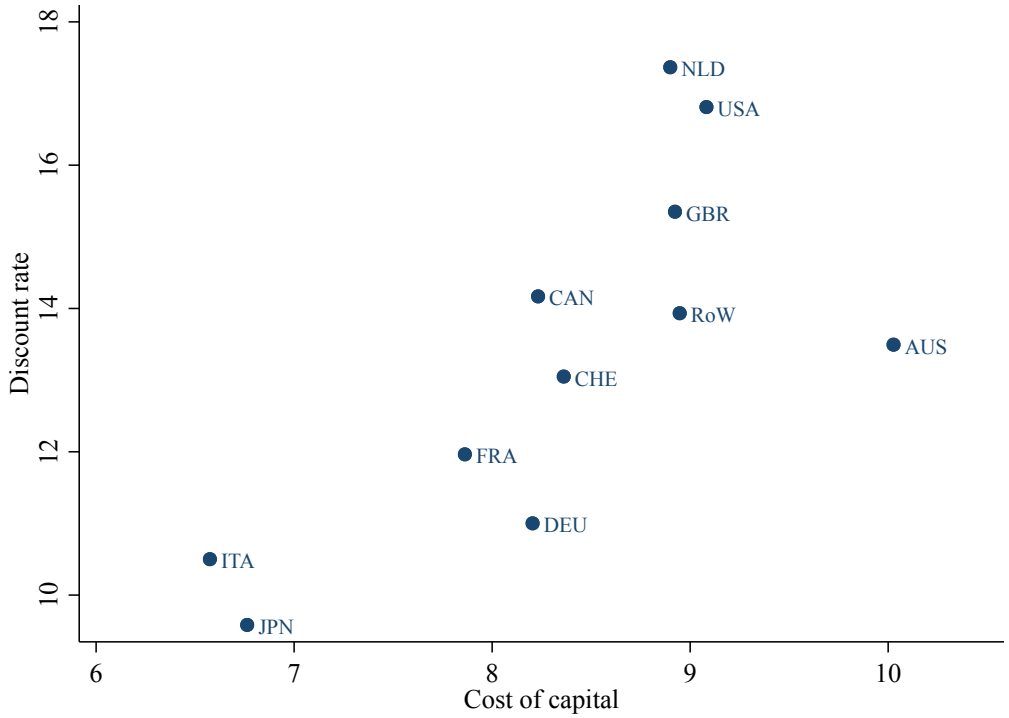


Figure 5
The Discount Rate Wedge

This figure plots the discount rate wedge in the US sample. We estimate the average discount rate and cost of capital for each year using firm fixed effects. The wedge is the ratio of the discount rate to the cost of capital.

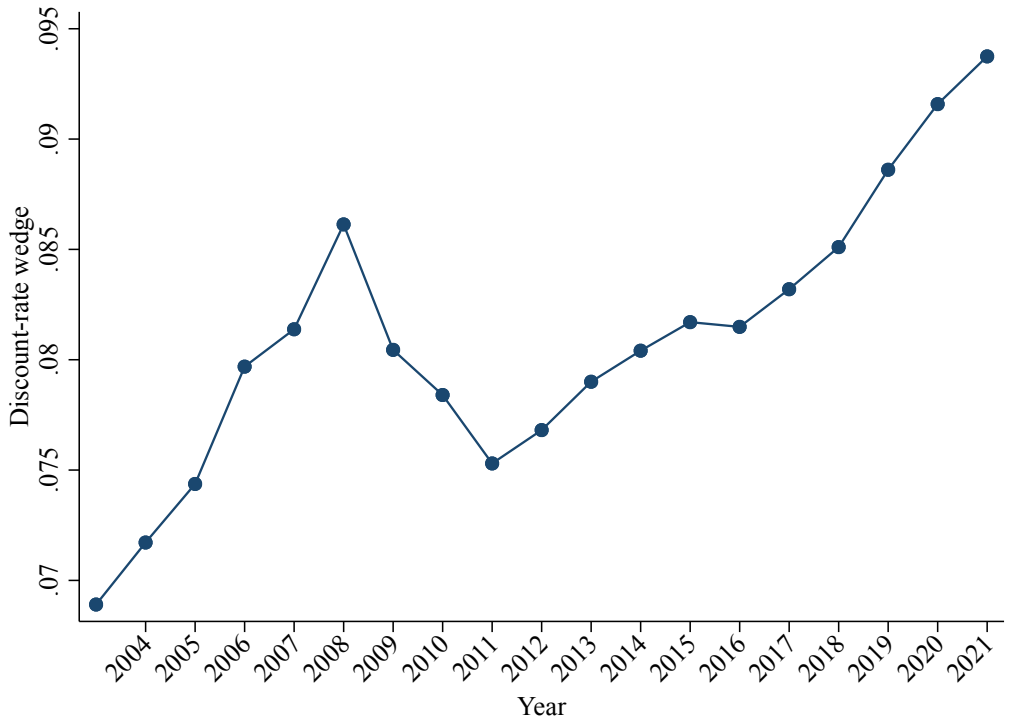


Figure 6
Discount Rates and Investment in the US

This figure the time series of discount rates and net investment in the US. Investment is lead by one year relative to hurdle rates. We measure net investment in the BEA Tables.

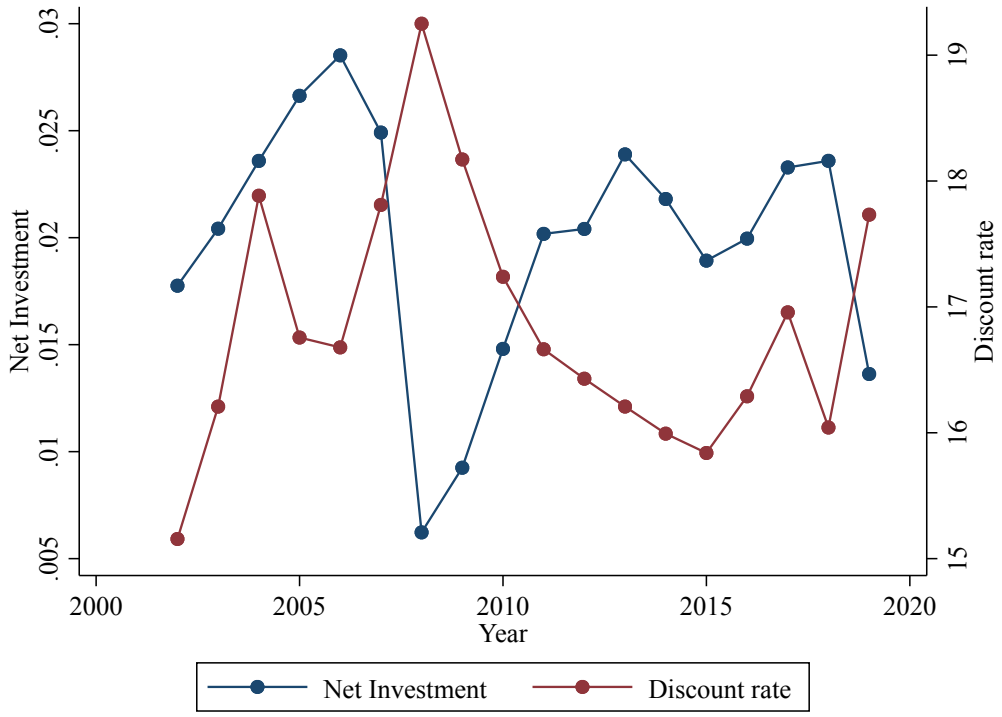


Figure 7
The Effect on Investment With and Without Discount Rate Wedges

This figure plots the effect on investment of changes in the cost of capital and cost of debt (interest rates). The leftmost bar shows the effect in a standard model without discount rate wedges. The middle bar shows the effect in our model with discount rate wedges and perfect pass-through of the cost of capital to discount rates (see text for details). The right figure shows the effect obtained by multiplying the empirically observed investment effect with the empirically observed pass-through of changes in the cost of capital to discount rates.

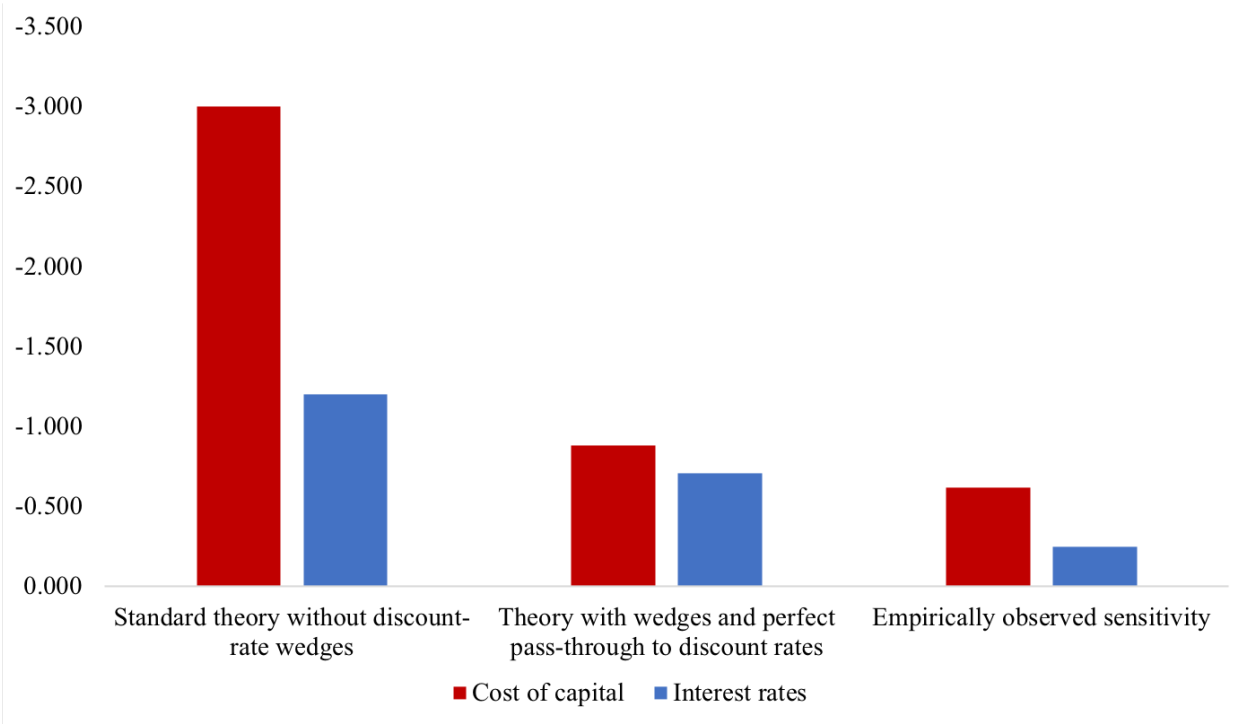


Figure 8
The "Adjusted Q"

This figure plots Tobin's Q as measured by Crouzet and Eberly (2021) as well as "Adjusted Q". Adjusted Q is Tobin's Q adjusted for the wedge between discount rates and the cost of capital, as explained in the text. The sample is the United States.

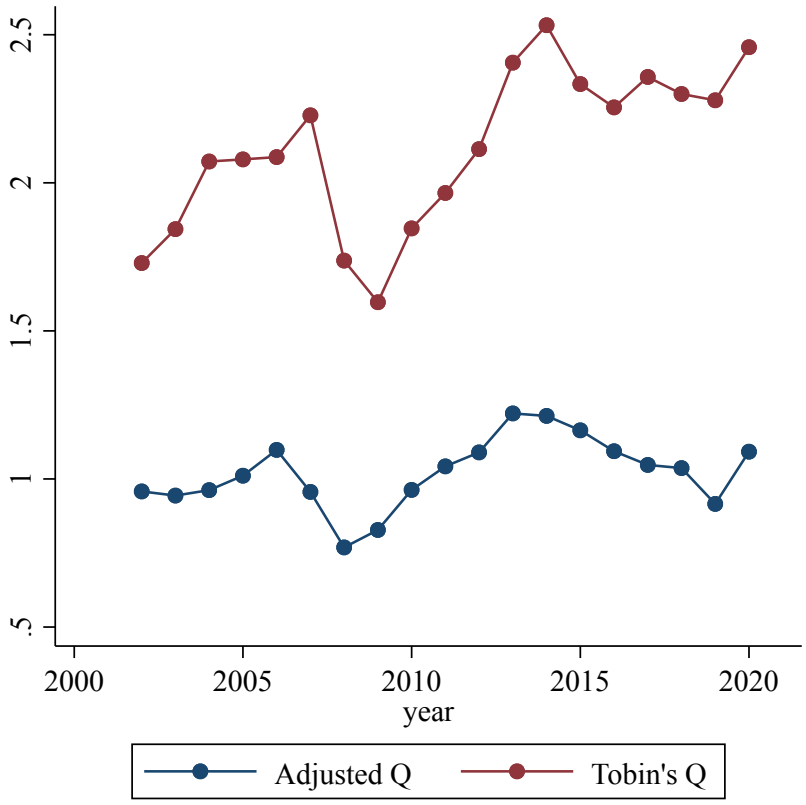


Figure 9
Adjusted Q and the Missing Investment

This figure plots Tobin's Q and adjusted Q by decade along with the net investment ratio by decade. The figure to the left considers Tobin's Q; the figure to the right considers adjusted Q. Adjusted Q is calculated by accounting for the wedge between discount rates and the cost of capital, as explained in the text. The figures assumes that discount rates are 4% higher than the cost of capital in the pre-2002 sample. We measure Q using book to market value of equity to maximize sample length. The sample is the United States.

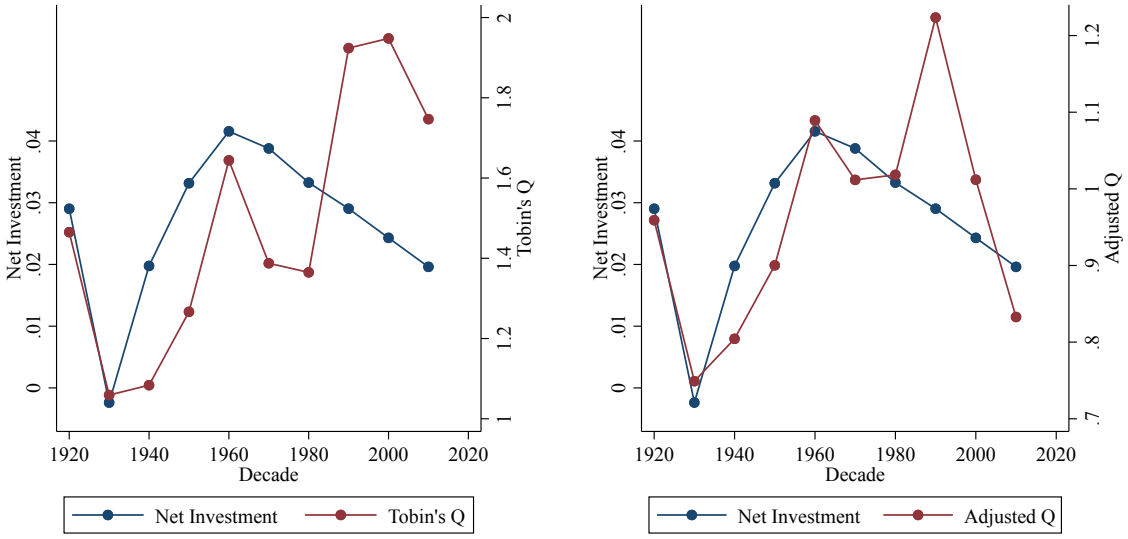


Figure 10
Investment Residuals

This figure plots the cumulative investment shortfall in percent relative to the capital stock, calculated using Tobin's Q as measured by the book-to-market as well as "adjusted-Q". Adjusted Q is calculated by accounting for the wedge between discount rates and the cost of capital, as explained in the text. We fit investment on Q models using the 1927-2002 sample and calculate cumulative residual with respect to these (see text for details). The sample is the United States.

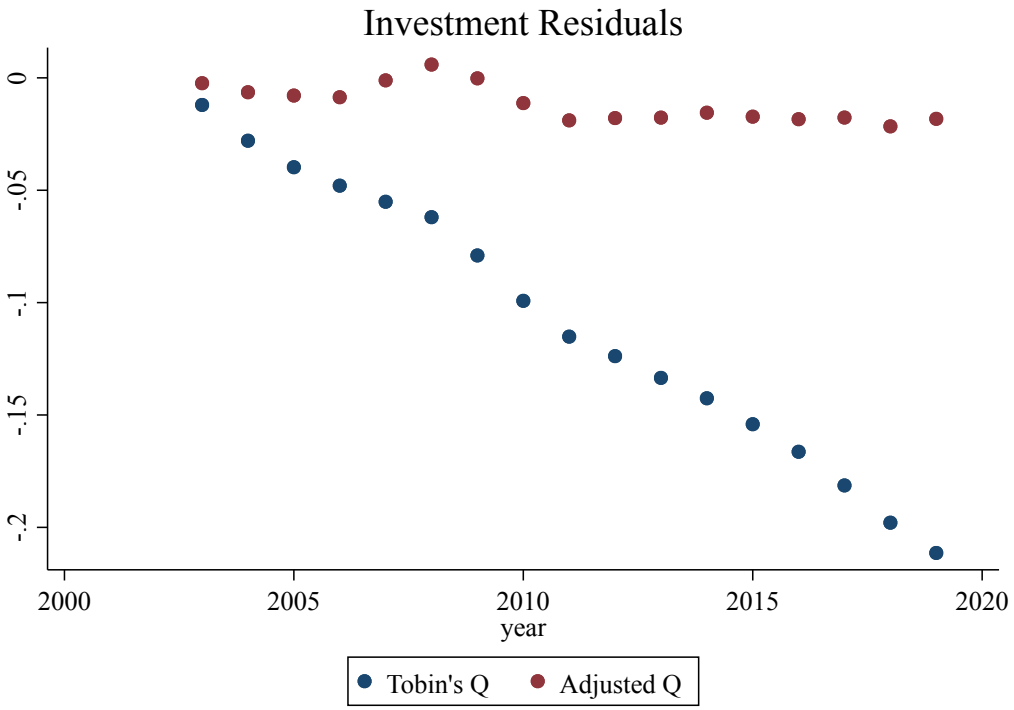


Figure 11
Market Power and Discount Rate Wedges

This figure plots the discount rate wedge for high- and low-markup firms over time. We group firm into high- and low-markup firms based on the average markup of the firm in the 2000-2002 period. For each group we estimate the annual average annual discount rate including firm-fixed effects. Based on these discount rates, we calculate discount rate wedges relative to the average cost of capital. We smooth the resulting time-series for discount rate wedges over three years and normalize both series to start at 0 in 2004. Markups are measured using the baseline measure in De Loecker et al. (2020).

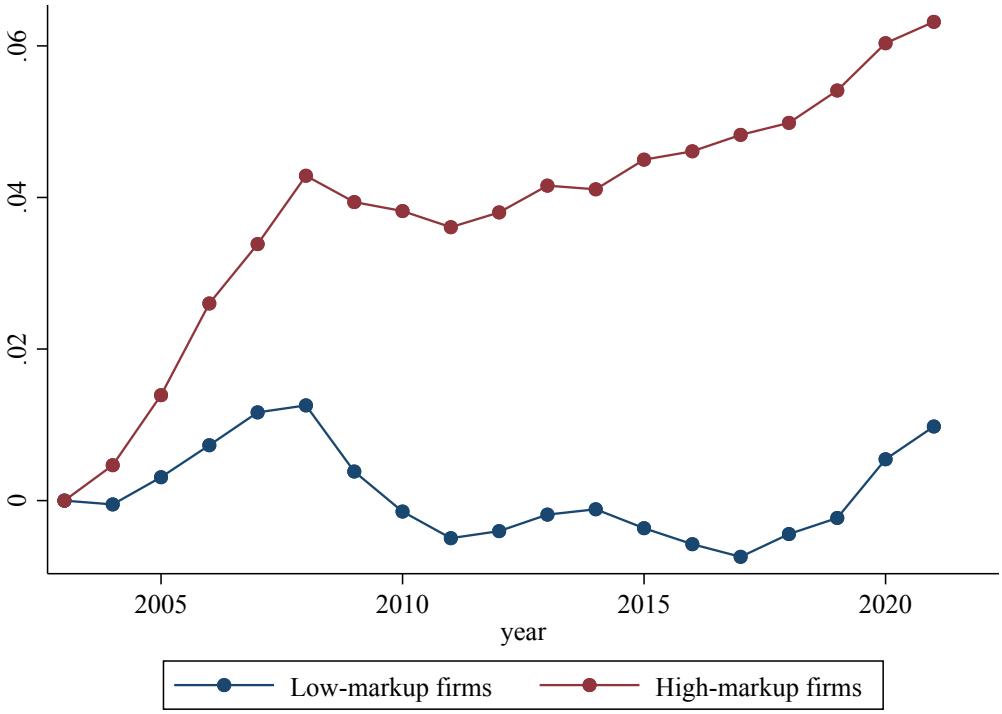


Figure 12
Within-Firm Variation in Discount Rates and Cost of Capital

This figure plots the within-firm standard deviation of the perceived cost of capital (left) and hurdle rates (right). Sample is 2005 to 2021. We consider with-in firm variation of all firms with more than 4 quarterly observations. The figure excludes firms for which hurdle rates and cost of capital are constant.

