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Buyout activity: The impact of aggregate discount rates

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Federal Reserve Bank of New York
Staff Reports

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March 2013



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Buyout Activity: The Impact of Aggregate Discount Rates

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Abstract

We argue that buyout waves form in response to fluctuations in aggregate discount rates. In our model, discount rates alter the present value of cash flow improvements and the illiquidity premium demanded by buyout investors. We confirm our predictions empirically. Overall deal activity varies positively with the risk premium and negatively with the risk-free rate, exhibiting heterogeneous effects across firms. Cross-sectionally, firms with high levels of systematic risk or idiosyncratic risk are less likely targets. We decompose variation in activity structurally between changes in the value of cash flow and the illiquidity premium. The positive correlation of the two explains the wave behavior of activity.

Key words: buyouts, discount rates, illiquidity, governance

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1 Introduction

Since their emergence in the 1980s, buyouts have been seen as a powerful means to alter incentives in firms. But the employment of this tool varies wildly over time; buyout activity exhibits extreme booms and busts. Peak years experience close to 100 public-to-private buyout transactions and troughs as few as 10. These fluctuations are puzzling, especially given that buyout activity peaks when prices for public firms are high. The academic literature remains largely silent on why some periods are more conducive to changes in ownership. What coordinates this movement of firms from public to private markets?

We argue buyout waves reflect the response of all parties in this market to fundamental forces — aggregate discount rates. Buyout transactions involve the valuation of firms. Since firm values are affected by discount rates, investors' decisions change with these rates. As illustrated by Figure 1, buyout activity varies with the two components of discount rates, negatively with the risk premium and positively with the risk-free rate. These two variables explain over 30% of the variation in activity. We provide a systematic study of this relation, first by outlining precise economic channels by which discount rates influence buyout decisions and second by documenting and quantifying these channels empirically.

In our model, investors compare the potential privatized value of the firm to its public market value. We consider two economic channels that impact this trade-off: changes in cash-flow and changes in illiquidity. The cash-flow channel reflects the benefit of a buyout, as better firm management improves cash-flow. The illiquidity channel is the cost; the ownership structure changes and the acquirer must hold a concentrated, undiversified position in the target. The components of the discount rate interact with these channels.

The value of the cash-flow gain follows Gordon growth model intuition, increasing with

the difference between the firm's growth rate and the discount rate.¹ When the risk premium is high, high discount rates lower the value of cash-flow gains reducing the likelihood of a deal. Periods of high risk-free rates coincide with economic growth (Stock and Watson, 1999), therefore the future cash-flow lost from mismanagement is greater at these times and the value of eliminating these losses increases.

The illiquidity channel compares the valuation of the same cash-flow stream under two different forms of ownership. The private value is lower than the public value as we assume private owners must hold an illiquid, undiversified portfolio consisting of the target firm.² As a result, firms with greater idiosyncratic or aggregate risk are less attractive targets. When bearing risk is costly, i.e. when the risk premium is high, investors are less willing to invest in illiquid assets. This explains the low number of deals in periods with a high risk premium and high prices.

Risk and discount rates also vary in the cross-section of firms. Therefore the model provides original predictions on the types of firms bought out. Firms with high exposure to aggregate risk are less likely targets via both channels. They have higher discount rates on cash-flow gains and their excessive aggregate risk is unappealing to illiquid investors. Firms with high idiosyncratic risk are less attractive to undiversified investors by way of the illiquidity channel.

We study a sample of non-strategic public-to-private deals from 1982 to 2011 and document a novel set of facts consistent with the model. Buyout activity is negatively related to market-wide risk premium and positively related to the risk-free rate. This relation is robust to the inclusion of market signals corresponding to other hypotheses: credit market

¹The net present value of a cash-flow stream starting at X , growing exponentially at rate g and discounted at rate r is $X/(r - g)$.

²See Longstaff (2001), Schwartz and Tebaldi (2006).

specific conditions (Axelson et al., 2013) or measures of stock-debt mispricings (Kaplan and Strömberg, 2009). Our two factors explain over 30% of the variation in activity whereas including credit factors only raises the R -squared by 6%. In the cross-section of firms, we demonstrate the relevance of firm risk characteristics on the propensity of a firm to be bought out. Firms with high aggregate risk or high idiosyncratic volatility are less likely targets. This fact is robust to measuring volatility using stock returns or directly from firms' cash-flow.

Using simple structural restrictions imposed by the model, we quantify the role of the two channels. Overall, we find the cash-flow channel is the larger force, but the strong correlation between the channels helps explain fluctuations in activity. Taken separately, the cash-flow and illiquidity channels account for 48% and 13% of the explained variation in activity, respectively. The remaining 39% is due to the covariation between the two channels. If we consider the discount rate components, the risk premium is the primary driver of extreme variation, as it impacts both channels. When the risk premium is high, not only do buyouts create less present value, two-thirds of its impact, but private investors are less willing to hold illiquid assets, one-third. These results highlight how an aggregate force like the risk premium can simultaneously impact the supply and demand side of the market to generate booms and busts.

Finally, we provide additional reduced-form evidence for each of the two channels. For the cash-flow channel, the model predicts firms with higher agency costs are not only more likely targets but also more sensitive to changes in the risk-free rate. We confirm this result using measures of governance and free cash-flow as proxies for agency problems. For the illiquidity channel, firms that need to be held longer have higher illiquidity costs and are therefore more sensitive to changes in the risk premium. We measure the ease of exit for

private investors using industry-level merger or IPO activity and find that those firms in less liquid industries are more sensitive to the risk premium.

Our paper is unique in its emphasis on aggregate discount rates. Kaplan and Strömberg (2009) outline the history of aggregate private equity activity, but systematic explanations for buyout waves remain unresolved. The closest analysis to ours, Martos-Vila et al. (2012), provides an explanation for the dynamics of financial versus strategic acquisition activity. Their analysis focuses on mispricing in the debt market rather than changes in aggregate prices. These explanations are not mutually exclusive, particularly given their focus on the composition of activity; both aggregate fundamentals and relative mis-valuation can play a role.

A number of papers isolate specific events that impact buyout activity. Shivdasani and Wang (2011) use cross-sectional evidence to argue that the advent of structured credit improved access to capital for buyout investors. Similarly, the emergence of the high-yield securitization market likely stimulated activity, as Kaplan and Stein (1993) observe important changes in the structure of deals during this period. Particular innovations in financial markets indeed matter. For instance, discount rates fail to capture the intensity of the boom in the 1980s. But aggregate forces are first order contributors to oscillations in activity and they should be considered as such when quantifying other hypotheses. The literature on cross-sectional determinants of buyouts is more developed (Bharath and Dittmar (2010), Opler and Titman (1993)), but our focus on risk measures is novel here as well.

More generally, our theory contributes to the broader literature emphasizing the role of time-varying discount rates for corporate decisions. Time variation in the discount rate has been shown to affect investment, Cochrane (1991) and Berk et al. (1999), and other forms

of financial activity (for a survey see Cochrane (2011)). For instance, Pastor and Veronesi (2005) demonstrate the role of pricing conditions for initial public offerings.

2 Model

In this section, we present a model of buyout decisions centered on the role of pricing and risk. The model studies the trade-off between the profits gained through better management of the firm and the portfolio illiquidity investors undertake to deliver these profits. We conclude with a summary of the model's empirical implications.

2.1 Buyout decision

We assume that at a given instant, a firm, *the target* hereafter, meets an investor, *the acquirer*. They can jointly decide to partake in a buyout, taking the target from public to private ownership. For simplicity, we assume that the deal cannot be delayed once the opportunity arrives. If the investors choose to go ahead with the buyout, two elements of the target change simultaneously: the evolution of cash-flow and the ownership structure. This is a reduced-form representation of the idea that the change in financing structure reduces an agency problem at the target firm (Jensen and Meckling, 1976).

The benefit of the transaction is the suppression of agency costs, parameterized by d . However, to obtain larger cash-flows, the firm has to move from public (*pub*) to private (*pr*) ownership and incur a larger cost of capital. We assume a deal occurs if the price private investors are willing to pay, P_0^{pr} , exceeds the public market price, P_d^{pub} . In other words, the deal happens as long as it generates positive surplus.³ We introduce a third,

³We do not take a stand on how the surplus is shared as we are focused on relative measures of activity over time.

purely fictitious, situation in which the firm eliminates agency costs without changing the ownership structure, the corresponding price is P_0^{pub} . This intermediate value allows us to separate the deal surplus into two economically meaningful terms, an *illiquidity channel* and a *cash-flow channel*. The deal happens if and only if:

$$0 < \log(P_0^{pr}) - \log(P_d^{pub}) = \underbrace{\log(P_0^{pr}) - \log(P_0^{pub})}_{\text{Illiquidity channel}} + \underbrace{\log(P_0^{pub}) - \log(P_d^{pub})}_{\text{Cash-flow channel}}. \quad (1)$$

The decomposition breaks the change in firm value into changes in the funding structure and changes in cash-flow growth. The first part corresponds to the cost of the deal and is typically negative whereas the second one is the benefit, typically positive. When looking at the data through the lens of the model, we can ascribe fluctuations in buyout activity to each of these two channels.

In the remainder of this section, we compute the price comparisons of Equation (1) assuming constant risk-free rate and risk premium. We provide comparative statics determining which pricing conditions are more favorable to buyout activity and which types of firms are more likely to be buyout targets.⁴

2.2 Cash-flow channel

The cash-flow channel is the (log) difference in value of a publicly owned firm without and with agency costs. Before deriving valuations, we specify the evolution of the firm's cash-flow, D_t . For a firm with agency costs d , it follows:

$$\frac{D_{t+1,d}}{D_{t,d}} = \exp \left(g - d + b_i \lambda \varepsilon_{t+1} + \sigma_i \nu_{t+1} - \frac{1}{2} (b_i \lambda)^2 - \frac{1}{2} \sigma_i^2 \right). \quad (2)$$

⁴Appendix E contains a model with time-varying pricing conditions that delivers similar insights.

The expected growth rate of cash-flow is $g - d$. Higher values of d corresponds to higher agency costs. Two shocks affect the growth of the firm, ε_{t+1} and ν_{t+1} . We assume the shocks are independent over time and from each other, following a standard normal distribution $\mathcal{N}(0, 1)$. The shock $\lambda\varepsilon_{t+1}$ is an aggregate priced shock impacting all firms and the coefficient b_i is the firm's exposure to this shock. The shock $\sigma_i\nu_{t+1}$ is an idiosyncratic shock, specific to firm i .

We assume that the buyout eliminates agency costs and the expected growth rate becomes g . Rather than a simple diversion of cash, we interpret agency costs as a form of malinvestment that foregoes profitable opportunities. Examples of this type of agency problem include empire-building and investment with the goal of entrenchment (Shleifer and Vishny, 1989). A number of studies have found growth improvements in post-buyout firms relative to their public peers.⁵

We assume there is no arbitrage on public markets. Therefore firms are valued by a unique stochastic discount factor. For simplicity we assume the discount factor S_t exhibits a constant risk-free rate r_f and a constant price of risk λ :

$$\frac{S_{t+1}}{S_t} = \exp\left(-r_f - \lambda\varepsilon_{t+1} - \frac{1}{2}\lambda^2\right). \quad (3)$$

Under these assumptions, the firm's valuation is the expected discounted sum of all future cash-flows,

$$\frac{P_{t,d}^{pub}}{D_t} = \mathbb{E}_t \left[\sum_{\tau=1}^{\infty} \frac{S_{t+\tau}}{S_t} \frac{D_{t+\tau}}{D_t} \right] = \frac{1}{1 - \exp(g - d - r_f - \lambda^2 b_i)}. \quad (4)$$

⁵For early evidence see Kaplan (1989), Lehn and Poulsen (1989). Boucly et al. (2011) analyze French LBOs and find significant increases in *growth*. The more recent wave of U.S. buyouts is discussed in Guo et al. (2011).

This expression is reminiscent of the Gordon growth formula. The price to cash-flow ratio is increasing in the growth rate g , decreasing in agency costs d , and decreasing in the discount rate $r_f + \lambda^2 b_i$. In Appendix A, we show that up to a linear coefficient, λ^2 coincides with the expected excess market return and b_i corresponds to the market beta of the firm. Therefore they can be estimated from price data.

Periods of high risk-free rates coincide with economic growth (e.g. Stock and Watson (1999)), so we assume the risk-free rate and the growth rate of the firm are positively related: $g = \phi r_f$ where $\phi > 1$. This relation is grounded in economic reasoning at the macroeconomic level. The risk-free rate and the aggregate growth rate are positively tied by the intertemporal elasticity of substitution. Additionally, public firms' growth tends to move more than one-to-one with aggregate growth.⁶ We confirm a ϕ larger than one in the data.

The following proposition provides exact comparative statics for a change in the price difference to model parameters, as well as an intuitive approximation. We leave the proofs to the appendix.

Proposition 1. Cash-flow channel: *The log difference between the public market price of the firm without and with agency costs is approximately:*

$$\log \left(\frac{P_0^{pub}}{P_d^{pub}} \right) \approx \frac{d}{r_f(1 - \phi) + \lambda^2 b_i} > 0 \quad (5)$$

Exactly, $\log(P_0^{pub}/P_d^{pub})$ is:

i. decreasing in the price of risk λ^2 ,

⁶For instance, the long-run risk model of Bansal and Yaron (2004) generates such a relation where $\phi = \text{IES} \times \text{exposure}$. Their baseline calibration effectively yields $\phi = 4.5$.

- ii. increasing in the risk-free rate r_f ,*
- iii. decreasing in the exposure b_i ,*
- iv. independent of idiosyncratic risk σ_i .*

Each of these results reflect the same mechanism. When the growth adjusted discount rate $r_f(1 - \phi) + \lambda^2 b_i$ is large, the values of a firm without and with agency costs get closer together in percentage terms. Agency costs accumulate over time, as they impede firm's growth. When discount rates are larger, these future costs represent a smaller fraction of the value of the firm.

A key assumption to deliver these results is the non-immediacy of agency gains; they need to impact the growth rate of the firm. The assumption they accumulate forever is merely for simplicity and can be relaxed. It is important to distinguish this result from the fact that all asset prices are low when discount rates are high. It is the fraction by which agency costs reduce the valuation which is changing. The buyout decision is a comparison of similar long-lived assets under different forms of ownership, not a comparison to immediate consumption or short-lived investment goods.

2.3 Illiquidity channel

The other side of the buyout transaction is a change in financing structure. If the target stays public, it is owned by diversified investors. The buyout occurs only if the acquirer commits all her wealth into an illiquid position in the target for a period T . We assume she purchases a fraction α of the cash-flow stream. The other share, $(1 - \alpha)$, remains in the hands of diversified investors. A typical public-to-private buyout is financed by 60-70% debt and 30-40% equity. Both the debt and equity can range from extremely illiquid and

undiversified (General Partners, management, mezzanine debt) to illiquid but diversified (Limited Partners, bank lenders) to liquid and diversified (securitized debt). For clarity we abstract from some of these nuances and split investors into only two groups. This structure is summarized in Figure 2.

There is no price discount on the portion of the deal financed by diversified investors. Therefore, we can focus on the price illiquid investors are willing to pay, P_0^{acq} , relative to the public market price, P_0^{pub} . Predictions with respect to this ratio extend immediately to the illiquidity channel defined earlier,

$$\frac{P_0^{pr}}{P_0^{pub}} = (1 - \alpha) + \alpha \frac{P_0^{acq}}{P_0^{pub}}. \quad (6)$$

To characterize the risk-return tradeoff faced by the acquirer, we assume she has mean-variance preferences:

$$U = \mathbb{E} \sum_{t=0}^{\infty} \beta^t \left(\mathbb{E}_t[r_{t+1}^e] - \frac{\gamma}{2} \text{var}_t[r_{t+1}^e] \right). \quad (7)$$

To find out how much the acquirer is willing to pay, we compare her utility from holding an optimal portfolio with that of holding the target and we derive a compensating differential in returns corresponding to a discount on the price. Without loss of generality, a portfolio return takes the following form:⁷

$$r_{t+1}^e = b\lambda^2 + b\lambda\varepsilon_{t+1} + \sigma\nu_{t+1}, \quad (8)$$

with b and σ being free parameters. Plugging into the preferences and taking first order condition, we find the optimal loadings: $b^* = 1/\gamma$ and $\sigma^* = 0$.

⁷For convenience of exposition, we ignore the Jensen terms due to taking log returns. Appendix A details this approximation.

For the target we denote $b = b_i$ and $\sigma = \sigma_i$. We can then compute the difference in utilities for the period of the investment, T ,

$$U^{(i)} - U^* = \sum_{t=0}^{T-1} \beta^t \left(-\frac{\gamma}{2} (b_i - b^*)^2 \lambda^2 - \frac{\gamma}{2} \sigma_i^2 \right) \leq 0. \quad (9)$$

The acquirer does not want to deviate from her optimal portfolio at market prices because she has to take on both excess systematic risk and excess idiosyncratic risk. This distaste is measured by the deviation of the target's risk from the optimum multiplied by the risk aversion. The acquirer will only buy the assets at a discount that provides the extra returns needed to compensate her for the utility loss.

We introduce a market portfolio for which $b = b_m$ and $\sigma = 0$. To simplify, we assume the preferences of the acquirer are such that her optimal portfolio is the market. This corresponds to the restriction $\gamma = \mathbb{E}[r_m^e] / \sigma_m^2$. The illiquidity discount behaves similarly for other target portfolios. The parameter γ should not necessarily be interpreted as a preference parameter *stricto sensu* but rather as a way to calibrate the target portfolio of the fund and its risk-return tradeoff.

This analysis leads to an exact formula for the illiquidity channel and the following comparative statics.

Proposition 2. Illiquidity channel: *The log difference between the price the acquirer is willing to pay and the price on public markets for a firm without agency costs is:*

$$\log \left(\frac{P_0^{acq}}{P_0^{pub}} \right) = -\frac{T}{2} \left((\beta_i - 1)^2 \mathbb{E}[r_{m,t+1}^e] + \gamma \sigma_i^2 \right) < 0. \quad (10)$$

It is:

- i. decreasing in the risk premium $\mathbb{E}[r_{m,t+1}^e]$,*
- ii. independent of the risk-free rate r_f ,*
- iii. decreasing in the exposure β_i , if $\beta_i > 1$,*
- iv. decreasing in idiosyncratic volatility σ_i .*

These results correspond to risk factors that decrease the acquirer’s willingness to deviate from her optimal portfolio. The prediction for β_i is not monotone, as investors dislike deviations in systematic risk. We focus on the empirically relevant case where the illiquid portfolio involves excess systematic risk. Note that the independence from the risk-free rate provides us an exclusion restriction which allows us to identify the cash-flow channel from the illiquidity channel in the data.

We assume the acquirer cannot smooth returns by saving or hedging. This assumption simplifies the analysis as her wealth process has a simple evolution. However, it increases the illiquidity cost of the position. The key determinants of the acquirer’s choice are not affected. The parameter α provides some control on the degree of illiquidity required by the deal. In our empirical analysis, we do not take a stand on the value of α and let the data inform us on the importance of illiquidity costs in the buyout decision.

We abstract from the precise structure of financial contracts to clarify the exposition of the model. When using structural restrictions in Section 4, we take the distinction between debt and equity into account. In particular, the leverage of the equity position is a key source of illiquidity risk for the fund. However, it is important to notice that we do not assume any differential pricing of debt and equity in public markets — diversified investors use the same stochastic discount factor to value all claims. Consequently, there are no periods where debt is ‘cheap’ relative to equity in the model.

2.4 Summary

Before moving on to the empirical analysis of buyout waves, we summarize the qualitative predictions of the model. To do so, we gather the predictions from Propositions 1 and 2. Over time, we should observe more buyout transactions in times of *low* expected excess returns and *high* risk-free rates. The dependence on the risk-free rate comes solely from the cash-flow channel whereas the dependence on the risk premium comes via both channels. During periods of a high risk premium, buyouts do not create as much value relative to the public market alternative and acquirers are less willing to transact. Synchronization between the two channels can account for the dramatic booms and busts inactivity.

In the cross-section of targets, our model generates novel predictions as well. Firms with higher idiosyncratic risk are less likely to be targets of buyouts, as acquirers do not want to carry idiosyncratic risk in their portfolio while public market investors are indifferent. Similarly, firms with high systematic risk require an illiquidity discount, but with an additional consideration that the potential cash-flow gain is discounted at higher rates than firms with low systematic risk.

3 Reduced form results

We test the predictions by examining the reduced form relationships between buyouts, discount rates, and firm risk. We estimate these relationships on aggregate and in a panel of firms controlling for other factors.

3.1 The role of discount rates

We begin by considering the relation between discount rates and deal activity. As outlined above, a firm's deal surplus should negatively co-vary with the risk premium and positively co-vary with the risk-free rate in the time-series. This covariation is common to all potential targets so we expect it to be reflected in aggregate activity.

3.1.1 Data

Our sample of U.S. buyouts comes from Thomson Reuters SDC (SDC). We select completed transactions where public targets were 100% purchased by private acquirers and the acquisition is made for investment purposes, see Appendix B.1 for details. The bulk of our sample is explicitly labeled as a leveraged or management buyout. Deal announcements date the timing of a transaction. We begin our period of analysis in the fourth quarter of 1982, as activity is extremely limited prior to this quarter. The resulting sample of buyouts includes 1,143 deals between 1982Q4 and 2011Q4.

Given the model is agnostic on firm size, our preferred metric for deal activity is volume. For each quarter, we scale the volume of deals by the number of public firms in Compustat (*Volume %*). We also report results for value, where *Value %* is the sum of deal equity values scaled by the sum of public market capitalizations. In order to minimize the importance of extremely large deals on the series, we exclude mega-deals from the measure of value.⁸

We proxy for components of the aggregate discount rate using the real risk-free rate and estimates of expected excess returns. We choose the real rate as it is a more stationary process and more consistent with our focus on real quantities in the model. The real risk-

⁸We define mega-deals as those deals representing greater than 2.5bps of aggregate market capitalization or \$4.6bn in 2010. This excludes 93 deals, or < 10% of the sample, that primarily occur in the late 1980s and the mid 2000s.

free rate (r_f) is the annual yield on the three-month treasury bill less three-month inflation expectations estimated by the Federal Reserve Bank of Cleveland (Haubrich et al., 2012). We estimate expected returns by predicting the annualized excess return on the value-weight market portfolio over the next three years ($R_{M,t+1}^e$) using three factors: the dividend-price ratio, cay , and the term premium. Each of these factors have been shown to predict excess returns.⁹ We use a three-year window to mirror the longer term nature of these investments.¹⁰ The prediction regression is estimated quarterly from 1965Q2 to 2009Q2 and yields the following,

$$\mathbb{E}(R_{M,t+1}^e) = -5.74 + \underset{(2.68)}{0.92(D/P)_t} + \underset{(2.43)}{0.63cay_t} + \underset{(1.70)}{0.87(Term\ Premium)_t}. \quad (11)$$

We use this predicted value as a proxy for the expected excess returns (i.e. risk premium) in the economy, \hat{r}^p .

Table 1 summarizes the aggregate variables. On average there are 9.8 deals per quarter. This level of activity corresponds to 0.19% of public firms going-private each quarter. The average value of these deals is \$3.7bn in 2010 dollars while the median deal is \$793m. The average real risk-free rate in our sample is 1.4% and the average annual risk premium is 5.4%. Figure 1 illustrates the variation in the time series. Discount rates appear to co-vary strongly with a number of booms and busts. The dearth of activity in the early 1990's corresponds to a high risk premium and low real rates. The spikes in activity around 2000 and 2007 correspond to periods of lower expected returns and high risk-free rates. Finally, the modest rebound in volume in 2010 matches the rebound in the returns. The one boom that does not as cleanly correspond to either of these two factors is the late 1980s. We discuss this

⁹ D/P : Campbell and Shiller (1988), Fama and French (1988), Cochrane (2008); cay : Lettau and Ludvigson (2001); Term structure of interest rates: Campbell (1987), Fama and French (1989).

¹⁰In unreported analysis we find our results are similar across longer/shorter horizons.

divergence further in Section 4.2.3.

In addition to our discount rate proxies, we consider several credit market controls other researchers have emphasized as important to explaining buyout activity and that may be correlated with changes in aggregate rates. Axelson et al. (2013) find that the yield on the Merrill Lynch High Yield Index less LIBOR is correlated with leveraged buyout EV/EBITDA ratios. We construct a similar measure that covers the entire length of our sample using a composite of yields from various high-yield bond indices less the yield on the three month T-bill (*HY Spread*). We also measure aggregate market leverage, *Leverage*, as the ratio of total debt to total market capitalization for Compustat firms. Finally, Kaplan and Strömberg (2009) suggest firms' ability to finance profitably with high-yield debt is an important condition for activity. We construct a similar measure to the one they propose, the median EV/EBITDA ratio for COMPUSTAT firms less the yield on our composite high yield bond index. Statistics for these variables are summarized in Table 1.

3.1.2 Analysis

Measures of activity are censored at zero; therefore, we use a Tobit model in our preferred specification to estimate the relationship between activity and discount rates,

$$\begin{aligned}
 Activity_t^* &= \alpha + \lambda_{rf}r_{f,t} + \lambda_{rp}\hat{r}p_t + \gamma'\mathbf{Controls}_t + u_t & (12) \\
 Activity_t &= \begin{cases} Activity_t^* & Activity_t^* > 0 \\ 0 & Activity_t^* \leq 0 \end{cases} .
 \end{aligned}$$

We include a dummy variable for the first quarter to account for deal seasonality. Given the persistence of independent variables, we estimate Newey-West standard errors lagged for the

prior 12 quarters.

The Tobit estimation results are displayed in Table 2. When we consider volume, we find the coefficient on the risk-free rate is positive and the coefficient on the risk premium is negative, Column (1). Both are significant at the 1% level. The discount rate components do not appear to be proxying for credit factors, as the results are robust to including the high yield spread, (2), aggregate market leverage, (3), the median EBITDA/EV less the yield on high-yield bond index, (4), or all three credit market controls, (5). The economic magnitude is meaningful. Based on specification (5), a one standard deviation increase in the risk-free rate increases deal activity by roughly 22% and a one standard deviation rise in the risk premium decreases deal activity by 41% on average. We find similar statistical significance using the value measure of activity, Column (6), though the magnitude of the sensitivity to the risk premium is smaller.

Robustness These relationships are robust to a number of alternative specifications (see Appendix B.2). The pattern of coefficients is largely repeated within industries (Table 8) and is robust to alternative proxies for the risk premium (Table 9).¹¹ We also repeat the analysis using OLS (Table 10). One advantage of the linear specification is it allows us to quantify the degree to which our aggregate factors explain quarterly variation in activity. The R -squared for the regression of volume activity on the risk-free rate and risk premium is 30.5%. The addition of the credit market factors increases the R -squared to 36.2% suggesting that the predicted variation is predominantly explained by aggregate discount rates.

If firm types co-vary with the discount rate, our results may capture underlying trends in firm characteristics that impact their likelihood to do a deal. To address this concern, we

¹¹We consider rolling estimates, estimates *excluding* the quarter of buyout activity in the dependent variable, and estimates excluding the term premium as a factor to minimize any influence from credit markets.

repeat the analysis in a panel of firms, allowing us to control for changes in key characteristics over time. In brief, we find similar significance and magnitude when controlling for firm characteristics (Table 11). The details of the panel data are discussed in the next section.

3.2 The role of risk characteristics

In addition to the time-series predictions related to discount rates, the model makes cross-sectional predictions related to firms' risks. Riskier firms are relatively more costly to potential investors and therefore less likely to be targeted. Greater systematic risk decreases the surplus via both channels, while idiosyncratic risk increases the cost of a deal to private investors via the illiquidity channel.

3.2.1 Data

We construct a quarterly panel of U.S. public companies using annual accounting data from Compustat and quarterly share price information from CRSP. As we are looking to exploit accounting data, we exclude the financial industry as defined by the Fama-French 12 classification. Once a firm announces a buyout they exit the sample.¹² The resulting unbalanced panel of 501,176 firm-quarters tracks 14,386 unique firms over 117 quarters and contains 1,048 deal firm-quarters, where a deal firm-quarter is defined as the firm-quarter preceding a buyout announcement.

We use this panel to consider cross-sectional predictions related to the risk characteristics of firms' dividend processes. The model predicts that firms with greater volatility will be less attractive targets. We proxy for volatility using the monthly return volatility over the past two years, $\sigma(R^e)$, as well as an accounting based metric, the standard deviation

¹²Bias resulting from the exit of buyout firms is small given the the low number of deals relative to the number of public firms.

of free cash flow, $\sigma(FCF/Assets)$. The model ascribes different roles to systematic and idiosyncratic risk. Empirically, it is difficult to observe the parameters for firms' cash-flow processes; however, we can estimate the market regression to calculate market beta, β , and the residual, $\sigma(\varepsilon)$, as proxies for systematic and idiosyncratic risk. We calculate market beta for each firm i using OLS.

$$R_{it}^e = \alpha_i + \beta_i^M R_{Mt}^e + \varepsilon_{it} \quad (13)$$

R_{it}^e is the monthly excess return for firm i and R_{Mt}^e is the excess monthly market return on the value-weight portfolio. β_i^M is estimated using the trailing two years of monthly returns.

Table 3 compares the full panel of firm-quarters to deal firm-quarters. The summary statistics for the risk proxies demonstrate that the average buyout has lower risk across each of the measures. We also consider several firm characteristics that Opler and Titman (1993), and more recently Bharath and Dittmar (2010), identify as empirically important to explaining which types of firms are bought out or go-private: cash-flow ($FCF/Assets$), capital intensity ($CapEx/Sales$), costs of financial distress ($R\&D/Sales$), liquidity ($Turnover$), payout policy ($Dividend Dummy$), and net leverage ($Net Debt/Assets$).¹³ In addition we control for firm size ($\log(Assets)$). The summary table is consistent with prior findings; deal firms are more profitable, spend less on capital expenditures and research and development, are less liquid and have higher net debt than the average public firm.

¹³We also note the book-to-market of firms, although this is not a factor in our analysis, as it is a pricing factor. In unreported results we find our conclusions are robust to this additional control, but this is not our preferred specification.

3.2.2 Analysis

We cannot observe individual firm surpluses, but the likelihood of a firm being a target is increasing in this ratio. Therefore we use a dummy variable equal to one for the firm-quarter preceding a deal announcement and estimate the likelihood of a firm going private via pooled Probit conditional on firm risk factors and controls,

$$\mathbb{P}(Deal_{it}|\beta_{it}, \sigma(\varepsilon)_{it}, \mathbf{Controls}_{it}) = \Phi(\alpha + \lambda_{\beta}\beta_{it} + \lambda_{\sigma}\sigma(\varepsilon)_{it} + \gamma'\mathbf{Controls}_{it} + \varepsilon_{it}). \quad (14)$$

The set of controls includes the firm level variables discussed above. The risk characteristics exhibit time-variation and this variation may be correlated with other factors, particularly discount rates. Therefore, we also include time fixed effects to focus the analysis on cross-sectional differences between firms rather than time-series differences in firm risk estimates. Standard errors are clustered in two dimensions, by firm and by quarter.

Table 4 summarizes the Probit results. Consistent with the aggregate estimates for the role of discount rates, Column (1) demonstrates that even when controlling for firm characteristics, credit market factors, and industry fixed effects, deal likelihood is increasing in the risk-free rate and decreasing with the risk premium. We also find that deal likelihood is sensitive to firm risk factors. Columns (2)-(9) summarize the role of firm risk characteristics, (2)-(5) include quarter fixed effects and (6)-(9) consider accounting based controls. Both stock return volatility and cash-flow volatility decrease the likelihood of a deal, (2) and (3), even when controlling for other factors, (6) and (7), at the 1% significance level. Market beta and idiosyncratic risk decrease the likelihood of a deal in both specifications at the 1% and 5% significance levels respectively, Columns (4) and (8). Finally we consider unlevered

measures of these risk factors, as the model considers total firm risk.¹⁴ The likelihood of a buyout is decreasing in both unlevered risk measures at the 1% significance level, Columns (5) and (9).

Robustness Fixed effects in Probit models can bias results (Neyman and Scott, 1948), therefore we verify our findings in both logit and a linear probability specifications. We also consider a matched sample of firms that resembles the sample of buyout firms based on our set of controls and Fama-French 12 industry fixed effects. We estimate propensity scores and select a sample of nearest-neighbor firm-quarters within each quarter. Repeating the analysis in this subset of firms generates similar results, albeit at weaker significance levels (10%). These results can be found in Appendix B.3.

4 Structural approach

The reduced-form results demonstrate a key role for discount rates and risk factors. In this section, we use structural restrictions implied by the model to quantify the correlation between activity and discount rates into either the cash-flow or illiquidity channels. This approach allows us to discern the relative importance of these two mechanisms in generating waves of activity.

4.1 Model restrictions

To estimate the quantitative role of the two channels we use a sufficient statistic approach, focusing only on distinguishing the two channels rather than recovering specific parameter

¹⁴Both β and $\sigma(\varepsilon)$ are unlevered by rescaling by $\frac{1}{1+(1-\tau)*\frac{Debt}{Mkt\ Cap}}$ where we assume of $\tau = 35\%$.

values. It allows us to be robust to a large class of model mis-specifications at the cost of being able to extract less information.

4.1.1 Assumptions and estimation methodology

We start from the model of Section 2 and show how we can build up relations to estimate in the data. Recall the buyout decision depends on the deal surplus which can be decomposed into the cash-flow channel and the illiquidity channel. From Proposition 1, a sufficient statistic for the role of pricing variables in the cash-flow channel is:

$$C = -\beta_i \mathbb{E}[R_m^e] + r_f(\phi - 1). \quad (15)$$

This expression is the opposite of the growth-adjusted discount rate. Similarly, for the illiquidity term, pricing variables enter in the form:

$$I = -(\beta_i - 1)^2 \mathbb{E}[R_m^e] - \gamma \sigma^2. \quad (16)$$

We interpret this term as a measure of the cost of deviating from the optimal portfolio. Including the other parameters, the model predicts the deal surplus is an increasing function of C and I :

$$\log(P_0^{pr}) - \log(P_d^{pub}) = f(C, I) \quad (17)$$

As C increases, the growth adjusted discount rate declines and the value of the cash-flow gain increases. As I increases the cost of illiquidity approaches zero. This formulation only relies on two parameters: the growth multiplier ϕ and the risk aversion γ .

We can account for firm characteristics, X_{it} , by adding additional controls to this function.

To identify these relations in the presence of unobserved sources of heterogeneity, we need the additional heterogeneity to be orthogonal to the pricing variables. The buyout market structure (e.g. how do acquirers and targets meet) is an additional layer in going from deal surplus to deal probability. Again, we assume that pricing variables do not affect deal likelihood beyond their effect on the deal surplus. Further, we assume that any unobserved factor affecting the market structure is orthogonal to the pricing variables.

Under these assumptions, the relation we want to estimate is the probability of a deal as a function of the cash-flow and illiquidity channels,

$$\mathbb{P}(Deal_{it}) = F(C_{it}, I_{it}, X_{it}). \quad (18)$$

Our reduced-form estimations correspond to a similar exercise,

$$\mathbb{P}(Deal_{it}) = G(\beta_{it}, \sigma_{it}, \mathbb{E}[R_m^e]_t, r_{f,t}, X_{it}). \quad (19)$$

If we linearize both functional forms inside a Probit and specify ϕ and γ , we can retrieve the role of the cash-flow channel and the illiquidity channel (Equation (18)) from the reduced form estimates (Equation (19)).¹⁵ We estimate $\phi = 3.2$ by regressing firm EBITDA growth on the risk-free rate in our panel. Recall we calibrate γ such that the acquirers' optimal portfolio is the market. Using our sample we obtain $\gamma = \mathbb{E}[r_m^e]/\sigma_m^2 = 2.4$.

In the time series, the coefficient on the risk-free rate identifies the sensitivity to the cash-flow channel while the coefficient on the risk premium contains the impact of both channels, as the risk premium impacts both valuation ratios. This arrangement corresponds

¹⁵Appendix C contains a special case where we completely specify the model to obtain Probit estimation equations. We also detail the estimation equations and make explicit how to recover the structural coefficients.

to a triangular linear system of two equations in two unknowns. Using the risk-free rate coefficient and ϕ , we can adjust the risk premium coefficient to determine the role of the illiquidity channel. This procedure only relies on the reduced form discount rate estimates, Table 4, Column (1). The cross-sectional estimates, based on firm risk factors, provide a second path to disentangle the two channels, Column(9). The coefficient on idiosyncratic volatility solely corresponds to the illiquidity channel. Adjusting for illiquidity and γ , the coefficient on market beta provides the effect of a change in the cash-flow channel.

4.1.2 Additional model features

Before turning to the results, we introduce two institutional features that impact the illiquidity cost to private equity investors. Equity investors' illiquidity is most impacted by the public to private transaction, therefore we adjust the model to reflect leverage and to account for their partial diversification.

A private equity investor typically borrows against the value of the target.¹⁶ We introduce a leverage parameter ℓ to reflect this in our estimation. We assume the illiquid claim to the firm assets is a levered claim with leverage ℓ . To match the typical structure of such a deal, we choose $\ell = 2$, which corresponds to 60% debt and 40% equity.¹⁷ Leverage does not affect the calculation of the cash-flow channel as we do not assume any default friction. The cash-flow channel is a calculation for the whole firm in a Modigliani-Miller world so capital structure is irrelevant. For the illiquidity channel, the cost of deviating from the portfolio

¹⁶There are several reasons for this, including the disciplining benefits of debt and the ability of leverage to concentrate equity ownership thereby mitigating agency problems.

¹⁷In a sample of international buyouts from 1980-2008 Axelson et al. (2013) find the average LBO in their sample has a Debt/Enterprise Value of .69 which implies a ℓ of 2.4. Similarly, Guo et al. (2011) observe a D/EV ratio of 0.70. However both samples are biased toward larger, more leveraged deals.

becomes,

$$I = -(\ell\beta_i - 1)^2\mathbb{E}[R^e] - \gamma\ell^2\sigma^2. \quad (20)$$

Leverage scales up both the idiosyncratic and the systematic risk borne by the acquirer. Notice, it is important to use the unlevered beta coefficients, and not the pre-buyout equity beta.

The second feature is the partial diversification of the acquirer. Again, this feature has no impact on the cash-flow channel calculation. For the illiquidity channel, we can directly include the number N of targets:

$$I = -(\ell\beta_i - 1)^2\mathbb{E}[R^e] - \gamma\frac{1}{N}\ell^2\sigma^2. \quad (21)$$

Underlying this result, we assume that idiosyncratic risk is independent across targets and that systematic exposures are identical. Private equity investors range from almost completely undiversified (management) to well diversified (LPs). We choose to focus on the somewhat diversified GPs and management; both are integral to the investment decision and sensitive to illiquidity. For our estimation we assume $N = 4$.

4.2 Structural results

We turn to the results of the structural estimation. We first present estimates for the deal likelihood sensitivity to the sufficient statistics C and I . We can compare the sensitivities implied by the time-series and cross-sectional variables. Then we use the results to break down the impact of the discount rate changes into the two channels. Finally, we decompose the variation over time to illustrate the co-movement of the channels during peak deal periods. Keep in mind, we are not running a structural test of the model. We are taking the

model as given, and using restrictions implied by the model to interpret our reduced-form empirical results.

4.2.1 Structural coefficients

The parameter choices, ϕ and γ , and the panel Probit results in Table 4 are sufficient to recover the structural effects. We obtain two sets of estimates for the impact of the structural quantities C and I on deal likelihood, Equation (18)). The first uses the time-series coefficients on r_f and $\hat{r}p$. The second uses cross-sectional coefficients β and $\sigma(\varepsilon)$. These estimates allow us to compare the implied sensitivity of deals to the time-series and cross-sectional variables. Using the time-series, we find coefficients of 1.59 on cash-flow, C , and of 1.21 on illiquidity, I . The cross-sectional estimates are 0.63 and 0.17, respectively.¹⁸

Relative to the model's predictions, buyout likelihood is less sensitive to cross-sectional variables than time-series variables. The difference is strongest for the illiquidity channel. Recall the sensitivity to illiquidity in the cross-section is identified using the sensitivity to idiosyncratic risk. This suggests that idiosyncratic risk is not a large economic determinant in the buyout decision. One potential explanation is that private equity funds and their investors are more diversified than we assume. Another possibility is that our proxies for risk are noisy measures, attenuating the estimated effect.

4.2.2 Decomposition

In the panel Probits, a one standard deviation increase in the risk premium corresponds to a 56% reduction in buyout likelihood. For the risk-free rate, a one standard deviation increase raises buyout likelihood by 22%. Aggregating across firms, we can compare these changes

¹⁸In the time-series the standard error is 0.42 for C and 0.86 for I . In the cross-section, 0.32 for C and 0.053 for I .

in likelihood to changes in aggregate activity, i.e. the percentage of firms that do a deal.¹⁹ Using the structural coefficients, we can ascribe these changes to each of the two channels. We detail the results of this exercise in Table 5. The model attributes all of the effect of a change in the risk-free rate to the cash-flow channel. The risk premium impacts activity through both channels. Based on the time-series estimates, we find the cash-flow channel accounts for 67% of the risk premium’s negative effect on activity and the illiquidity channel 33%.

We can perform a similar decomposition in the cross-section. Changes in deal likelihood related to idiosyncratic volatility are only attributed to the illiquidity channel. Exposure to systematic risk flows through both channels. According to our cross-sectional estimates, the lower likelihood of a deal for high beta firms is 61% due to the cash-flow channel and 39% due to the illiquidity channel. Both decompositions suggest a greater role for the cash-flow channel in explaining fluctuations in activity, though both channels are important.

4.2.3 Explaining the waves

To emphasize the quantitative role of the two channels, we present a counterfactual exercise. What would the fluctuation in buyout activity be if only one of the two channels was at play? This is not a policy exercise, but rather an economic decomposition that allows us to characterize the relative importance of each channel over time.

To produce the two counterfactual activity series, we compute the series of C_t and I_t based on the structural coefficients and time-variation in the pricing factors. To obtain cash-flow channel fluctuations, we plug C_t and \bar{I} , the empirical average of I_t , into Equation (18). We repeat this exercise to estimate fluctuations for the illiquidity channel. We show the

¹⁹These magnitudes are quite similar to the aggregate estimates based on the Tobit results of 41% for the risk premium and 22% for the risk-free rate.

two counterfactual series as well as the true deal activity in Figure 3. The figure illustrates the the cash-flow channel is a larger source of fluctuation than the illiquidity channel. Low illiquidity constitutes a larger part of the explanation for the buyout wave of the late nineties. Conversely, the peak in 2007 was primarily due to the cash-flow channel, as this is a period of low risk premium and the risk premium has a larger impact via the cash-flow channel.

To understand the overall successes and limitations of the model, we plot the predicted activity against the data in Figure 4. We see the model captures the last three waves of buyouts, the late 1990s, 2005-2007 and 2011, as well as the dearth of activity in the early- to mid-90s. The latest spurt of buyout activity corresponds to the time period after the end of the financial crisis of 2007-09 but before the European debt crisis had reached its peak. During this period of relative stability, financial markets recovered largely from the crisis and risk premia were low. Our model predicts that these are favorable conditions for the emergence of buyout activity and indeed we saw an increase in deal volume.

The most significant failure of the predicted series is the first buyout wave of the 1980s. Even if the model predicts more buyouts in this period than in subsequent years, it fails to capture the intensity of the boom. This was a period of significant institutional change during which buyout funds and high yield bonds emerged and proliferated. This bolus of activity could simply reflect a pent-up inventory of high-surplus deals that were executed as the buyout market matured. As this result emphasizes, we cannot claim that buyout activity is completely explained by fluctuations in aggregate pricing conditions. However, it should be clear that pricing conditions on their own can explain a large fraction of variation in activity.

Our two-sided mechanism can help explain the extreme cyclicity of buyout activity. As the two channels are strongly positively correlated, the total variance in activity is much

larger than when considering each channel independently. Changes in pricing factors can simultaneously increase the value of a target and decrease acquirer’s perceived costs. We can decompose the explained variance in buyout activity into each channel and the covariance term and obtain,

$$\text{var}[Activity] = \underbrace{\text{var}[Cash-Flow]}_{48\%} + \underbrace{\text{var}[Illiquidity]}_{13\%} + \underbrace{2\text{cov}[Cash-Flow, Illiquidity]}_{39\%}. \quad (22)$$

Even though the variance explained by the illiquidity channel is less than a third of that explained by the cash-flow channel alone (13% versus 48%), its presence doubles the total variance of buyout activity.

5 Further evidence

In this section we present further evidence that the cash-flow and liquidity channels are important mechanisms by which aggregate discount rates influence buyout activity. We first show additional comparative statics of the model specific to each channel. We consider cross-sectional differences in agency costs, which impact the cash-flow channel, and in illiquidity duration, which impacts the illiquidity channel. We cannot directly observe these parameters so we focus on reduced-form tests using proxies.

5.1 Cash-flow channel

To exemplify the role of the cash-flow channel, we look across firm types for a heterogeneous response to aggregate conditions. Going back to the model of section 2, we know the risk-free rate only affects deal likelihood through the cash-flow channel. Additionally, the lost growth

through agency costs, d , only enters the price comparison through the cash-flow channel. It is immediate to see that firms with larger agency costs gain more from being bought out. The following proposition provides us with a clear prediction of the interaction of agency costs with the risk free rate.

Proposition 3. *The log difference between the price on public markets of a firm with and without agency costs:*

i. is increasing in d ,

ii. has a positive cross derivative as a function of d and r_f :

$$\frac{\partial^2}{\partial d \partial r_f} \left(\frac{P_0^{pub}}{P_d^{pub}} \right) > 0. \quad (23)$$

In other words, firms with higher agency costs are more sensitive to the risk-free rate. The intuition for this result is the same as the direct effect; higher agency costs impact a larger fraction of firm value when the growth-adjusted discount rate is low.

We use three proxies for the agency costs of a firm. The first two are based on the the free-cash flow (FCF) hypothesis (Jensen, 1986), which states that managers with more free-cash flow will invest it in negative net present value projects. We measure firms' exposure to the free-cash flow problem using the FCF/Assets of the firm and a more upstream measure that precedes many investment decisions, EBITDA/Assets. The third proxy is based on the Governance Index of Gompers et al. (2003). The index uses a firm's governance rules to proxy for shareholder rights. We generate a dummy variable, GIM , equal to one if a firm is in the weakest third based on this metric in a given year. Unfortunately this metric is only available for a subset of larger firms beginning in 1990.

We estimate Probits of deal likelihood on the discount rate components, the interaction of the risk-free rate and the agency proxy, the firm controls from earlier and industry fixed effects. In this context, interaction effects cannot be directly interpreted into changes in likelihood, but in our framework the likelihood score is actually the object of interest. The results of this estimation can be found in Table 6. We find that the coefficient on the risk-free rate is heterogenous and increasing with both FCF and EBITDA, Columns (1) and (2). Those firms with greater potential for diversion have a higher likelihood score when the risk-free rate is high. In addition, we find those firms with worse corporate governance as measured by the Governance Index are also more sensitive to changes in the risk-free rate. These correlations are consistent with our description of the cash-flow mechanism. The findings are significant at 5% significance levels and are robust to a logit specification or the use of a matched sub-sample of firm-quarters (Appendix D).

5.2 Illiquidity channel

We can also show evidence of the illiquidity channel. Acquirers are more reluctant to invest in firms with a higher duration of illiquidity. We are interested in the differential sensitivity of firms with various T to the risk premium. The time T during which the firm's ownership is illiquid has no impact on the cash-flow channel so long as we believe the aggregate cash-flow gains are independent from their ease of exit. We obtain the relevant comparative statics in the following proposition.

Proposition 4. *The log difference between the price the acquirer is willing to pay and the price on public markets a of a firm without agency costs:*

- i. is decreasing in the illiquidity duration T ,*

ii. has a negative cross derivative with a function of T and $\mathbb{E}[r_m^e]$

$$\frac{\partial^2}{\partial T \partial \mathbb{E}[r_m^e]} \log \left(\frac{P_0^{acq}}{P_0^{pub}} \right) < 0. \quad (24)$$

Firms with higher illiquidity duration T are more sensitive to the risk premium than their more liquid counterparts. Again, the intuition is the same as the direct effect, as the illiquidity cost is exactly the product of the per-period cost of deviating from the optimal portfolio and the duration of illiquidity.

We develop several proxies for the duration of investment using industry differences in the liquidity of assets. We consider the volume and value of M&A and IPO activity to proxy for the ease with which assets in a particular industry are traded. Using data from Thomson SDC we compile a list of all reported value, completed M&A transactions and a list of IPOs. We organize this activity into Fama-French 48 industry classifications and scale the number of deals by the the number of public firms in the industry. Similarly, we scale the enterprise value of activity by the enterprise value of public firms in the industry. We create three-year moving averages for the measures of activity, as we want to estimate persistent measures of liquidity within industries.

We estimate Probits of deal likelihood on the discount rate components, the interaction of the risk premium and the duration proxy, the firm controls from earlier and industry fixed effects. Again, the impact to likelihood score is the object of interest. The results of this estimation can be found in Table 7. The sensitivity of the score to the risk premium is decreasing with the volume measures of activity, (1) and (3), and the value measures of activity, (2) and (4)); however only the former pair is statistically significant (5% level). Firms in industries with more M&A deals or more IPOs are less sensitive to variation in the

risk premium. This is consistent with the model in which sensitivity to the risk premium is increasing with the duration of the investment. The results are similar in a logit specification or in a matched sample (Appendix D).

5.3 Other predictions

In the model buyout activity reflects agents' beliefs regarding expected returns in the economy, therefore buyout activity should predict future stock returns. A monthly regression of annualized returns for the next three years on the volume measure of buyout activity from 9/1982 to 6/2009 yields,²⁰

$$R_{M,t+1}^e = 10.61 + \underset{(0.27)}{-0.72}(\text{Volume}\%_t) + \varepsilon_{t+1}. \quad (25)$$

While not surprising given the earlier results, it is worth noting that at a monthly frequency buyout activity has statistically significant predictive power on long term stock market returns.

The model also predicts return patterns for buyout investors. An observable analog are private equity funds. First, funds should outperform public markets, as some portion of the investors must be compensated for their liquidity risk. Second, peak deal activity will be associated with lower returns as it corresponds to periods of low risk premia and vice versa. Recent work suggests both these implications are reflected in the data. Buyout fund returns outperform the market in both up and down markets, as cataloged using data based on a large LP's portfolio (Robinson and Sensoy, 2011) and an aggregator of fund returns (Harris et al., 2012)). In addition, these two papers observe cyclical patterns in PE returns;

²⁰The standard errors are Newey-West with autocorrelation over the prior 36 months and the R -squared is 0.13.

investments in ‘hot’ deal markets suffer from lower returns, consistent with our prediction. This result also helps to assuage concerns that boom markets are simply a sign of greater opportunities for PE funds (higher d , or lower cost of credit), as the returns to investments at these times in fact look lower than at other times. A fundamental force impacting all investors, like the discount rate, is critical to rationalizing these observed patterns.

6 Final remarks

In this paper, we show that a parsimonious model of buyouts focused on the role of discount rates can explain large variations in buyout activity. We rely on two channels that interact with aggregate rates. The first channel drives time variation in the supply of buyout-worthy firms by varying the present value of cash-flow gains. The second channel impacts the buyout investors’ demand by varying their willingness to invest in illiquid assets. A particular novelty of this approach is it holistically models the buyout market by considering the acquirer’s and the target’s relative valuations.

We document empirical evidence consistent with the model’s predictions. The risk premium and risk-free rate are respectively negatively and positively correlated with buyout activity. In the cross-section, firm risk characteristics impact buyout likelihood. Using structural restriction from the model we decompose the explained variation into our two channels. We find the coincidence of the channels accounts for large changes in the volume of activity. This correlation is driven by the risk premium, as a decline in the risk premium simultaneously increases the present value of gains and reduces costs of illiquidity.

This paper does not argue that institutions, contracts, or capital structure are irrelevant. But it does suggest that a significant portion of extensive margin variation in buyouts can

be explained in the absence of these details. Therefore, the role of institutional factors in buyout activity need to be considered in the context of aggregate variation in discount rates.

We have limited our analysis to the discussion of public-to-private buyouts, but the channels described here can be applied to a broader swath of activities. A number of other corporate financial transactions are subject to significant swings in volume over time (e.g. mergers and acquisitions, secondary stock offerings and new business creation). Extending our analysis to these activities would help explain their joint dynamics in an integrated markets framework.

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Figure 1: Time-Series of Buyout Volume and Aggregate Discount Rates

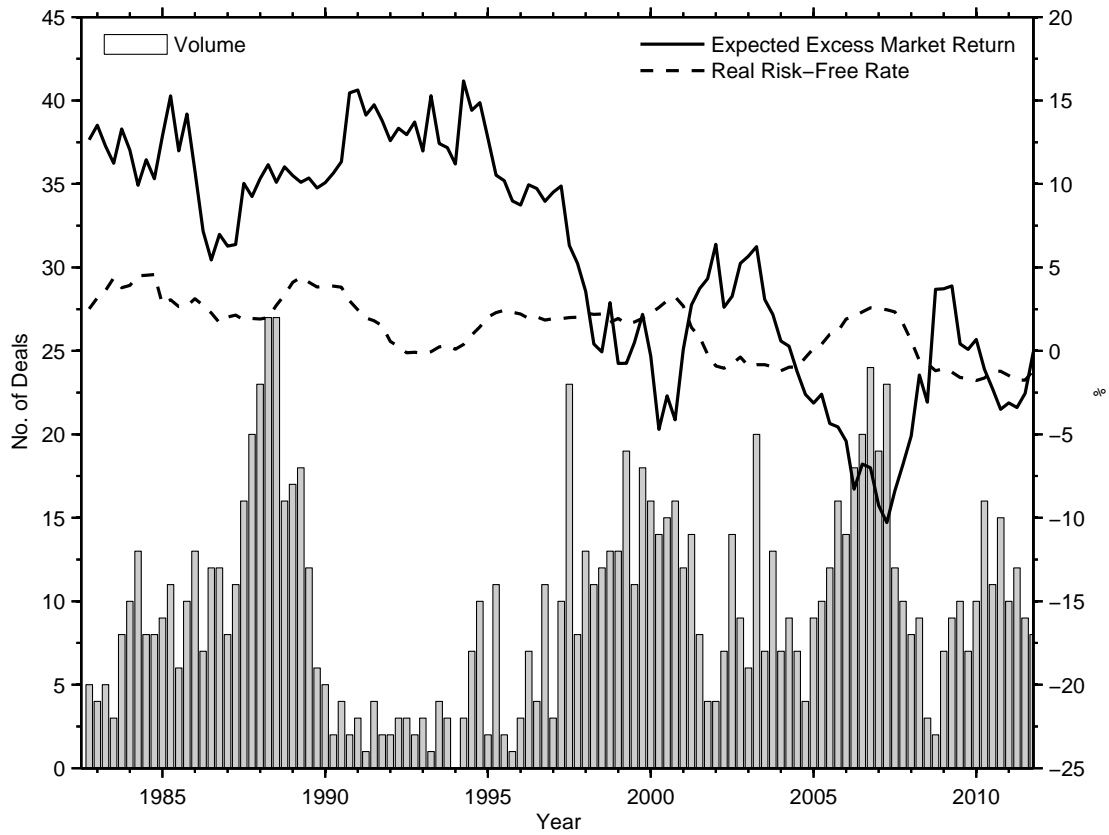


Figure 1 illustrates quarterly deal volume of buyout transactions. The real risk free-rate is the annual rate for the three month T-Bill less inflation expectations. Expected excess market returns are predicted annual returns for a three-year period using D/P , cay and the term premium.

Figure 2: Public vs. Private Ownership

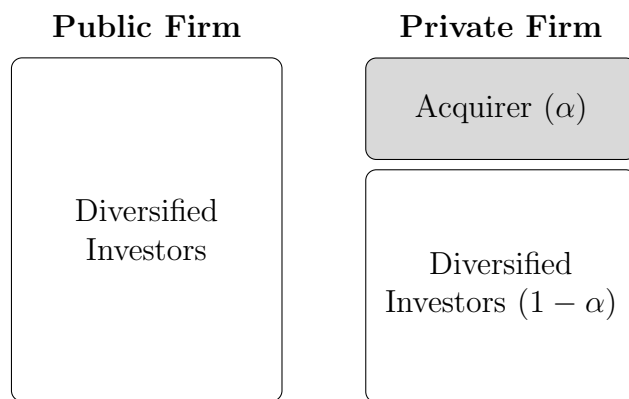


Figure 3: Cash-Flow and Illiquidity Channel Variation Over Time

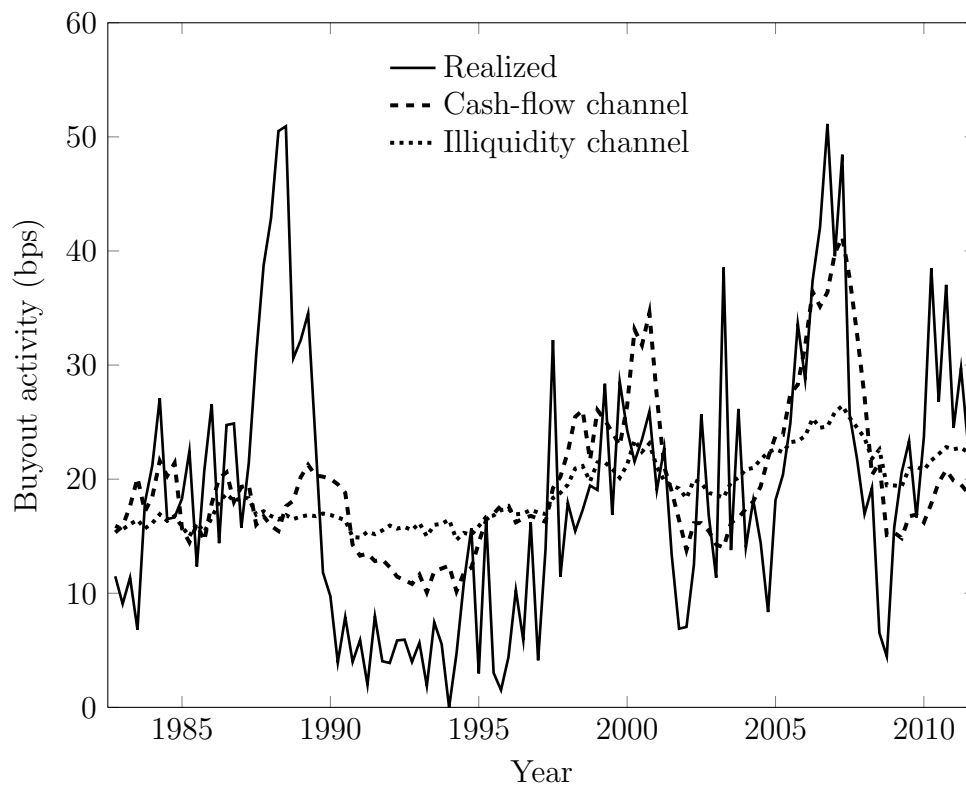


Figure 3 illustrates the estimated variation in the volume of activity for the cash-flow channel and the illiquidity channel taken independently. Volume of activity is the percentage of public firms bought out, while the predicted variation is the average expected probability of a buyout.

Figure 4: Realized vs. Predicted Deal Activity

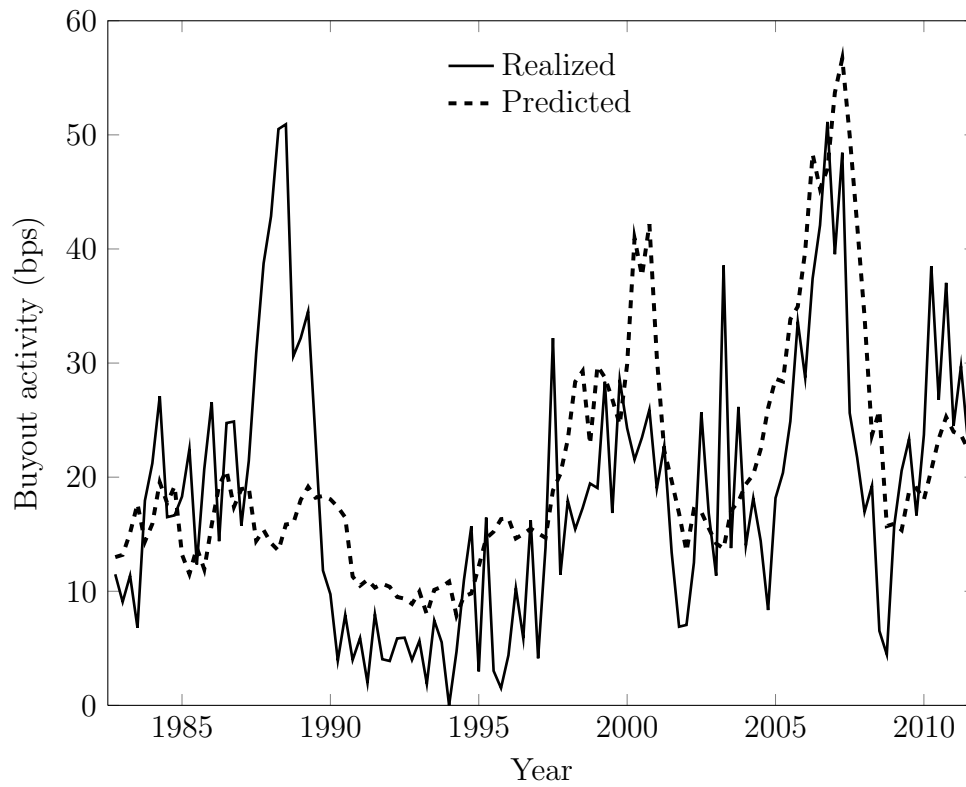


Figure 4 illustrates the predicted variation in the volume of activity versus the realized activity in the data. Volume of activity is the percentage of public firms bought out, while the predicted variation is the average expected probability of a buyout.

Table 1: Aggregate Summary Statistics

VARIABLE	Mean	Median	Max	Std. Dev.
Buyout Activity				
Volume (No. of Deals)	9.8	9.0	27.0	6.1
Volume % (bps)	18.7	17.3	51.1	11.8
Value (mm)	\$3,711	\$793	\$54,511	\$8,167
Value % (bps)	10.2	3.4	125.8	16.8
Value Excl. Mega (mm)	\$1,380	\$650	\$8,201	\$1,869
Value Excl. Mega % (bps)	3.7	2.6	16.5	3.5
Aggregate Factors				
r_f (%)	1.40	1.93	4.57	1.75
\hat{r}^p (%)	5.41	6.31	16.17	6.97
Leverage	0.69	0.68	1.21	0.14
HY Spread (%)	11.54	11.14	19.51	2.69
Median EBITDA/EV - HY	-2.20	-2.02	1.73	1.86

Table 1 contains quarterly summary statistics for buyout activity and aggregate factors for 117 quarters from 1982Q3 to 2011Q4. The value of deals is in 2010 dollars. *Volume %* is the volume of buyouts scaled by the total number of public firms in Compustat. *Value %* is value of buyouts scaled by the total market capitalization of firms in Compustat. Value measures exclude deals where the target market cap is greater than 2.5bps of the total public market cap (approx. \$4.6bn in 2010). r_f is the 3-month T-Bill less inflation expectations. \hat{r}^p is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. *Term Premium* is the yield on a 10-year treasury less the 3-month T-Bill. *HY Spread* is the yield on a composite index of high-yield bonds less the 3-month T-Bill. *Leverage* is the ratio of aggregate debt of public companies to aggregate market capitalization. *Median EBITDA/EV - HY* is the difference between the median public firm EBITDA/EV and the yield on a composite index of high-yield bonds.

Table 2: Tobit: Buyout Activity on Aggregate Discount Rates

	<i>Volume</i>					<i>Value</i>
	(1)	(2)	(3)	(4)	(5)	(6)
r_f	1.86*** (0.70)	1.83*** (0.70)	2.15*** (0.63)	2.05*** (0.70)	2.40*** (0.55)	0.96*** (0.16)
$\hat{r}p$	-0.98*** (0.20)	-0.99*** (0.24)	-1.09*** (0.17)	-0.91*** (0.22)	-1.10*** (0.20)	-0.17** (0.070)
HY Spread		0.087 (0.56)			0.82 (0.77)	0.018 (0.31)
Leverage			15.0** (7.60)		15.3*** (4.90)	5.96* (3.16)
EBITDA/EV-HY				0.74 (0.65)	1.95* (1.01)	0.62 (0.38)
Observations	117	117	117	117	117	117

Table 2 contains Tobit estimates of quarterly buyout activity on the real risk-free rate, expected returns, and other macro-variables from 1982Q3 to 2011Q4. The dependent variable in (1)-(5) is the volume of activity scaled by the number of public firms (in basis points). In (6), the dependent variable is the value of going private activity (excl. mega-deals) scaled by total public market capitalization. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using D/P , cay , and $Term\ Premium$ as factors. $HY\ Spread$ is the yield on a composite index of high-yield bonds less the 3-month T-Bill. $Leverage$ is the ratio of aggregate public company debt to aggregate market capitalization. $Median\ EBITDA/EV - HY$ is the difference between the median public firm EBITDA/EV and the yield on a composite index of high-yield bonds. Each Tobit also includes first quarter dummy variables to account for seasonality. Standard errors in parentheses calculated using Newey-West (12 lags); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Summary of Firm-Quarters: Full Sample and LBO Firm-Quarters

VARIABLE	All Firm-Quarters				LBO Firm-Quarters			
	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Deal Dummy	501,176	0.002	0.000	0.046	1,043	1.000	1.000	0.000
Firm Characteristics:								
Assets	501,176	\$2,028	\$155	\$12,733	1,043	\$978	\$211	\$2,962
log(Assets)	501,176	5.19	5.04	2.13	1,043	5.48	5.35	1.59
FCF/Assets	489,637	-0.05	0.01	0.21	1,017	0.01	0.03	0.14
CapEx/Sales	486,054	0.14	0.04	0.45	1,030	0.07	0.03	0.17
R&D/Sales	485,800	0.18	0.00	1.04	1,030	0.03	0.00	0.18
Net Debt/Assets	494,956	0.07	0.11	0.36	1,036	0.14	0.18	0.35
Turnover	488,367	1.15	0.63	1.89	1,036	1.05	0.59	3.73
Dividend Dummy	501,176	0.32	0.00	0.46	1,043	0.31	0.00	0.46
Book/Market	484,490	0.74	0.55	0.70	997	0.93	0.74	0.77
Risk Proxies:								
$\sigma(R)$	431,467	15.83	13.44	10.69	963	14.26	12.25	8.22
β	431,467	1.14	1.03	1.16	963	1.02	0.96	0.92
$\sigma(\varepsilon)$	431,467	14.49	12.12	10.31	963	13.01	11.11	7.85
$\sigma(FCF/Assets)$	493,300	0.13	0.09	0.13	1,002	0.09	0.07	0.09
$\sigma(EBITDA/Assets)$	489,358	0.12	0.08	0.14	997	0.07	0.05	0.08

Table 3 contains summary statistics for the sample of firm-quarters from 1982Q3 to 2011Q4. *Assets* are book assets in 2010 dollars. Accounting ratios trimmed at the 99% level. *Dividend Dummy* is equal to one if the firm pays a dividend. $\sigma(R)$ is the standard deviation of the prior two-years monthly returns. $\sigma(FCF/Assets)$ is the standard deviation of the FCF-to-assets ratio over the observable life of a firm. β is the market beta of the firm based on lagged two-years of monthly returns. $\sigma(\varepsilon)$ is the standard deviation of the residuals from the market regression. *Deal Dummy* is equal to one if a firm announces a deal in the upcoming quarter.

Table 4: Probit: Deal Likelihood, Discount Rates and Risk Characteristics

	(1)	(2)	(3)	(4)	Unlevered		(8)	Unlevered	
					(5)	(6)	(7)	(9)	
r_f	0.035*** (0.0092)								
$\hat{r}p$	-0.021*** (0.0031)								
$\sigma(R)$		-0.0064*** (0.0018)				-0.0069*** (0.0019)			
$\sigma(\frac{EBITDA}{Assets})$			-1.19*** (0.21)				-1.11*** (0.28)		
β				-0.051*** (0.010)	-0.073*** (0.014)			-0.039*** (0.012)	-0.056*** (0.017)
$\sigma(\varepsilon)$				-0.0039** (0.0018)	-0.0093*** (0.0025)			-0.0045** (0.0019)	-0.011*** (0.0033)
Credit Controls	X								
Firm Controls	X					X	X	X	X
Industry FE	X					X	X	X	X
Time FE		X	X	X	X	X	X	X	X
Observations	464,104	431,467	493,300	431,467	371,850	409,434	459,717	409,434	357,021

Table 4 contains Probit estimates of a quarterly deal indicator (*Deal*) on firm risk characteristics and cross-sectional controls from 1982Q3 to 2011Q4. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using D/P , cay , and *Term Premium* as factors. $\sigma(R)$ is the s.d. of the monthly stock price for the past 2 years. $\sigma(\frac{FCF}{Assets})$ is the s.d. of the firms FCF/Assets ratio. β is the market beta of the firm. $\sigma(\varepsilon)$ is the s.d. of the residuals from the market regression. Columns (5) and (9) use unlevered β and $\sigma(\varepsilon)$. Columns (2)-(5) contain quarter fixed effects, columns (6)-(9) contain firm level controls ($\log(Assets)$, $EBITDA/Assets$, $CapEx/Sales$, $R\&D/Sales$, $Net\ Debt/Assets$, $Turnover$, $Dividend\ Dummy$), industry fixed effects (Fama-French 12), and semi-annual fixed effects. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Decomposition of Pricing and Risk Variables on Deal Likelihood

	S.D.	Deal Prob.		Share of Change	
	Change	Δ (bps)	%	Cash-Flow	Illiquidity
Time-Series:					
r_f	1.8%	4.2	22.4%	100%	0%
\hat{r}_p	7.0%	-10.5	-55.8%	67%	33%
Cross-Section:					
β	1.0	-3.7	-19.9%	61%	39%
$\sigma(\varepsilon)$	10.3%	-3.9	-20.9%	0%	100%

Table 5 summarizes the impact of a one standard deviation change in each variable on deal likelihood. The cross-sectional variables are unlevered. This change is displayed as a change in deal likelihood and a percent change based on an average likelihood of 18.7bps. We decompose the impact of the change into the cash-flow and illiquidity channels using the exclusion restrictions and structural coefficients. The model restrictions determine that r_f and $\sigma(\varepsilon)$ have no impact on the illiquidity and cash-flow channels, respectively.

Table 6: Probit: Deal Likelihood and Agency Proxies

	(1)	(2)	(3)
<i>d</i> Proxy (<i>X</i>):	FCF/Assets	EBITDA/Assets	GIM
r_f	0.022** (0.0097)	0.0028 (0.010)	-0.0040 (0.018)
X	0.24 (0.16)	-0.28** (0.12)	-0.012 (0.069)
$(X)(r_f)$	0.15** (0.073)	0.23*** (0.060)	0.070** (0.032)
Firm Controls	X	X	X
Industry FE	X	X	X
Observations	455,948	464,104	105,150

Table 6 contains Probit estimates of a quarterly deal indicator (*Deal*) on r_f , \hat{r}_p , the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. \hat{r}_p is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. *GIM* is a dummy variable equal to one if a firm is in the lowest tercile of shareholder rights as measured by the Governance Index of Gompers et al. (2003). Column (3) is limited to those firms that are matched to this measure beginning in 1990. Firm level controls: $\log(\text{Assets})$, *EBITDA/Assets*, *CapEx/Sales*, *R&D/Sales*, *Net Debt/Assets*, *Turnover*, *Dividend Dummy*. Industry fixed effects: Fama-French 12. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Probit: Deal Likelihood and Duration Proxies

	(1)	(2)	(3)	(4)
<i>T</i> Proxy (X):	Ind. M&A Volume	Ind. M&A Value	Ind. IPO Volume	Ind. IPO Value
$\hat{r}p$	-0.019*** (0.0041)	-0.018*** (0.0025)	-0.023*** (0.0030)	-0.018*** (0.0026)
<i>X</i>	4.71*** (0.86)	4.15*** (0.98)	-0.32 (0.74)	9.31* (5.55)
(<i>X</i>)($\hat{r}p$)	0.24** (0.12)	0.12 (0.10)	0.25** (0.11)	0.27 (0.84)
Firm Controls	X	X	X	X
Observations	462,207	462,207	462,207	462,207

Table 7 contains Probit estimates of a quarterly deal indicator (*Deal*) on r_f , $\hat{r}p$, the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. Industry interaction terms are 3 year trailing averages of activity for the Fama-French 48 industry classification. Volumes are scaled by the number of public firms in the industry, values are scaled by the value of public firms in the industry. Firm level controls: *log(Assets)*, *EBITDA/Assets*, *CapEx/Sales*, *R&D/Sales*, *Net Debt/Assets*, *Turnover*, *Dividend Dummy*. Industry fixed effects: Fama-French 12. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A Model

A.1 Environment / Setup

We specify the evolution of the firm's cash-flow process D_t where we suppress the subscript d . For a firm with an agency cost d , it follows:

$$\frac{D_{t+1}}{D_t} = \exp\left(g - d + b_i \lambda \varepsilon_{t+1} + \sigma_i \nu_{t+1} - \frac{1}{2}(b_i \lambda)^2 - \frac{1}{2}\sigma_i^2\right), \quad (26)$$

We specify the SDF, S_t , with constant risk-free rate r_f and a constant price of risk λ :

$$\frac{S_{t+1}}{S_t} = \exp\left(-r_f - \lambda \varepsilon_{t+1} - \frac{1}{2}\lambda^2\right) \quad (27)$$

We are interested in the price of the stream of dividends, $\{D_t\}$:

$$V_t = \frac{P_t}{D_t} = \mathbb{E}_t \sum_{\tau=1}^{\infty} \frac{S_{t+\tau}}{S_t} \frac{D_{t+\tau}}{D_t} \quad (28)$$

To find the price, we focus on the value of dividend strips. We write $V_t^{(\tau)}$, the price of a claim to the dividend of the firm τ periods from now, divided by the current dividend. We use the recursive structure of dividend strips to find their price:

$$\begin{aligned} V_t^{(\tau)} &= \mathbb{E} \frac{S_{t+\tau}}{S_t} \frac{D_{t+\tau}}{D_t} = \mathbb{E}_t \frac{S_{t+1}}{S_t} \frac{D_{t+1}}{D_t} V_t^{(\tau-1)} \\ &= V_t^{(\tau-1)} \exp\left(g - d - r_f + \frac{1}{2}(b_i - 1)^2 \lambda^2 - \frac{1}{2}(b_i \lambda)^2 - \frac{1}{2}\lambda^2\right) \\ &= V_t^{(\tau-1)} \exp(g - d - r_f - \lambda^2 b_i) \\ &= \exp(\tau(g - d - r_f - \lambda^2 b_i)). \end{aligned} \quad (29)$$

Finally we recover the price-dividend ratio by adding the price of the strips:

$$V_t = \sum_{\tau=1}^{\infty} V_t^{(\tau)} = \frac{1}{1 - \exp(g - d - r_f - \lambda^2 b_i)} - 1 \quad (30)$$

$$\simeq \frac{1}{r_f + \lambda^2 b_i - g + d} - 1 \quad (31)$$

A.2 Empirical counterparts

We show here a simple correspondence between the model parameters and standard pricing variables.

First we compute the returns of the firm:

$$\begin{aligned} R_{t+1} &= \frac{D_{t+1}}{D_t}(1 + 1/V) = \frac{D_{t+1}}{D_t} \exp(g - d - r_f - \lambda^2 b_i) \\ &= \exp\left(r_f + b_i \lambda \varepsilon_{t+1} + \sigma_i \nu_{t+1} + \lambda^2 b_i - \frac{1}{2}(b_i \lambda)^2 - \frac{1}{2}\sigma_i^2\right) \end{aligned}$$

The adjusted logarithm of excess returns are given by:²¹

$$r_{i,t+1}^e + \frac{1}{2} \text{var}_t[r_{i,t+1}^e] = b_i \lambda^2 + b_i \lambda \varepsilon_{t+1} + \sigma_i \nu_{t+1} \quad (32)$$

We assume that the market return is a mimicking portfolio for the state-price density. This implies that it only loads on the shock ε_{t+1} . Without loss of generality, it takes the following form:

$$r_{m,t+1}^e + \frac{1}{2} \text{var}_t[r_{m,t+1}^e] = b_m \lambda^2 + b_m \lambda \varepsilon_{t+1} \quad (33)$$

Market beta and b_i : The beta of a firm is proportional to its exposure b_i :

$$\beta_{im} = \frac{\text{cov}_t(r_{i,t+1}^e, r_{m,t+1}^e)}{\text{var}_t(r_{m,t+1}^e)} = \frac{b_i}{b_m} \quad (34)$$

Risk premium and λ^2 : We also see the market risk premium is proportional to λ^2 .

$$\mathbb{E}[r_{m,t+1}] - r_f + \frac{1}{2} \text{var}_t(r_{m,t+1}) = b_m \lambda^2 \quad (35)$$

Idiosyncratic risk and σ_i : Finally we notice the stock return has the same loading σ_i on the idiosyncratic shock as cash-flow growth.

A.3 Cash-flow channel

The cash flow channel is $\log(P_d^{pub}) - \log(P_0^{pub}) = \log(V_d^{pub}) - \log(V_0^{pub})$.

²¹The adjustment is to take care of Jensen terms and is negligible empirically.

As all of our comparative statics are monotone, we focus on the case of small d , and in particular study the derivative of V with respect to d at $d = 0$. Define:

$$\delta^C = \frac{\partial \log(V)}{\partial d} \Big|_{d=0} = -\frac{\partial \log(V)}{\partial g} \Big|_{d=0}. \quad (36)$$

From the value of the firm derived in ((30)), we obtain:

$$\delta^C = -\frac{1}{1 - \exp(g - r_f - \lambda^2 b_i)} < 0. \quad (37)$$

Or if we use the approximation derived in ((31)):

$$\delta^C \simeq -\frac{1}{r_f - g + \lambda^2 b_i}. \quad (38)$$

We can derive comparative statics for each of the parameters.

Price of risk

$$\frac{\partial \delta^C}{\partial \lambda} = 2\lambda b_i \frac{\exp(g - r_f - \lambda^2 b_i)}{(1 - \exp(g - r_f - \lambda^2 b_i))^2} > 0.$$

Risk-free rate and growth rate In order to do comparative statics with the risk-free rate and the growth rate, we need to specify the link between both quantities. We assume that $g = \phi r_f$.

$$\frac{\partial \delta^C}{\partial r_f} = (\phi - 1) \frac{\exp(g - r_f - \lambda^2 b_i)}{(1 - \exp(g - r_f - \lambda^2 b_i))^2}.$$

Hence we have that $\frac{\partial \delta^C}{\partial r_f} < 0$ if and only if $\phi > 1$.

Systematic risk exposure

$$\frac{\partial \delta^C}{\partial b_i} = \lambda^2 \frac{\exp(g - r_f - \lambda^2 b_i)}{(1 - \exp(g - r_f - \lambda^2 b_i))^2} > 0.$$

Idiosyncratic risk exposure

$$\frac{\partial \delta^C}{\partial \sigma_i} = 0.$$

A.4 Illiquidity channel

In this section we derive the discount that has to be offered to the fund compared to the public market valuation of the firm such that it invests in the buyout. First we assume that the fund has mean-variance preferences:

$$U = \mathbb{E} \sum_{t=0}^{\infty} \beta^t \left(\mathbb{E}_t \{r_{t+1}^e\} - \frac{\gamma}{2} \text{var}_t \{r_{t+1}^e\} \right)$$

where r_{t+1}^e are the correctly variance adjusted log returns. The adjustment is the Jensen term so that we obtain the correct expected returns.²²

Optimal portfolio of the fund A typical excess return can be written as:

$$r_{t+1}^e = b\lambda^2 + b\lambda\varepsilon_{t+1} + \sigma\nu_{t+1}.$$

In particular for the firm we have $b = b_i$ and $\sigma = \sigma_i$. For the market excess return we assume that $\sigma = 0$ and write $b = b_m$. Using the mean-variance preferences, the per-period utility is:

$$\mathbb{E}_t \{r_{t+1}^e\} - \frac{\gamma}{2} \text{var}_t \{r_{t+1}^e\} = b\lambda^2 - \frac{\gamma}{2} b^2 \lambda^2 - \frac{\gamma}{2} \sigma^2$$

The optimum verifies $\sigma^* = 0$ and

$$b^* = 1/\gamma$$

Discount To find the discount, we compute the difference between utility at the optimum and utility from holding the firm — without receiving any compensation. The difference of valuation yields:

$$-\frac{\gamma}{2} (b_i - b^*)^2 \lambda^2 - \frac{\gamma}{2} \sigma_i^2.$$

This utility cost can be compensated with an extra expected return of this exact amount each period. The discount adds up to:

$$\log \left(\frac{P_0^{acc}}{P_0^{pub}} \right) = -T \frac{\gamma}{2} \left((b_i - b^*)^2 \lambda^2 + \sigma_i^2 \right)$$

²² $r_{t+1}^e = \tilde{r}_{t+1}^e + \text{var}(\tilde{r}_{t+1}^e)/2$ where \tilde{r} is the standard log excess return.

Restriction: We impose that the fund's optimal portfolio is the market portfolio. This restriction corresponds to $b^* = b_m$ or equivalently $\gamma = 1/b_m$. Using the fact that $\beta_i = b_i/b_m$ we have:

$$\begin{aligned} \log\left(\frac{P_0^{acq}}{P_0^{pub}}\right) &= -\frac{T}{2}\gamma((b_i - b^*)\lambda^2 + \gamma\sigma_i^2) \\ &= -\frac{T}{2}((\beta_i - 1)^2 b_m \lambda^2 + \gamma\sigma_i^2) \\ &= -\frac{T}{2}((\beta_i - 1)^2 \mathbb{E}\{r_m^e\} + \gamma\sigma_i^2) \end{aligned}$$

The market expected return is $b_m \lambda^2$ and the market volatility is $\sigma_m = b_m \lambda$, then we have:

$$\gamma = \frac{\mathbb{E}[r_m^e]}{\sigma_m^2}$$

B Reduced form results

B.1 Data and variable construction

Transaction Data: Using Thomson SDC, we select a subset of completed transactions where public targets are 100% purchased by private acquirers. We include transactions described as leveraged or management buyouts. We also include transactions where the acquiring firm is in a different Fama-French 48 industry and the purchaser is listed as an investor, a financial acquirer or a management group. Finally, we exclude any of the above transactions described as spin-offs, divestitures, or creditor actions. If the target cannot be matched to accounting data in COMPUSTAT or share price data in CRSP, it is excluded. For comparison purposes Bharath and Dittmar (2010) compile a list of 1,023 going-private transactions (including strategic acquisitions), using 13e-3 SEC filings between 1980 and 2004. Over this same time period, our sample includes 793 transactions.

Panel Data: Panel data is formed by combining Compustat annual filings and CRSP quarterly share price information. Firms with multiple securities are combined into a single observation with a market capitalization that reflects the sum of outstanding public securities. We exclude firm-quarters with missing prices or asset values, and firm-quarters whose assets grow more than 700% over the past year. For control variables of interest we trim the lowest and highest 0.50% of the distribution. Buyout firms are identified using the SDC transaction data and matched using CUSIP and tickers.

Aggregate Variables:

Volume % – By quarter, the ratio of buyout deals over the number of public firms with non-missing share prices and assets in CRSP-Compustat, in basis points.

Value % – By quarter, the ratio of the total market capitalization of buyout deals from SDC over the of total market capitalization of public firms with non-missing share prices and assets in CRSP-Compustat, in basis points.

r_f – Annual real risk-free rate. Calculated as the three-month constant maturity rate (FRED) less inflation expectations (Cleveland Fed). We use the three-month inflation expectation to match the maturity of our risk-free rate proxy.

\hat{r}_p – The risk premium proxy is the expected excess return on the market. The prediction regression is estimated quarterly from 1953Q1 to 2009Q2. The dependent variable is annualized excess returns over the next three years on the value-weighted market portfolio (CRSP). The independent variables are the dividend-price ratio (CRSP), *cay* (Martin Lettau’s website), and the Term Premium (FRED, 10-year

treasury constant maturity less 3-month treasury constant maturity rate).

$$\mathbb{E}(R_{M,t+1}^e) = -5.74 + \underset{(2.68)}{0.92(D/P)_t} + \underset{(2.43)}{0.63cay_t} + \underset{(1.70)}{0.87(Term\ Premium)_t}.$$

Standard errors are Newey-West lagged over 36 months. The R -squared of this regression is .16.

HY Spread – The yield on a composite of high yield bond indices less the three-month t-bill. The composite of indices is constructed so as to cover the entire sample period. Yields on the Merrill Lynch HY Master II (1986-2011), the Merrill Lynch HY Cash Pay (1984-2011), and the Merrill Lynch High Yield 175 (1980-2004) are sourced from Datastream and averaged. These funds track closely, in both level and changes, for periods in which they overlap. Correlation coefficients between the funds are 0.97 or higher.

Aggregate Leverage – The sum of public firm debt (Compustat, $Debt=dclo+dlc+dltt$) over the sum of public firm market capitalization in millions as of the last trading day in the quarter (CRSP-Compustat, $MktCap=shROUT*prc/1000$).

Median EBITDA/EV - HY – The median EBITDA/EV ratio (Compustat, $EBITDA=ebit+dp$, $EV=MktCap+Debt+mib-che$) for public Compustat firms less the yield on the composite of high yield bond indices.

Cross-Sectional Variables:

Deal Dummy – Indicator equal to one if a firm is the target of a buyout announced in the upcoming quarter (SDC).

Assets – Total Assets (Compustat, at) in 2010 dollars based on the CPI for All Urban Consumers (FRED).

$\log(Assets)$ – Natural log of *Assets*.

EBITDA/Assets – Ratio of EBITDA to assets (Compustat, $EBITDA=ebit+dp$, $Assets=at$).

CapEx/Sales – Ratio of capital expenditures to assets (Compustat, $CapEx=capx$, $Sales=sale$).

R&D/Sales – Ratio of R&D to sales (Compustat, $R\&D=xrd$, $Sales=sale$). If R&D is missing I assume it is zero.

Net Debt/Assets – Ratio of net debt to assets (Compustat, $Net\ Debt=Debt-che$, $Assets=at$).

Turnover – The three-month average of monthly trading volume relative to shares outstanding (CRSP).

Dividend Dummy – Indicator equal to one if a firm pays a common dividend during the past year (Compustat, `Dividend=dvc`).

Book/Market – Ratio of book value to market capitalization (Compustat, `Book=seq+txdb`).

$\sigma(R)$ – Standard deviation of monthly returns (CRSP) over the prior two years.

$\sigma(FCF/Assets)$ – Standard deviation of FCF/Assets by firm.

β – We calculate market beta for each firm i using OLS.

$$R_{it}^e = \alpha_i + \beta_i^M R_{Mt}^e + \epsilon_{it}$$

R_{it}^e is the monthly excess return for firm i and R_{Mt}^e is the excess monthly market return on the value-weight portfolio. β_i^M is estimated using the trailing two years of monthly returns. Unlevered beta is calculated by rescaling by $\frac{1}{1+(1-\tau)*\frac{Debt}{Mkt\ Cap}}$ where $\tau = 35\%$.

$\sigma(\epsilon)$ – The standard deviation of the residual from the trailing 24- month market regression, (13). Unlevered standard deviation is calculated by rescaling by $\frac{1}{1+(1-\tau)*\frac{Debt}{Mkt\ Cap}}$ where $\tau = 35\%$.

GIM – Indicator equal to one if a firm is in the lowest tercile for shareholder rights in a given year (Gompers et al., 2003). The measure is available at Andrew Metrick’s website. As the data is updated every 2-3 years from 1990-2006, firms are assigned their most recent rating.

Industry M&A Volume and Value – We construct a time-series of M&A transactions for each Fama-French 48 industry. We focus on reported value M&A and scale the volume (or enterprise value) by the aggregate volume (or enterprise value) in public markets (Compustat) for each quarter. We then construct 3-year moving averages for deal activity.

Industry IPO Volume and Value – We construct a time-series of IPOs for each Fama-French 48 industry. We focus on reported value IPOs and scale the volume (or enterprise value) by the aggregate volume (or enterprise value) in public markets (Compustat) for each quarter. We then construct 3-year moving averages for IPO activity.

B.2 Role of discount rates: Robustness

Table 8: Tobit: Industry Buyout Activity on Aggregate Discount Rates

	Tobit Coefficients		Total No. of Deals	Average Activity / Quarter (bps)
	r_f	$\hat{r}p$		
Aggregate	0.099***	-0.052***	1,143	18.7
FF12:				
Retail	0.11**	-0.075***	228	34.9
Other	0.043	-0.092***	204	25.6
Business Equipment	-0.13	-0.12***	161	15.4
Manufacturing	0.30***	-0.056**	160	23.2
Finance	0.36***	-0.14***	98	8.20
Consumer Non-Durables	0.66***	-0.033	89	24.8
Healthcare	0.089	-0.16***	76	12.9
Consumer Durables	0.97***	-0.13*	44	26.6
Telecom	0.021	-0.090*	36	23.7
Chemicals	1.18	0.16	19	13.6
Energy	-2.11	0.16	16	6.30
Utilities	3.33**	-1.67***	11	6.57

Table 8 contains Tobit coefficients of quarterly buyout activity on the real risk-free rate and expected returns from 1982Q3 to 2011Q4. The dependent variable is the volume of activity in an industry scaled by the number of public firms in that industry (in basis points). Each Tobit includes a first quarter fixed effect. Newey-West standard errors using 12 lags; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Tobit: Buyout Volume on Alternative Aggregate Discount Rates

	$\hat{r}p_{Rolling}$		$\hat{r}p_{Skip}$		$\hat{r}p_{Excl. TP}$	
	(1)	(2)	(3)	(4)	(5)	(6)
r_f	2.34** (1.07)	3.51*** (0.77)	1.80*** (0.66)	2.25*** (0.56)	3.08*** (0.71)	3.64*** (0.63)
$\hat{r}p$	-0.98*** (0.25)	-1.21*** (0.21)	-1.36*** (0.26)	-1.49*** (0.26)	-1.13*** (0.17)	-1.22*** (0.17)
HY Spread		0.67 (0.91)		0.79 (0.78)		0.68 (0.87)
Total Leverage		24.3*** (5.13)		13.1*** (4.83)		14.0*** (4.91)
EBITDA/EV-HY		2.51** (1.19)		1.84* (1.03)		1.73 (1.08)
Observations	117	117	117	117	117	117

Table 9 contains Tobit estimates of quarterly going-private volume on the real risk-free rate, expected returns, and other macro-variables from 1982Q3 to 2011Q4. The dependent variable is the volume of activity scaled by the number of public firms (in basis points). r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ varies by column. Columns (1)-(2) use a rolling estimate using D/P , cay , and $Term Premium$. Columns (3)-(4) use an estimate using these factors, but excluding the upcoming quarter. Columns (5)-(6) excludes the $Term Premium$ as a factor. $HY Spread$ is the yield on a composite index of high-yield bonds less the 3-month T-Bill. $Leverage$ is the ratio of aggregate public company debt to aggregate market capitalization. $Median EBITDA/EV - HY$ is the difference between the median public firm EBITDA/EV and the yield on a composite index of high-yield bonds. Each Tobit also includes first quarter dummy variables to account for seasonality. Standard errors in parentheses calculated using Newey-West (12 lags); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: OLS: Buyout Activity on Aggregate Discount Rates

	<i>Volume</i>					<i>Value</i>
	(1)	(2)	(3)	(4)	(5)	(6)
r_f	1.83*** (0.69)	1.81*** (0.70)	2.11*** (0.62)	2.03*** (0.70)	2.38*** (0.55)	0.95*** (0.16)
$\hat{r}p$	-0.97*** (0.20)	-0.98*** (0.23)	-1.08*** (0.17)	-0.90*** (0.21)	-1.09*** (0.20)	-0.16** (0.068)
HY Spread		0.055 (0.55)			0.79 (0.77)	0.0058 (0.30)
Leverage			14.7* (7.54)		15.2*** (4.95)	5.94* (3.10)
EBITDA/EV-HY				0.77 (0.64)	1.95* (1.02)	0.61* (0.37)
Observations	117	117	117	117	117	117
R^2	0.305	0.305	0.330	0.317	0.362	0.275

Table 10 contains OLS estimates of quarterly going-private activity on the real risk-free rate, expected returns, and other macro-variables from 1982Q3 to 2011Q4. The dependent variable in (1)-(5) is the volume of activity scaled by the number of public firms (in basis points). In (6), the dependent variable is the value of going private activity (excl. mega-deals) scaled by total public market capitalization. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using D/P , cay , and $Term\ Premium$ as factors. $HY\ Spread$ is the yield on a composite index of high-yield bonds less the 3-month T-Bill. $Leverage$ is the ratio of aggregate public company debt to aggregate market capitalization. $Median\ EBITDA/EV - HY$ is the difference between the median public firm EBITDA/EV and the yield on a composite index of high-yield bonds. Each regression also includes first quarter dummy variables to account for seasonality. Standard errors in parentheses calculated using Newey-West (12 lags); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Probit: The Role of Discount Rates on Deal Likelihood

	Full Sample			Matched Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
r_f	0.025*** (0.0095)	0.034*** (0.0091)	0.035*** (0.0092)	0.028** (0.011)	0.039*** (0.011)	0.038*** (0.011)
$\hat{r}p$	-0.017*** (0.0024)	-0.022*** (0.0031)	-0.021*** (0.0031)	-0.021*** (0.0028)	-0.025*** (0.0036)	-0.025*** (0.0036)
HY Spread		0.026 (0.016)	0.025 (0.016)		0.029 (0.019)	0.030 (0.019)
Total Leverage		0.25** (0.11)	0.27** (0.11)		0.30** (0.14)	0.30** (0.14)
EBITDA/EV-HY		0.043** (0.021)	0.042** (0.021)		0.048* (0.025)	0.049* (0.025)
log(Assets)	-0.0083 (0.0072)	-0.0092 (0.0073)	-0.0060 (0.0078)	-0.010 (0.0083)	-0.011 (0.0085)	-0.010 (0.0088)
EBITDA/Assets	0.42*** (0.11)	0.40*** (0.11)	0.45*** (0.11)	0.25 (0.16)	0.24 (0.16)	0.37** (0.17)
CapEx/Sales	-0.29*** (0.11)	-0.29*** (0.11)	-0.13 (0.078)	-0.057 (0.12)	-0.054 (0.12)	0.00075 (0.11)
R&D/Sales	-0.55** (0.25)	-0.55** (0.26)	-0.35* (0.19)	-0.14 (0.13)	-0.15 (0.13)	-0.048 (0.088)
Net Debt/Assets	0.17*** (0.039)	0.17*** (0.039)	0.17*** (0.037)	0.16*** (0.044)	0.17*** (0.044)	0.18*** (0.045)
Turnover	-0.0080 (0.019)	-0.0088 (0.019)	-0.0095 (0.020)	-0.0092 (0.019)	-0.010 (0.020)	-0.011 (0.020)
Dividends	-0.066* (0.036)	-0.072** (0.036)	-0.068** (0.035)	-0.061 (0.040)	-0.069* (0.040)	-0.087** (0.041)
Fixed Effects			Industry			Industry
Observations	464,104	464,104	464,104	99,654	99,654	99,654

Table 11 contains Probit estimates of a quarterly deal indicator (*Deal*) on the real risk-free rate and expected returns, cross-sectional controls, and other macro-variables from 1982Q3 to 2011Q4. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using D/P , cay , and *Term Premium* as factors. *HY Spread* is the yield on a composite index of high-yield bonds less the 3-month T-Bill. *Leverage* is the ratio of aggregate public company debt to aggregate market capitalization. *EBITDA/EV - HY* is the difference between the median public firm EBITDA/EV and the yield on a composite index of high-yield bonds. Each Probit also includes a first quarter dummy variable to account for seasonality. The matched sample is formed by calculating propensity scores using cross-sectional characteristics, then selecting firm-quarters within a caliper range of buyout firm-quarters. The resulting distribution is stable over time. This exercise is intended to focus the counterfactual sample to address the timing of buyout activity for similar types of firms. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Logit: Deal Likelihood, Discount Rates and Risk Characteristics

	(1)	(2)	(3)	(4)	Unlevered		(8)	Unlevered	
					(5)	(6)	(7)	(9)	
r_f	0.10*** (0.029)								
$\hat{r}p$	-0.067*** (0.0099)								
$\sigma(R)$		-0.021*** (0.0055)				-0.021*** (0.0059)			
$\sigma(\frac{EBITDA}{Assets})$			-4.11*** (0.69)				-3.88*** (0.98)		
β				-0.15*** (0.030)	-0.22*** (0.044)			-0.11*** (0.037)	-0.17*** (0.052)
$\sigma(\epsilon)$				-0.013** (0.0055)	-0.031*** (0.0072)			-0.014** (0.0057)	-0.038*** (0.0098)
Credit Controls	X								
Firm Controls	X					X	X	X	X
Industry FE	X					X	X	X	X
Time FE		X	X	X	X	X	X	X	X
Observations	464104	431467	493300	431467	371850	409434	459717	409434	357021

Table 12 contains logit estimates of a quarterly deal indicator (*Deal*) on firm risk characteristics and cross-sectional controls from 1982Q3 to 2011Q4. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. $\sigma(R)$ is the s.d. of the monthly stock price for the past 2 years. $\sigma(\frac{FCF}{Assets})$ is the s.d. of the firms FCF/Assets ratio. β is the market beta of the firm. $\sigma(\epsilon)$ is the s.d. of the residuals from the market regression. Columns (5) and (9) use unlevered β and $\sigma(\epsilon)$. Columns (2)-(5) contain quarter fixed effects, columns (6)-(9) contain firm level controls (*log(Assets)*, *EBITDA/Assets*, *CapEx/Sales*, *R&D/Sales*, *Net Debt/Assets*, *Turnover*, *Dividend Dummy*), industry fixed effects (Fama-French 12), and semi-annual fixed effects. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 13: OLS: Deal Likelihood, Discount Rates and Risk Characteristics

	(1)	(2)	(3)	(4)	Unlevered (5)	(6)	(7)	(8)	Unlevered (9)
r_f	0.00024*** (0.000065)								
\hat{r}_p	-0.00015*** (0.000023)								
$\sigma(R)$		-0.000031** (0.000014)				-0.000031*** (9.2e-06)			
$\sigma(\frac{EBITDA}{Assets})$			-0.0042*** (0.0010)				-0.0038*** (0.00072)		
β				-0.00028*** (0.000066)	-0.00038*** (0.000091)			-0.00022*** (0.000054)	-0.00030*** (0.000078)
$\sigma(\epsilon)$				-0.000019 (0.000015)	-0.000038*** (0.000014)			-0.000020** (1.0e-05)	-0.000040*** (7.3e-06)
Credit Controls	X								
Firm Controls	X					X	X	X	X
Industry FE	X					X	X	X	X
Time FE		X	X	X	X	X	X	X	X
Observations	464104	431467	493300	431467	371850	409434	459717	409434	357021
R^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 13 contains OLS estimates of a quarterly deal indicator (*Deal*) on firm risk characteristics and cross-sectional controls from 1982Q3 to 2011Q4. r_f is the 3-month T-Bill less inflation expectations. \hat{r}_p is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. $\sigma(R)$ is the s.d. of the monthly stock price for the past 2 years. $\sigma(\frac{FCF}{Assets})$ is the s.d. of the firms FCF/Assets ratio. β is the market beta of the firm. $\sigma(\epsilon)$ is the s.d. of the residuals from the market regression. Columns (5) and (9) use unlevered β and $\sigma(\epsilon)$. Columns (2)-(5) contain quarter fixed effects, columns (6)-(9) contain firm level controls (*log(Assets)*, *EBITDA/Assets*, *CapEx/Sales*, *R&D/Sales*, *Net Debt/Assets*, *Turnover*, *Dividend Dummy*), industry fixed effects (Fama-French 12), and semi-annual fixed effects. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter) and are robust to common autocorrelation across firms for the prior two years; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Matched Sample: Deal Likelihood and Risk Characteristics

	Probit				OLS			
	(1)	(2)	(3)	Unlevered (4)	(5)	(6)	(7)	Unlevered (8)
$\sigma(R)$	-0.0052** (0.0024)				-0.0013* (0.00070)			
$\sigma(\frac{EBITDA}{Assets})$		-1.13*** (0.32)				-0.25*** (0.061)		
β			-0.035* (0.018)	-0.045* (0.027)			-0.0088*** (0.0028)	-0.011** (0.0044)
$\sigma(\varepsilon)$			-0.0033 (0.0024)	-0.0066* (0.0038)			-0.00082 (0.00073)	-0.0016** (0.00075)
Time FE	X	X	X	X	X	X	X	X
Observations	5,259	5,743	5,259	4,610	5,259	5,743	5,259	4,610
R^2					0.001	0.004	0.001	0.002

Table 14 contains Probit and OLS estimates of a quarterly deal indicator (*Deal*) on firm risk characteristics and cross-sectional controls from 1982Q3 to 2011Q4 in a matched sample of firms. r_f is the 3-month T-Bill less inflation expectations. \hat{r}_p is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. $\sigma(R)$ is the s.d. of the monthly stock price for the past 2 years. $\sigma(\frac{FCF}{Assets})$ is the s.d. of the firms FCF/Assets ratio. β is the market beta of the firm. $\sigma(\varepsilon)$ is the s.d. of the residuals from the market regression. Columns (4) and (8) use unlevered β and $\sigma(\varepsilon)$. Time fixed-effects are for each quarter. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter) and are robust to common autocorrelation across firms for the prior two years; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

C Structural estimation

In this appendix, we first detail a precise structure to go from the firm-level model to a deal probability specification. Then we show the details of the linearizations in order to obtain a probit representation for the structural test.

C.1 From deal surplus to deal probability

The model tells us that the deal surplus is $f(C_{i,t}, I_{i,t}, X_{i,t})$ where $X_{i,t}$ are observable controls. We add to this expression an unobserved deal specific component of the surplus $\rho_{i,t}$ assumed to be i.i.d. normally distributed across time and firms. We assume it has mean zero and unit variance. It is without loss of generality as we can rescale the function f . The deal happens only if the surplus is positive. So, noting Φ the cdf of a normal distribution, we have:

$$\mathbb{P}(Deal_{i,t}|C_{i,t}, I_{i,t}, X_{i,t}) = \Phi(f(C_{i,t}, I_{i,t}, X_{i,t})) \quad (39)$$

To obtain a simple specification, we can linearize the function f and obtain a Probit specification:

$$\mathbb{P}(Deal_{i,t}) = \Phi(\theta_C C_{i,t} + \theta_I I_{i,t} + \theta_X X_{i,t} + constant) \quad (40)$$

C.2 Probit equivalence

To estimate the coefficients of the structural Probit, we linearize the two sufficient statistics C and I around their sample means.

$$\begin{aligned} C_{i,t} &\approx -\bar{\beta}\mathbb{E}[R_m^e]_t + (\phi - 1)r_{f,t} - \mathbb{E}[\bar{R}_m^e]\beta_{i,t} + constant \\ I_{i,t} &\approx -(\ell\bar{\beta} - 1)^2\mathbb{E}[R_m^e]_t - 2\ell(\ell\bar{\beta} - 1)^2\mathbb{E}[\bar{R}_m^e]\beta_{i,t} - 2\frac{\gamma}{N}\ell^2\bar{\sigma}\sigma_{i,t} + constant \end{aligned}$$

The reduced form Probit we estimate directly is:

$$\mathbb{P}(Deal_{i,t}) = \Phi(\theta_{\mathbb{E}[\mathbb{R}]}\mathbb{E}[R_m^e]_t + \theta_{r_f}r_{f,t} + \theta_{\beta}\beta_{i,t} + \theta_{\sigma}\sigma_{i,t} + \theta_X X_{i,t} + constant) \quad (41)$$

There are two possible identification strategies for the structural coefficients: using the time-series variables, risk premium and risk-free rate, or the cross-sectional variables, market beta and idiosyncratic volatility. Rather than use them jointly, we estimate them separately to see how the time series and the cross section respectively inform us about the model. Let us first focus on time-series variation. As C and I are an invertible combination of $\mathbb{E}[R_m^e]_t$

and $r_{f,t}$ the same is true of the coefficients. The time-series identification restriction is:

$$\begin{aligned}\theta_{r_f} &= (\phi - 1)\theta_C \\ \theta_{\mathbb{E}[R]} &= -\bar{\beta}\theta_C - (\ell\bar{\beta} - 1)^2\theta_I\end{aligned}$$

which gives us the coefficients θ_C and θ_I from the estimated coefficients θ_{r_f} and $\theta_{\mathbb{E}[R]}$. Conversely we can do the same calculation using the cross-sectional coefficients:

$$\begin{aligned}\theta_\sigma &= -2\frac{\gamma}{N}\ell^2\bar{\sigma}\theta_I \\ \theta_\beta &= -\mathbb{E}[\bar{R}_m^e]\theta_C - 2\ell(\ell\bar{\beta} - 1)^2\mathbb{E}[\bar{R}_m^e]\theta_I\end{aligned}$$

D Further evidence

Table 15: Logit: Deal Likelihood and Agency Proxies

	(1)	(2)	(3)
<i>d</i> Proxy (X):	FCF/Assets	EBITDA/Assets	GIM
r_f	0.064** (0.031)	-0.0017 (0.032)	-0.023 (0.058)
X	0.85 (0.56)	-0.81** (0.36)	-0.050 (0.22)
$(X)(r_f)$	0.47** (0.24)	0.74*** (0.16)	0.22** (0.10)
Firm Controls	X	X	X
Industry FE	X	X	X
Observations	464,104	455,948	105,150

Table 15 contains logit estimates of a quarterly deal indicator (*Deal*) on r_f , \hat{r}_p , the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. \hat{r}_p is the predicted market excess return using D/P , cay , and *Term Premium* as factors. *GIM* is a dummy variable equal to one if a firm is in the lowest tercile of shareholder rights as measured by the Governance Index of Gompers et al. (2003). Column (3) is limited to those firms that are matched to this measure beginning in 1990. Firm level controls: $\log(Assets)$, $EBITDA/Assets$, $CapEx/Sales$, $R\&D/Sales$, $Net\ Debt/Assets$, $Turnover$, *Dividend Dummy*. Industry fixed effects: Fama-French 12. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Matched Sample Probit: Deal Likelihood and Agency Proxies

	(1)	(2)	(3)
<i>d</i> Proxy (X):	FCF/Assets	EBITDA/Assets	GIM
r_f	0.023** (0.011)	-0.0013 (0.013)	0.0038 (0.027)
X	0.071 (0.23)	-0.50*** (0.14)	-0.018 (0.10)
$(X)(r_f)$	0.22** (0.099)	0.29*** (0.075)	0.088* (0.049)
Firm Controls	X	X	X
Industry FE	X	X	X
Observations	99,654	98,700	4,507

Table 16 contains Probit estimates of a quarterly deal indicator (*Deal*) on r_f , $\hat{r}p$, the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using D/P , cay , and *Term Premium* as factors. *GIM* is a dummy variable equal to one if a firm is in the lowest tercile of shareholder rights as measured by the Governance Index of Gompers et al. (2003). Column (3) is limited to those firms that are matched to this measure beginning in 1990. Firm level controls: $\log(Assets)$, $EBITDA/Assets$, $CapEx/Sales$, $R\&D/Sales$, $Net\ Debt/Assets$, $Turnover$, *Dividend Dummy*. Industry fixed effects: Fama-French 12. The matched sample is formed by calculating propensity scores using cross-sectional characteristics, then selecting firm-quarters within a caliper range of buyout firm-quarters. The resulting distribution is stable over time. This exercise is intended to focus the counterfactual sample to address the timing of buyout activity for similar types of firms. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 17: Logit: Deal Likelihood and Duration Proxies

	(1)	(2)	(3)	(4)
<i>T</i> Proxy (<i>X</i>):	Ind. M&A Volume	Ind. M&A Value	Ind. IPO Volume	Ind. IPO Value
$\hat{r}p$	-0.060*** (0.013)	-0.058*** (0.0080)	-0.071*** (0.0092)	-0.057*** (0.0082)
<i>X</i>	13.8*** (2.50)	11.2*** (2.55)	-0.50 (2.22)	27.6* (16.1)
(<i>X</i>)($\hat{r}p$)	0.74** (0.35)	0.39 (0.27)	0.76** (0.33)	0.79 (2.53)
Firm Controls	X	X	X	X
Observations	462,207	462,207	462,207	462,207

Table 17 contains logit estimates of a quarterly deal indicator (*Deal*) on r_f , $\hat{r}p$, the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. Industry interaction terms are 3 year trailing averages of activity for the Fama-French 48 industry classification. Volumes are scaled by the number of public firms in the industry, values are scaled by the value of public firms in the industry. Firm level controls: $\log(\text{Assets})$, $\text{EBITDA}/\text{Assets}$, $\text{CapEx}/\text{Sales}$, $\text{R\&D}/\text{Sales}$, $\text{Net Debt}/\text{Assets}$, *Turnover*, *Dividend Dummy*. Industry fixed effects: Fama-French 12. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 18: Matched Sample Probit: Deal Likelihood and Duration Proxies

	(1)	(2)	(3)	(4)
<i>T</i> Proxy (<i>X</i>):	Ind. M&A Volume	Ind. M&A Value	Ind. IPO Volume	Ind. IPO Value
$\hat{r}p$	-0.063*** (0.013)	-0.060*** (0.0079)	-0.072*** (0.0091)	-0.060*** (0.0080)
<i>X</i>	14.0*** (2.53)	11.9*** (2.53)	0.13 (2.26)	26.7* (15.7)
$(X)(\hat{r}p)$	0.81** (0.36)	0.40 (0.27)	0.72** (0.33)	1.22 (2.47)
Firm Controls	X	X	X	X
Observations	146,594	146,594	146,594	146,594

Table 18 contains Probit estimates of a quarterly deal indicator (*Deal*) on r_f , $\hat{r}p$, the specified interaction and cross-sectional controls. r_f is the 3-month T-Bill less inflation expectations. $\hat{r}p$ is the predicted market excess return using *D/P*, *cay*, and *Term Premium* as factors. Industry interaction terms are 3 year trailing averages of activity for the Fama-French 48 industry classification. Volumes are scaled by the number of public firms in the industry, values are scaled by the value of public firms in the industry. Firm level controls: $\log(\text{Assets})$, $\text{EBITDA}/\text{Assets}$, $\text{CapEx}/\text{Sales}$, $\text{R\&D}/\text{Sales}$, $\text{Net Debt}/\text{Assets}$, *Turnover*, *Dividend Dummy*. Industry fixed effects: Fama-French 12. The matched sample is formed by calculating propensity scores using cross-sectional characteristics, then selecting firm-quarters within a caliper range of buyout firm-quarters. The resulting distribution is stable over time. This exercise is intended to focus the counterfactual sample to address the timing of buyout activity for similar types of firms. Standard errors in parentheses calculated by clustering two-ways (by firm and quarter); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

E Model with time-varying discount rates

In this appendix, we present a version of the model with time-varying pricing conditions. We obtain extensions of the comparative statics of the simple model.

E.1 Setup

We specify the SDF, S_t exogenously as in equation (3):

$$\frac{S_{t+1}}{S_t} = \exp\left(-r_{f,t} - \lambda_t \varepsilon_{t+1}^d - \frac{1}{2} \lambda_t^2\right) \quad (42)$$

The price of risk λ_t and the risk-free rate $r_{f,t}$ depend on the state variables of the economy (s_t, y_t) as follows:

$$r_{f,t} = y_0 + y_t, \quad (43)$$

$$\lambda_t^2 = \lambda_0 + \lambda_1 s_t. \quad (44)$$

We specify the dynamics of state variables, following autoregressive processes:

$$s_{t+1} = \rho_s s_t + \sigma_s \varepsilon_{t+1}^s, \quad (45)$$

$$y_{t+1} = \rho_y y_t + \sigma_y \varepsilon_{t+1}^y. \quad (46)$$

Finally we specify the evolution of the firm's cash-flow process as in equation (2):

$$\frac{D_{t+1}}{D_t} = \exp\left(g + \varphi y_t + \gamma \lambda_t \varepsilon_{t+1}^d + \sigma \varepsilon_{t+1}^i - \frac{1}{2} (\gamma \lambda_t)^2 - \frac{1}{2} \sigma_i^2\right), \quad (47)$$

The term φy_t captures the link between the growth rate of the economy and the risk-free rate, as in the static model.

E.2 Asset Pricing

We use standard log-linearization techniques to price the cash flow stream $(D_t)_t$. Starting with the definition of returns:

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} = \frac{P_{t+1} + D_{t+1}}{D_{t+1}} \frac{D_{t+1}}{D_t} \frac{D_t}{P_t}$$

We linearize this equality around the average of the logarithm of the price-dividend ratio, \bar{pd} :

$$\begin{aligned} r_{t+1} &= \log(R_{t+1}) = \log(e^{pd_{t+1}} + 1) + \Delta d_{t+1} - pd_t \\ &\simeq \kappa_0 + \kappa_1 pd_{t+1} + \Delta d_{t+1} - pd_t. \end{aligned} \quad (48)$$

And the coefficients κ_0 and κ_1 are given by:

$$\kappa_1 = \frac{e^{\bar{pd}}}{e^{\bar{pd}} + 1} \quad \text{and} \quad \kappa_0 = \log(e^{\bar{pd}} + 1) - \kappa_1 \bar{pd}$$

From this approximation we conjecture that a price-dividend ratio affine in the state variables solve the Euler equation:

$$pd_t = A + Bs_t + Cy_t \quad (49)$$

We verify that such a conjecture is valid, using the pricing equation $\mathbb{E}\{\frac{S_{t+1}}{S_t}R_{t+1}\} = 1$:

$$\begin{aligned} 1 &= \mathbb{E} \left\{ \frac{S_{t+1}}{S_t} \exp(\kappa_0 + \kappa_1 pd_{t+1} + \Delta d_{t+1} - pd_t) \right\}, \\ &= \mathbb{E} \left\{ \exp \left(-y_o - y_t - \frac{1}{2} \lambda_t^2 - \lambda_t \varepsilon_{t+1}^d + \kappa_0 + \kappa_1 A + \kappa_1 B s_{t+1} + \kappa_1 C y_{t+1} \right. \right. \\ &\quad \left. \left. + g + \varphi y_t + \gamma \lambda_t \varepsilon_{t+1}^d + \sigma \varepsilon_{t+1}^i - \frac{1}{2} (\gamma \lambda_t)^2 - \frac{1}{2} \sigma^2 - A - B s_t - C y_t \right) \right\}, \end{aligned}$$

Taking the logarithm we have:

$$\begin{aligned} 0 &= -y_o + \kappa_0 + \kappa_1 A + g - A - \gamma \lambda_0 + \frac{1}{2} \kappa_1^2 B^2 \sigma_s^2 + \frac{1}{2} \kappa_1^2 C^2 \sigma_y^2 \\ &\quad + s_t (\kappa_1 B \rho_s - B - \gamma \lambda_1) \\ &\quad + y_t (\varphi - 1 + \kappa_1 C \rho_y). \end{aligned}$$

We solve for each of the three coefficients A , B and C :

$$B = \frac{-\gamma \lambda_1}{1 - \kappa_1 \rho_s}, \quad (50)$$

$$C = \frac{\varphi - 1}{1 - \kappa_1 \rho_y}, \quad (51)$$

$$A = \frac{1}{1 - \kappa_1} \left(g - y_o + \kappa_0 - \gamma \lambda_0 + \frac{1}{2} \kappa_1^2 (B^2 \sigma_s^2 + C^2 \sigma_y^2) \right) \quad (52)$$

As $\bar{pd} = A$, we solve simultaneously for A , κ_0 and κ_1 , by using the expression for B and C obtained above. This gives us a unique equation in A that we solve before going back to the other unknowns.

E.3 Empirical counterparts

Again we show the correspondence between the model parameters and standard empirical asset pricing variables.

Market beta: As in the case with constant risk premium and risk-free rate, we assume that the market return is a mimicking portfolio for the state-price density. This implies that it only loads on the shock ε^d . Similarly to cash-flow, we assume that its loading on systematic risk is proportional to the price of risk. We then show it takes the following form:

$$r_{m,t+1} = r_{f,t} + \gamma^m \lambda_t^2 - \frac{1}{2} (\gamma^m \lambda_t)^2 + \gamma^m \lambda_t \varepsilon_{t+1}^d \quad (53)$$

It is easy to check that the Euler equation holds, as in $1 = \mathbb{E}\left\{\frac{S_{t+1}}{S_t} \exp(r_{m,t+1})\right\}$. Then we can compute the beta of a firm:

$$\beta_{im} = \frac{\text{cov}_t(r_{i,t+1}^e, r_{m,t+1}^e)}{\text{var}_t(r_{m,t+1}^e)} = \frac{\gamma^i}{\gamma^m} \quad (54)$$

Therefore β_{im} is a linear function of γ^i , and so is the risk premium received by asset i :

$$\mathbb{E}\{r_{i,t+1}\} - r_{f,t} + \frac{1}{2} \text{var}_t(r_{i,t+1}) = \gamma^i \lambda_t^2 \quad (55)$$

Price of risk: The market risk premium is proportionnal to λ_t^2 , using the expected returns on the market:

$$\mathbb{E}\{r_{m,t+1}\} - r_{f,t} + \frac{1}{2} \text{var}_t(r_{m,t+1}) = \gamma^m \lambda_t^2 = \gamma^m (\lambda_0 + \lambda_1 s_t) \quad (56)$$

Risk-free rate: We assumed a direct mapping between the risk-free rate and the state variable y_t as $r_{f,t} = y_0 + y_t$.

E.4 Cash-flow channel

For the agency discount we compute the same limit (low agency cost) as in the constant risk premium case, $\delta^C = pd^{\text{pub}} - pd^{\text{pr}} \simeq -\frac{\partial pd}{\partial g}$. We show that $\delta^C < 0$ and various comparative dynamics and statics.

Sign of the agency discount: Using equation (52), and the derivatives of κ_0, κ_1, B and C with respect to A itself we obtain:

$$\frac{\partial A}{\partial g} = \left(1 - \kappa_1^2 (B^2 \sigma_s^2 + C^2 \sigma_y^2) - \kappa_1^3 \left(B^2 \sigma_s^2 \frac{\rho_s}{1 - \kappa_1 \rho_s} + C^2 \sigma_y^2 \frac{\rho_y}{1 - \kappa_1 \rho_y} \right) \right)^{-1} \frac{1}{1 - \kappa_1} \quad (57)$$

Once we ignore the Jensen terms, as they are quantitatively small,²³

$$\frac{\partial A}{\partial g} \approx 1 + \exp(A) > 0 \quad (58)$$

We conclude that $\partial A / \partial g > 0$, hence $\delta^C < 0$, that is the agency discount is negative.

For later use, we compute the sensitivity of the average price-dividend ratio to the cash-flow exposure, $\partial A / \partial \gamma$. As in the previous calculation we use equation (52) and we get:

$$\frac{\partial A}{\partial \gamma} = \left(1 - \kappa_1^2 (B^2 \sigma_s^2 + C^2 \sigma_y^2) - \kappa_1^3 \left(B^2 \sigma_s^2 \frac{\rho_s}{1 - \kappa_1 \rho_s} + C^2 \sigma_y^2 \frac{\rho_y}{1 - \kappa_1 \rho_y} \right) \right)^{-1} \frac{-\lambda_0 + \kappa_1^2 B^2 \sigma_s^2 / \lambda_1}{1 - \kappa_1},$$

which, once we ignore the Jensen terms, translates into:

$$\frac{\partial A}{\partial \gamma} = \frac{-\lambda_0}{1 - \kappa_1} = -\lambda_0 (1 + \exp(A)) < 0. \quad (59)$$

²³We maintain this approximation in the rest of our calculations.

The price-dividend ratio is decreasing in the exposure to systematic shocks.

Price of risk: The discount increases in the price of risk as:

$$\frac{\partial \delta^C}{\partial s_t} = -\frac{\partial}{\partial g} \left(\frac{\partial pd}{\partial s_t} \right) = \frac{-\partial B}{\partial g} \quad (60)$$

$$= \gamma \lambda_1 \rho_s \frac{\kappa_1}{(1 - \kappa_1 \rho_s)^2} > 0 \quad (61)$$

In the special case where $\rho_s \rightarrow 1$ and changes to the price of risk are permanent, we obtain:

$$\frac{\partial \delta^C}{\partial s_t} = \exp(A)(1 + \exp(A))\gamma \lambda_1 \quad (62)$$

Risk-free rate: The discount is decreasing in the risk-free rate iff $\varphi > 1$

$$\frac{\partial \delta^C}{\partial y_t} = -\frac{\partial}{\partial g} \left(\frac{\partial pd}{\partial y_t} \right) = \frac{-\partial C}{\partial g} \quad (63)$$

$$= (\varphi - 1)\rho_y \frac{\kappa_1}{(1 - \kappa_1 \rho_s)^2} \quad (64)$$

Again in the special case where $\rho_y \rightarrow 1$ and changes to the risk-free rate are permanent, we obtain:

$$\frac{\partial \delta^C}{\partial y_t} = -\exp(A)(1 + \exp(A))(\varphi - 1) \quad (65)$$

Systematic risk exposure: For this calculation, we focus on the mean value of the state variables. We checked numerically that the result extends to the rest of the state space. We compute the sensitivity of the agency discount to the systematic risk exposure γ for the average risk-free rate and price of risk:

$$\left. \frac{\partial \delta^C}{\partial \gamma} \right|_{s_t=y_t=0} = -\frac{\partial}{\partial \gamma} \left(\frac{\partial A}{\partial g} \right) \quad (66)$$

$$= \exp(A)(1 + \exp(A))\lambda_0 > 0 \quad (67)$$

E.5 Illiquidity channel

We derive the discount that is offered to the fund compared to the public valuation of the firm. As in the case with constant risk premium, the fund has mean-variance preferences: $U = \mathbb{E} \sum_{t=0}^{\infty} \beta^t \left(\mathbb{E}_t \{r_{t+1}^e\} - \frac{\gamma}{2} \text{var}_t \{r_{t+1}^e\} \right)$, with r_{t+1}^e the variance adjusted log return.

We write a typical excess return for a firm i as:

$$r_{i,t+1}^e = b_i \lambda_t^2 + b_i \lambda_t \varepsilon_{t+1}^d + \sigma_i \varepsilon_{t+1}^i$$

Using the funds' preferences, the per-period utility of holding asset i is,

$$U_t = b_i \lambda_t^2 - \frac{\gamma}{2} (b_i^2 \lambda_t^2 + \sigma_i^2)$$

At the optimum the funds choose an asset such that $\sigma^* = 0$ and $b^* = \frac{1}{\gamma}$.

To find the discount that must be offered to the fund, we compute again the discrepancy between utility at the optimum and utility from holding the asset, the per-period utility cost is:

$$-\frac{\gamma}{2} (b_i - b^*)^2 \lambda_t^2 - \frac{\gamma}{2} \sigma_i^2$$

The total compensation is aggregated over the holding period T of the fund:

$$\begin{aligned} \log \left(\frac{P_0^{\text{acq}}}{P_0^{\text{pub}}} \right) &= -\frac{\gamma}{2} \mathbb{E}_0 \left((b_i - b^*)^2 \sum_{t=1}^T \lambda_t^2 + T \sigma_i^2 \right) \\ &= -\frac{1}{2} \mathbb{E}_0 \left((\beta_i - 1)^2 b_m \sum_{t=1}^T \lambda_t^2 + T \gamma \sigma_i^2 \right) \\ &= -\frac{(\beta_i - 1)^2}{2} \left(T \overline{\mathbb{E}\{r_{m,t}^e\}} + \frac{\rho_s - \rho_s^T}{1 - \rho_s} \left(\mathbb{E}_0\{r_{m,1}^e\} - \overline{\mathbb{E}\{r_{m,t}^e\}} \right) \right) - \frac{T}{2} \gamma \sigma_i^2 \end{aligned}$$

This formula is akin to the ones with constant risk premium and risk-free rate. The extra term comes from time variation in the price of risk; mean-reversion in the price of risk dampens differences in the cost induced by differences in risk premia.