Maturity Overhang: Evidence from M&A*

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Abstract

In the context of mergers and acquisitions, this paper analyzes a maturity overhang problem that is due to shorter debt maturities creating higher rollover risk. Using bond transaction data, we develop a market-based measure of rollover risk and find that i) rollover risk dampens merger activities at the firm and aggregate levels; ii) acquirers facing higher rollover risk are more sensitive to changes in cash reserves and prefer equity as a payment method over cash; and iii) positive market reactions to cash payment are observed only when firms have low rollover risk. Specifically, a one standard deviation increase in rollover risk leads to a nearly 43% decrease of the average acquisition rate, and a 6% reduction in the probability of an all-cash payment. To shed light on our empirical findings, we study a dynamic investment model that underscores the importance of precautionary savings and rollover risk for maturity overhang.

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1 Introduction

In this paper, we present the first empirical and theoretical study that thoroughly investigates how fluctuations in corporate bond market prices contribute to rollover risk, and how this risk distorts corporate investment and financing activities. To accomplish this, we utilize bond transaction data to develop a novel market-based measure of rollover risk that combines the firm's debt maturity structure with potential rollover loss. We employ this unique measure in a study of large, observable investments: mergers and acquisitions.

Debt rollovers lead to maturity overhang problems for several reasons.[1] Influenced by credit market supply and firm decisions, firms maintain stable maturity structures and issue new debt to replace maturing debt. When rolled over, short-term debt can turn into long-term debt. Additionally, when rolling over debt at prevailing market prices, firms may experience gains or losses depending on the difference between market prices and principal repayments. During deteriorating market conditions, firms issue new bonds at lower prices, resulting in larger rollover losses and higher distress risk. Firms with shorter debt maturity face greater potential losses and encounter more severe debt rollover risk, as they need to refinance debt more frequently.

Our measure of rollover risk — difference between the par and market value times inverse maturity — captures the interaction between potential rollover losses and rollover frequency. Our analysis demonstrates that rollover risk dampens merger activities at the firm and aggregate levels, a manifestation of maturity overhang. For example, a one standard deviation increase in rollover risk leads to a significant decrease by 1.5% in the cash acquisition rate, representing a nearly 43% decrease, given the average acquisition rate of 3.5% in our sample. The adverse effects from rollover risk are stronger among financially constrained acquirers than in unconstrained counterparts, with a difference representing 31% of the average of

[1] The classical debt overhang problem advanced by Myers (1977) is that the presence of long-term debt leads to underinvestment, that is, a situation in which some positive net present value (NPV) projects are foregone, because certain gains from this project go to long-term debt holders instead of equity holders.

acquisition expenses. This adverse effect holds for broader investments that include smaller investments (i.e., capital expenditure) as well. Moreover, rollover risk has a significant effect on the method of payment. For example, we find that a one standard deviation increase in rollover risk results in a 6% reduction in the probability of an all-cash payment, while the inverse maturity, a typical proxy for rollover risk, has no significant effect at all. This contrast highlights the importance of our market-based measure in empirical studies.

To alleviate concerns about endogeneity, we use the 2008 financial crisis as the exogenous shock, in which the rollover risk is heightened because the debt price slumps and the maturity cannot be shortened. We confirm it is the rollover risk that negatively impacts M&A activities during the crisis, whereas maturity alone does not demonstrate any significance. Furthermore, acquirers with elevated rollover risk exhibit heightened sensitivity to changes in cash reserves and prefer equity over cash as a payment method. Notably, equity markets respond positively to cash payment choices only when acquirers face low rollover risk.

We develop a dynamic model of investment to explore the economic forces driving these empirical findings. In our model of corporate investment, financing, and cash management, a representative firm possesses cash and risky debt and relies on external financing for capital investments. The firm commits to an initial debt maturity structure and rolls over its debt at prevailing market prices. When confronted with exogenous investment opportunities, the firm makes lump-sum investment and financing decisions.

Our model highlights the role of rollover risk for investment and financing decisions. When firms roll over their debt, they use cash to retire maturing debt if the proceeds from new debt issuance are insufficient to cover the retiring par value. When investment opportunities arise, firms facing rollover losses must make investment and financing decisions while managing their cash reserves. To avoid costly bankruptcy and remain solvent, firms with higher rollover risk and shorter debt maturity are more likely to engage in fewer acquisitions—a rollover-induced maturity overhang problem. If they do proceed with acquisitions, they are more inclined to utilize equity as a payment method over cash. In the context of acquisitions, cash payments entail lower costs but increase the probability of future default. Conversely, equity payments involve higher costs but offer lower rollover risks. In anticipation of potential rollover-induced defaults, acquirers with high rollover risk are more inclined to choose equity payments due to precautionary saving motives.

Furthermore, our model sheds light on payment methods in M&A by examining the sensitivities of equity values to cash. Equity values exhibit higher sensitivities to cash when firms have low levels of cash reserves. This observation aligns with our intuition, as firms that are cash-strapped and near bankruptcy raise concerns among equity and debt holders regarding their ability to repay from dwindling cash reserves. Moreover, shortening debt maturity amplifies the sensitivities of equity value to cash reserves due to frequent rollovers. Importantly, our empirical analyses provide further support for the preference of equity over cash as a payment choice among high-rollover risk firms.

Our work contributes to the empirical rollover risk literature by providing the first market-based rollover risk measure. The literature has been using the fraction of short-maturity debt in the long-term debt, to proxy for the rollover risk. Custódio, Ferreira, and Laureano (2013) find a trend towards greater utilization of short-term debt and attribute this trend to supply-side factors rather than firm choices. Harford, Klasa, and Maxwell (2014) document that firms with more short-term debt increase their cash holding in the cross section. Fu and Tang (2016) study the effect of debt maturity on M&A decisions. Choi, Hackbarth, and Zechner (2018) demonstrate that firms manage their debt maturity profiles and disperse maturity dates to reduce debt rollover risk. While previous empirical studies typically assume that short maturity leads to high rollover risk, we emphasize the distinction between rollover risk and debt maturity. Specifically, we argue that healthy firms might benefit from frequent rollovers due to their lower borrowing cost from the bond market. Therefore, short maturity does not necessarily imply high rollover risk in healthy firms and in expansions.

Our paper relates to research on mergers and acquisitions (Betton, Eckbo, and Thorburn, 2008). Harford (1999) finds that cash acquisitions are often value-decreasing for acquirers with excess cash, confirming the free cash flow problem (Jensen, 1986). Shleifer and Vishny (2003) and Fu, Lin, and Officer (2013) discover that overvalued acquirers are more inclined to use stock payment. Dasgupta, Harford, and Ma (2023) provide evidence on the influence of desired EPS accretion on the acquirer's preferred payment method in an acquisition. Travlos (1987) shows that cash offering conveys a positive signal. Gorbenko and Malenko (2018) show financial constraints relate negatively to cash offers. We highlight rollover risk's role for payment method and provide the first risk-based explanation by showing markets react positively to cash payment, only if acquirers have low rollover risk.

We also contribute to the merger wave literature (see recent survey by Harford (2024)), examining both neoclassical and behavioral explanations. Neoclassical theories, dated back to Gort (1969) and confirmed by Mitchell and Mulherin (1996) among others, attribute merger waves to economic, technological, or regulatory shocks. Harford (2005) highlights the role of capital liquidity, beyond these shocks. Bhagwat, Dam, and Harford (2016) find that increased market volatility during downturns diminishes merger incentives due to heightened uncertainty, in supportive of real options theory (Hackbarth and Morellec, 2008). Behavioral theories, advanced by Shleifer and Vishny (2003) and Rhodes-Kropf and Viswanathan (2004), emphasize misvaluation as a driver of merger waves. Our study reveals that, in addition to these behavioral and neoclassical factors, debt rollover risk significantly dampens aggregate M&A activities, as measured by the ratio of bidder firms to listed public firms.

Our study sheds light on the short-maturity overhang problem in the context of M&A, which contrasts with the traditional debt overhang problem (Myers, 1977) but aligns with the recent study by Diamond and He (2014). Myers observes that firms in financial distress underinvest because most gains go to existing long-term debt holders and suggests one solution is to ensure that debt matures before making investments by issuing short-term debt. In contrast, Diamond and He (2014) demonstrate that short-term debt leads to overhang. We complement and extend their study in the context of M&A. However, unlike their study that allows equity financing only, our model allows firms to accumulate cash and choose their payment method, because more than 70% of M&A deals use cash payments. We show that high-rollover-risk firms are reluctant to invest and, if they do, prefer equity payment because of the precautionary saving motive, worsening the maturity overhang problem. Moreover, we complement Diamond and He (2014) by constructing the first market-based rollover risk measure and providing extensive empirical support for the crucial role of rollover risk.

The remainder of the paper is organized as follows. Section 2 describes the data and variables definitions, and Section 3 reports empirical results. Section 4 presents the model, followed by model-generated results in Section 5. Finally, Section 6 concludes the paper. Additional robustness tests are relegated to the Appendix.

2 Data and Variables

2.1 Data

Our data universe spans from 1990 to 2021. We gather the mergers and acquisitions data from the Securities Data Company's (SDC) U.S. Mergers and Acquisitions Database.[2] We obtain firm characteristics, returns, and accounting information from the annual Compustat and the monthly CRSP tapes. To ensure data consistency and reliability, we exclude observations with negative sales, book assets less than $1 million, non-bond data, and less than two years of data in the Compustat/CRSP universe. Additionally, we winsorize at the top and bottom two percentiles to mitigate the potential impact of outliers for all accounting, M&A and bond variables. We also exclude financial firms (SIC codes from 6000 to 6999) and utility firms (SIC codes from 4900 to 4999).

We retrieve bond transaction data from Mergent FISD/NAIC and TRACE. The available

[2] We apply filters following the approach of Moeller, Schlingemann, and Stulz (2004) and Bhagwat et al. (2016): (1) only completed transactions are included, (2) deals involving buybacks, repurchases, self-tenders, or spinoffs are excluded, (3) deal values must be larger than $1 million, and (4) acquirers should hold less than 50% of the target's shares before the deal and acquire all shares after the deal. (5) both acquirers and targets are U.S. firms.

corporate bond data covers the period from 1994 to 2021. In cases where there are overlapping records in both NAIC and TRACE, we prioritize the transaction-based data from TRACE. Following the methodology of Dick-Nielsen (2014), we remove invalid transaction records in TRACE. Furthermore, we implement additional filters, as suggested by Ma (2019) and Chen, Chen, and Li (2022), to ensure that the bonds in our sample are sufficiently liquid and have reliable market values based on their prices.[3]

2.2 Variables

The key variable in our analysis is *Rollover risk*. It is defined as the difference between par value and market value of a bond scaled by its maturity as follows:

$$\text{Rollover risk} = \underbrace{\frac{\text{Par value} - \text{Market value}}{\text{Par value}}}_{\text{Price deviation}} \underbrace{\frac{1}{\text{Maturity}}}_{\text{Inverse maturity}} . \tag{1}$$

The first component of our rollover risk measure is *Price deviation*. To roll over the maturing debt, firms issue the same par amount as the maturing one, and receive proceeds at the market value. The positive (negative) difference between the par and market value of debt represents the rollover loss (gain). Larger deviations imply greater rollover loss and risk. We obtain the par value from the FISD Mergent. To calculate the market value of a firm's debt, we utilize corporate bond transaction data from TRACE and NAIC. We multiply the bond price by the amount outstanding to obtain the market value of each bond. In an effort to mitigate illiquidity bias, we calculate the value-weighted average of the market values with a weight of bond size across all bonds within the same firm.[4]

[3]Following Dick-Nielsen (2014), Ma (2019) and Chen et al. (2022) we remove (1) the transactions of reversal, cancellation and correction; (2) bonds that are not issued or traded in the U.S. market; (3) Yankee bonds and bonds that are issued by Canadian companies; (4) bonds that are asset-backed; (5) convertible bonds since the option makes them have the properties of equity; (6) puttable bonds; (7) defaulted bonds; and (8)bond transactions that are labeled as when-issued or lock-in.

[4]Additionally, Using transaction data from TRACE and applying the definition of Amihud (2002), we construct a measure of illiquidity of bonds, and calculate their value-weighted average as our firm-level illiquidty measure. We are not able to calculate this measure for NAIC bond data, and use an indicator of

The second component is *Inverse maturity*. We use the inverse maturity instead of maturity, which is consistent with our theoretical definition in the next section. It is worth noting again that short maturity alone does not capture fluctuations in bond prices and therefore rollover risk, because healthy firms benefit from relatively high bond prices and frequent rollovers. Instead, combined with the first component, price deviation, short maturity amplifies rollover risk. Similarly, we use the value-weighted years-to-maturity of bonds as a proxy for the firm-level bond maturity.

We follow the existing literature and construct firm-level and deal-level control variables to examine M&A behavior. The definitions of all other variables can be found in Table 1.

[Insert Table 1]

To examine the impact of rollover risk on merger activities at the aggregate level, we calculate the value-weighted rollover risk measure using the market value of a firm's debt as the weight. We include standard macroeconomic variables and Treasury bond interest rates as control variables,[5] as well as consumer sentiment index to proxy for the market sentiment.

2.3 Summary Statistics

We present summary statistics for firm and bond characteristics, as well as deal information, in Table 2. Our sample consists of the intersection between CRSP/Compustat and TRACE/FISD, resulting in 15,502 observations.

[Insert Table 2]

Panel A reports summary statistics for monthly aggregate variables. The average fraction of bidder firms to total public firms is 0.046, implying that 4.6% of public firms engage in merger activity every month. Our *Aggregate rollover risk* is the value-weighted average of

NAIC to control for missing Amihud illiquidty measure.

[5] The monthly data are obtained from the website of Amit Goyal at http://www.hec.unil.ch/agoyal.

firm-level rollover risk across all bond-issuing firms. It has a median of –0.003, indicating that about half of the firms suffer rollover losses from debt refinancing. The statistical distribution of other interest rate variables is consistent with our common knowledge. For example, the average credit spread between BAA– and AAA-rated bonds is 100 basis points on average, and the average inflation rate is 2.3%.

[Insert Figure 1]

Figure 1 illustrates the average and median maturity for firms in our sample over business cycles, represented by solid and dotted lines, respectively. The gray shaded areas indicate NBER recession dates. Consistent with the findings in Panel A of Table 2, the average maturity consistently exceeds the median maturity throughout the sample period. Both average and median maturities declined from 1995 to 2000. From 2000 to 2020, both measures remained relatively stable, although a notable decline in maturity occurred during the 2008 financial crisis. This decline suggests that firms issued a greater proportion of short-term bonds, despite the increasing severity of rollover risk. This is consistent with the findings in prior work that decreases in maturity have been driven by the supply-side of the credit market.

Panel B of Table 2 focuses on firm characteristics from the 15,502 firm-year observations in our sample intersecting CRSP/Compustat and TRACE/FISD. Average bond maturity is approximately 8 years, with a median of around 7 years, both of which are consistent with the literature. Both average and median values of *Price deviation* and *Rollover risk* are close to zero, similar to that at the aggregated level, while its standard deviation is also small at 2.1%. In terms of M&A activities, the average acquisition expenditure is 0.035 with a median of zero, suggesting that most of firms do not make cash acquisitions during the sample period.[6] We observe a similar pattern for transaction values.

[6]Note that this means that our firms are somewhat larger than an unconditional public firm sample, and so are also more acquisitive on average than typical unrestricted samples

Panel C provides summary statistics for our M&A sample. We restrict our analysis to acquirers present in the CRSP/Compustat universe and with bond observations in TRACE/FISD and deals with complete payment information. After applying the filters, our final sample consists of 1629 deals. The mean ratio of deal size relative to acquirer size is approximately 14%. The fraction of all-cash deals is around 72%, which represents the main payment choice in our sample, consistent with the well-documented shift toward cash acquisitions after the end of pooling accounting in 2001 (see, e.g. (Dasgupta et al., 2023)).

3 Empirical Results

Utilizing our market-based measure of rollover risk, we examine its effect on corporate investment and financing decisions at the aggregate and firm levels. Moreover, we use the financial crisis as the exogenous shock to alleviate potential endogeneity concerns.

3.1 Aggregate M&A Investments

We first study the effect of rollover risk on aggregate M&A activities, proxied by the fraction of bidder firms to the total number of public firms.

We begin with a visual representation in Figure 2. The solid line depicts the fraction of bidder firms to the total number of public firms, and the dotted line represents the aggregate rollover risk measure. The gray areas indicate NBER recessions.

[Insert Figure 2]

It is evident from Figure 2 that the fraction of bidder firms to total public firms and aggregate rollover risk are negatively associated. To statistically examine the association between the aggregate merger activities and our rollover risk measure, we estimate time series regressions as follows:

$$\text{Fraction of bidder firms}_t = a + b \text{ Aggregate rollover risk}_{t-1} + c \text{ Controls}_{t-1} + e_t, \tag{2}$$

where *Fraction of bidder firms* represents the number of bidder firms from the SDC M&A database in month t scaled by the number of public firms from CRSP, *Aggregate rollover risk* denotes the value-weighted measure of firm-level rollover risk in month $t-1$. We adjusted the standard errors using the Newey-West method with 12 lags.

[Insert Table 3]

Table 3's univariate regression in Column (1) indicates that the estimated coefficient of *Aggregate rollover risk* is –0.407 (t-statistic = –4.14). The adjusted R-squared value suggests that rollover risk alone explains 11% of the time series variation in the merger activities.

Column (2) considers aggregate variables known to explain merger waves, such as *T-bill rate*, *Term structure*, *Inflation*, *Credit spread*, *Consumer sentiment index* (Baker and Wurgler, 2006), *Change in VIX* (Bhagwat et al., 2016), *log of S&P index*, and *Market-to-book ratio* (M/B) (Shleifer and Vishny, 2003). Regarding interest rate factors derived from Treasury bond markets, the real rate (*T-bill rate*) has a positive effect, while *Inflation* negatively impacts merger activities. *Credit spread*, which is the yield difference between BAA- and AAA-rated bonds, exhibits a negative effect with a t-statistic of –3.89.

As *Aggregate rollover risk* is derived from corporate bond markets, we conduct a horse-race regression to compare it with other interest rate factors. The estimated coefficient in Column (3) rises to –0.539 (t-statistic = –3.36) in absolute terms, remaining both economically and statistically significant. Interestingly, the estimated coefficient of *Credit spread* declines substantially to 0.005 (t-statistic = 0.02), becoming economically and statistically insignificant despite its previous significance.

The full specification establishes that *Aggregate rollover risk* knocks out the explanatory power of *Credit spread*. Our rollover risk measure combines price deviation and inverse bond maturity, while credit spread does not incorporate maturity information. Moreover, the price deviation in our measure reflects changes in credit risk within the same firm, whereas credit spread captures differences across bonds with varying ratings. Therefore, our measure remains statistically significant in the horse-race test, because it is constructed to capture time series variation in corporate credit risk, combined with the effect of maturity amplification.

Our results reveal that rollover risk plays a crucial role in determining aggregate merger activity, incremental to the impact of standard behavioral, fundamental, and risk factors. Next, we proceed to examine the heterogeneous effect of rollover risk on firm-level M&A.

3.2 Firm-level M&A Investments

Having examined the impact of rollover risk on merger and acquisitions activity in the economy, we turn to examine their relationship at the firm level. To analyze firm-level M&A investments, we utilize two proxies: (1) M&A indicator and (2) cash expenditure on M&A. The M&A indicator variable captures the propensity of firms to engage in acquisitions, while the cash expenditure variable assesses the allocation of cash to a deal in the event of an acquisition.

3.2.1 Likelihood of M&A Investments

To estimate the acquisition propensity, we run Probit regressions as follows:

$$\begin{aligned} \text{Acquisition indicator}_{i,t} = a + b \text{ Rollover risk}_{i,t-1} + c \text{ Price deviation}_{i,t-1} \\ + d \text{ Inverse maturity}_{i,t-1} + f \text{ Controls}_{i,t-1} + e_{i,t}, \end{aligned} \tag{3}$$

where the *Acquisition indicator* is an indicator variable that equals one if the firm, i, acquires at least one target in a given year, t, and zero otherwise. We include standard control variables, such as *Leverage*, *Log sales*, *Tangibility*, *Profitability*, *Market-to-book ratio*, *Capital* *expenditures* and *Dividends*, and control for year and industry fixed effects in all regressions.

[Insert Table 4]

The results are reported in Table 4. In Column (1), the estimated coefficient of *Rollover risk* is –4.729, which is statistically significant with a t-statistic of –4.24. A one standard deviation increase in *Rollover risk* (0.021) leads to a significant decrease in the probability of acquiring a target by 2.76% (–1.314 × 0.021). This reduction is noteworthy, considering that the average probability of acquiring a target in our sample is approximately 22%.

Examining individual effects of the components of rollover risk, we find significantly negative coefficients –0.762 (t-statistic = –3.99) for *Price deviation* and –0.346 (t-statistic = –2.19) for *Inverse maturity* in Columns (2) and (3). The large t-statistic for the estimated coefficient of *Price deviation* implies that the price deviation might play a relatively more important role than short maturity.

We then examine further the adverse effect of rollover risk when the bond's market value is lower than its par value (the firm is in a rollover loss position). In Column (4), we regress on *Rollover risk* within a subsample of firms experiencing rollover loss. We observe a more pronounced effect of rollover risk on firms' acquisition propensity, with the coefficient on *Rollover risk* decreasing further from –4.729 to –5.293. Additionally, we examine the impact of the two components, *Price deviation* and *Inverse maturity*, within this subsample. In Column (5), we find a slightly stronger effect from *Price deviation*. In Column (6), however, the coefficient for *Inverse maturity* is approximately three times that in Column (3). These findings suggest that, when potential acquirers face a rollover loss, having short maturity that brings them closer to realizing that rollover loss severely impacts their acquisition decisions.

In short, in the context of M&A investments, we observe a significant, negative impact of a firm's rollover risk and its two components on the firm's propensity to invest.

3.2.2 M&A Expenditures

Because most firms have zero cash expenditures in M&As, there is a truncation problem when examining how rollover risk influences M&As. To overcome this problem, we estimate a Tobit model by regressing cash expenditure on rollover risk and control variables as follows:

$$\begin{aligned}\text{Acquisition expenses}_{i,t} &= a + b \text{ Rollover risk}_{i,t-1} + c \text{ Price deviation}_{i,t-1} \\ &\quad + d \text{ Inverse maturity}_{i,t-1} + f \text{ Controls}_{i,t-1} + e_{i,t},\end{aligned} \tag{4}$$

where *Acquisition expenses*$_{i,t}$ measures cash expenditures on acquisitions by firm, i, in year t.

[Insert Table 5]

As shown in Column (1) of Table 5, the coefficient on *Rollover risk* is –0.667 with a statistic of –6.37. A one standard deviation increase in *Rollover risk* (0.021) leads to a decrease in *Acquisition expenses* by 0.014 (0.667 $\times$ 0.021). This decrease is economically significant, representing a nearly 40% (0.014/0.035) decrease relative to the average expenses on acquisitions.

Examining the two components of rollover risk, we find both have a significantly negative impact. That is, the coefficient is –0.135 (t-statistic = –6.98) in Column (2) and –0.057 (t-statistic = –3.54) in Column (3) for *Price deviation* and *Inverse maturity*, respectively. While both have an effect, the economic and statistical significance of *Price deviation* is much larger than for *Inverse maturity*.

We then focus on the effect of rollover loss on acquisition expenses, when the market value of bonds are lower than their par values, in the next three columns. In Column (4), we regress acquisition expenses on *Rollover risk* within a subsample of firms suffering rollover loss. We observe a more pronounced effect of rollover risk on firms' acquisition expenses, with the coefficient on *Rollover risk* decreasing further from –0.667 to –0.724. Additionally, we analyze the effects of the two components, *Price deviation* and *Inverse maturity*, within this subsample. In Columns (5) and (6), we find stronger effects for both *Price deviation* and *Inverse maturity*.

In conclusion, our empirical findings demonstrate that rollover risk hinders acquisitions, and short bond maturity alone is not enough. Rather, when firms face a rollover loss, the impact is greatest, and only in the subsample of loss-facing firms is short maturity alone enough to predict reduced acquisition activity.

The above exercises mainly apply to large cash acquisitions. In the Appendix, we consider transaction values that includes both cash and stock payment in Table A1, and in Table A2, we use capital expenditures in order to include smaller investments. Our results consistently support our main conclusion regarding the role of rollover risk and its induced maturity overhang in shaping investment dynamics.

3.2.3 Financial Crisis

To address potential endogeneity concerns, we utilize the 2008 financial crisis as a natural experiment. Our rationale for employing this crisis is that the decline in corporate bond prices increased rollover risk for firms with substantial short-term debt, which, in turn, affected their M&A investment decisions. Note that firms burdened with short-term debt were unable to extend their debt maturity to mitigate their rollover risk, while observing the substantial decline in bond prices during the 2008 financial crisis. Instead, their maturity effectively slightly declines after the onset of the crisis in Figure 1.

Empirically, we investigate how firms with varying levels of rollover risk make M&A decisions before and after the onset of the financial crisis. We limit our sample to the pre-crisis period of 2005–2007 and the post-crisis period of 2008–2010. We define *Crisis* as an indicator variable that equals one during the post-crisis period. Based on the sign of *Rollover risk*, we categorize firms into rollover-loss and rollover-gain groups and include an indicator variable, *Rollover Loss*, which equals one for rollover-loss firms with positive rollover risk and zero otherwise. To evaluate the impact of short maturity alone on investment decisions, we also incorporate an indicator variable, *Short Maturity*, which equals one if the firm's maturity is below the sample median and zero otherwise. We run the panel regression as follows:

$$\begin{aligned} \mathrm{Y}_{i,t} = a &+ b \text{ Rollover loss}_{i,t-1} + c \text{ Crisis}_{t-1} + e \text{ Rollover loss}_{i,t-1} \times \text{Crisis}_{t-1} \\ &+ f \text{ Controls}_{i,t-1} + e_{i,t}, \end{aligned} \tag{5}$$

where $Y_{i,t}$ is the dependent variable, including *Acquisition dummy*$_{i,t}$ and *Transaction value*$_{i,t}$ by firm i at year t.

Table 6 reports the results. When the dependent variable is the acquisition dummy, the regression in Column (1) indicates that rollover risk during the crisis has a significant negative effect on firms' M&A investments. In contrast to the insignificant coefficient of *Rollover Loss*, the coefficient of the interaction term *(Rollover Loss* $\times$ *Crisis)* is negative and exhibits a significant t-statistic of 2.14. In Columns (3) and (4), we replace *Rollover Loss* with *Short Maturity*. Importantly, the estimates for *Short Maturity* and its interaction term remain statistically insignificant. Similar findings are observed when the dependent variable is *Transaction Value* in Columns (3) and (4).

[Insert Table 6]

Taken together, by using the 2008 financial crisis as an exogenous shock that depressed bond prices and heightened rollover risk, we find that rollover risk negatively impacts M&A activities during the crisis, whereas maturity alone does not produce any significant effects.

3.2.4 Financial Constraint

Costly rollover exhausts firms' cash holdings. When firms are short of cash, the difficulties of raising external capital further prevent high-rollover-risk firms from engaging M&A activities. We examine how the financial constraint effect exacerbates the effect of rollover risk by employing the Whited-Wu index (Whited and Wu, 2006) and sort firms into financially constrained (C) and unconstrained groups (U).[7] In Table 7 we estimate the following model separately for the two groups:

$$\mathrm{Y}_{i,t} = a + b\ \text{Rollover risk}_{i,t-1} + f\ \text{Controls}_{i,t-1} + e_{i,t}, \tag{6}$$

where $Y_{i,t}$ is the dependent variable, including *Acquisition dummy*$_{i,t}$, *Acquisition expenses*$_{i,t}$ and *Transaction value*$_{i,t}$ by firm i at year t.

[Insert Table 7]

A few observations in Table 7 are worth noting. First, when the dependent variable is *Acquisition dummy*$_{i,t}$, the estimate of *Rollover risk* is economically and statistically significant, –6.300 (t-statistic = –4.570) for constrained firms, in contrast to the insignificant estimate of –1.111 for unconstrained firms. Second, when the dependent variable is *Acquisition expenses*$_{i,t}$, the difference in the estimates for *Rollover risk* between constrained and unconstrained firm is 0.547 (0.810 – 0.263), which implies that the reduction in *Acquisition expenses* in constrained firms is 0.011 (0.547 × 0.021) more than that in unconstrained firms (based on the 0.021 S.D. of rollover risk). This difference is economically significant, representing nearly 31% (0.011/0.035) of average expenses on acquisitions. Lastly, our findings remain robust when the dependent variable is transaction value, with a difference of –2.537 (–2.473–0.064) and a t-statistic of 2.93. In sum, we confirm that financial constraints play a significant role in exacerbating rollover risk, thereby influencing acquisition activities.

3.3 Investment Financing

The payment method is directly tied to the financing of large M&A investments, with cash being the preferred choice for more than 70% of firms, as shown in Table 2. In this section, we examine the payment preferences of acquirers with varying levels of rollover risk and

[7] We obtain similar results when using other proxies, such as the KZ index (Kaplan and Zingales, 1997) and the SA index (Hadlock and Pierce, 2010).

analyze the market reaction to their chosen payment method.

3.3.1 Method of Payment

To assess the propensity to finance with cash, we use the following Probit specification:

$$\begin{aligned} \text{Cash financed deal}_j = a + b \text{ Rollover risk}_i + c \text{ Price deviation}_i \\ + d \text{ Inverse maturity}_i + f \text{ Controls}_i + e_j, \end{aligned} \tag{7}$$

where Cash financed deal$_j$ is an indicator variable that equals one if the acquisition deal (j) is completed with 100% cash payment.

In line with Harford, Klasa, and Walcott (2009) and de Bodt, Cousin, and Roll (2018), we incorporate various acquirer characteristics as control variables in our analysis. These variables include acquirers' *Cash*, *Leverage*, *Market-to-book ratio*, *Tangibility*, *Dividend policy*, *R&D expenses*, and *One-year return before the announcement*. Additionally, we include indicators for public target firms, target size, and relative size of the target to acquirer's size. We also include deal attitude and include an indicator for horizontal acquisitions. To account for time- and industry-specific effects, we include year and industry fixed effects in all regressions and cluster standard errors at the firm (acquirer) level. Industries are classified using two-digit SIC codes.

[Insert Table 8]

Table 8 presents the findings. In Column (1), we observe a statistically and economically significant estimated coefficient for *Rollover risk*. A one standard deviation increase in rollover risk (0.021) leads to a nearly 6% reduction (–2.704 × 0.021 = –0.057) in the probability of a full-cash payment.

We further analyze the two components of rollover risk. In Column (2), the estimated coefficient of *Price deviation* is –1.130 with a t-statistic of –1.69. Conversely, the coefficient of *Inverse maturity* in Column (3) is –0.648, which is both statistically and economically insignificant. This contrast suggests that the deviation from the issuance price exerts a more adverse influence on the payment choice compared to debt maturity. Recall that this test is conditional on acquiring, so the results are not due to firms with negative price deviations being less likely to acquire in the first place.

The estimates for control variables align with existing literature. For instance, larger targets are more likely to be acquired with equity payment due to the higher demand for cash reserves in such acquisitions. Acquirers with higher equity valuation (market-to-book ratio) exhibit a preference for equity payment, as demonstrated by Shleifer and Vishny (2003). The preference for cash payment in acquiring private targets is also in line with the findings of Harford et al. (2009) and de Bodt et al. (2018).

In short, our analysis reveals that rollover risk significantly influences the payment choice in mergers and acquisitions and its two components have a weaker effect. Particularly, the inverse maturity alone has no impact on the payment choice. In the Appendix, we employ linear models in Table A3 instead of Probit regression, and obtain similar results. This robust effect underscores the importance of rollover risk in payment choices in M&A transactions.

3.3.2 Market Reaction

Early studies report that cash payments generate higher abnormal returns than stock payments do because stock payment can be interpreted as managers knowing that the stock is overvalued (i.e., Travlos (1987) and Fuller, Netter, and Stegemoller (2002)). Next, we examine if the positive relation between cash payment and market reaction depends on the acquirer's rollover risk. That is, we test the relation between rollover risk and stock market reaction:

$$\text{Announcement return}_j = a + b \text{ Cash payment fraction}_j + c \text{ Controls}_j + e_j, \tag{8}$$

where *Announcement return* is cumulative abnormal returns (CARs) around the announcement date for acquirers. We consider 3 days and 5 days as event windows.

We adopt the methodology of Loughran and Vijh (1997) and Rau and Vermaelen (1998) by using the 25 Fama and French portfolios formed on size and book-to-market as benchmark portfolios to account for size and book-to-market ratio. The cash payment fraction represents the proportion of cash payment in the total transaction amount. We include the same set of control variables as in Equation (7) to ensure consistency.

To gain further insights into the impact of rollover risk, we divide acquirers into two groups based on the median of *Rollover risk*: those with high rollover risk and those with low rollover risk. Our focus is on the coefficient, b, on *Cash payment fraction*.

[Insert Table 9]

The findings are presented in Table 9. First, in Columns (1) and (2), where we use a 3-day event window for the announcement return, we observe a significantly positive coefficient of 0.027 (t-statistic of 3.14) in Column (1) on the *Cash payment fraction* for firms with low rollover risk. Given a standard deviation of 0.376 of *Cash payment fraction*, an increase of one standard deviation in *Cash payment fraction* corresponds to a 1.02% (0.376×0.027) higher excess return over the three days surrounding the announcement. Thus, for firms with low rollover risk, using cash payment in mergers and acquisitions generates a positive announcement return.

In contrast, for firms with high rollover risk, Column (2)'s coefficient on *Cash payment fraction* is only 0.010 and statistically insignificant (t-statistic = 1.37). This contrast shows that cash payment does not elicit a positive market reaction for firms with high rollover risk.

We observe similar patterns in Columns (3) and (4), where we extend the event window to 5 days for announcement returns. The cash premium increases from 0.017 (0.027 – 0.010) in the 3-day window to 0.028 (0.037 – 0.009) in the 5-day window.

Taken together, while the classic conclusion is that cash payment signals that privately informed acquirer management views its equity to be under (or at least not over) valued (e.g., Travlos (1987)), the contrast in our results shows that rollover risk plays a different role in the payment method choice than the signaling effect. In fact, using cash when facing high rollover risk can have an opposing effect on the market reaction, offsetting the typical positive reaction to cash payment.

3.4 Sensitivity of Equity to Cash

We investigate how rollover risk determines M&A payment choice through the lens of equity-cash sensitivities. The rationale behind this exercise is that equity holders decide on investment and financing. By analyzing the sensitivity of equity value to cash, we gain initial insights into managers' choice between equity and cash payments in M&A transactions.

To estimate the sensitivity, we regress the logarithm of equity values, $\log(\text{equity})_{i,t}$, on the logarithm of cash, $\log(\text{cash}_{i,t})$, as follows:

$$\begin{aligned}\log(\text{Equity value})_{i,t} &= a + b\ \log(\text{Cash})_{i,t} + c\ \text{Rollover loss}_{i,t} \\ &\quad + d\ \log(\text{Cash}_{i,t}) \times \text{Rollover loss}_{i,t} + f\ \text{Controls}_{i,t-1} + e_{i,t},\end{aligned} \tag{9}$$

where *Equity value* is the market value of equity and *Cash* denotes cash reserves. We include standard control variables, such as *Leverage, Log sales, Tangibility, Profitability, Market-to-book ratio, Capital expenditure* and *Dividend*. We are interested in the estimated coefficients, b and d. The latter indicates the marginal effect of rollover loss.[8]

[Insert Table 10]

As shown in Table 10, the estimated coefficient on $log(Cash)$ in Column (1) is 0.210, which is both economically and statistically significant when year- and industry-fixed effects are not included. Even when both year and industry fixed effects are introduced in Column

[8]Note that the estimated coefficient is the equity-cash elasticity, $\frac{\partial \log(Equity)}{\partial \log(\text{Cash})} = \frac{\partial \text{Equity}}{\partial \text{Cash}} / \frac{\text{Equity}}{\text{Cash}}$, which is the marginal value of cash divided by the average value of cash.

(2), the estimate is only somewhat reduced to 0.151, and is still highly significant (t-statistic of 6.45).

We introduce the interaction term of $log(Cash)$ with *Rollover risk* in Columns (3) and (4). The estimated coefficient, d, in Column (4) is 0.070 with a t-statistic of 2.63 when year- and industry-fixed effects are included. This estimate demonstrates that firms with high rollover risk exhibit a 54% (0.070/0.129) higher sensitivity to their cash reserves. This result aligns with the findings by Harford et al. (2014) who show that firms with lower debt maturity value their cash reserves more than their counterparts.[9]

Taken together, the contrast in the equity-cash sensitives suggests that high rollover risk firms value their cash holdings more than their counterparts. This difference implies that those high rollover risk firms are less likely to use cash as their acquisition payment, which is consistent with the finding that high-rollover-risk firms prefer equity as their payment over cash in Table 8 and equity markets react positively to their payment choice in Table 9.

In summary, we introduce a unique market-based measure of rollover risk and reveal several compelling findings as follows:

- At the aggregate level, rollover risk is negatively associated with merger activities, beyond existing risk and behavioral factors.
- Firms with heightened rollover risk tend not to acquire. If they do, acquirers allocate less capital to acquisitions. This impact is more pronounced during financial crises and among financially constrained firms
- High-rollover-risk firms prefer equity as a payment method over cash. The stock market exhibits a positive reaction to cash payment, but only when acquirers face low rollover risk.

[9]The marginal value of cash has been examined extensively in different frameworks. For instance, Faulkender and Wang (2006) discover that cash contributes less to equity value for firms with larger cash holdings and higher leverage. Dittmar and Mahrt-Smith (2007) and Harford, Mansi, and Maxwell (2008) find that cash is less valuable for firms with agency costs.

- Equity values of high-rollover-risk firms are more sensitive to changes in cash reserves.

4 Model

To understand these empirical observations, we develop a dynamic model, which incorporates cash accumulation, risky debt, lump-sum investments (e.g., M&A), and their payment methods, in the spirit of Bolton, Chen, and Wang (2011) and Della Seta, Morellec, and Zucchi (2020). Different from the one-period setup of Myers (1977), the rollover in our dynamic model effectively converts short-term debt into long-term debt, and this associated risk has significant implications for M&A investment and financing decisions.

4.1 Setup

We consider a representative firm with capital, K_s, in stage s, where $s \in \{pre, post\}$, denotes the pre- and post-merger stage. That is, the capital of the firm increases from K_{pre} to K_{post} after the merger. The asset, K_s, generates after-tax cash flow dY_t over a time increment dt:

$$dY_t = (1-\theta)[K_s^{\alpha}(\mu dt + \sigma dZ_t) + G(I)dt] \tag{10}$$

where μ and σ represent the average cash flow rate and its volatility, respectively, and Z_t is a standard Brownian motion. $\theta \in (0,1)$ denotes the corporate tax rate, and $\alpha < 1$ implies decreasing returns to scale.

The firm adopts either cash or stock payment to finance the deal. After the deal completion, it enjoys a synergy gain, $G(I)$, where I is the size of the target. We focus on operating synergies via capital acquisition, $G = 0$ before the acquisition and $G > 0$ after the acquisition.

The firm issues equity and risky debt to finance its M&A investment. Its debt structure can be characterized by a triplet, (C, P, M), where C is coupon payment, P is debt principal, and M is average debt maturity. As in Leland (1998) and Hackbarth, Miao, and Morellec

(2006), the firm retires debt, P/M, and issues the same amount of debt to keep its debt structure stationary, with a proportional cost κ.[10]

The firm accumulates cash, W_t, over time, with a carrying cost, while earning a risk-free rate r from its existing holdings, net of carrying cost of cash. The carrying cost can be interpreted as the opportunity cost of M&A investments as well. For sufficiently large cash reserves, the benefit of an additional dollar retained in the firm is decreasing.

Thus, its cash holdings, W_t evolve as follows:

$$\begin{aligned} dW_t = (1-\theta) & \Bigg[\underbrace{K_s^{\alpha}(\mu dt + \sigma dZ_t) - C dt}_{\text{Net income}} + \underbrace{(r-\lambda) W_t dt}_{\text{Net interest}} + \underbrace{G(I) dt}_{\text{Synergy gain}} \Bigg] \\ & - \underbrace{\frac{1}{M}[P - (1-\kappa) D(W_t)] dt}_{\text{Rollover loss/gain}} . \end{aligned} \tag{11}$$

The change in cash holdings, dW_t, has two components. The first component is from operating activities and includes net interest income from carrying cash, operating income net of coupon payments, and synergy gain $G(I)$ if a merger occurs. We assume $G(I) = gI$, which implies the additional gain from the increased capital, I. The second component represents the gain/loss from debt rollover payments. Over any time interval, dt, the firm issues a fraction m=$1/M$ of debt. If the firm is in financial difficulties, the market value of debt, $D_s(W_t)$, can be less than the par value P, resulting in a rollover loss. Intuitively, for short-maturity firms, the rollover loss can be large due to frequent rollovers if they fall into financial difficulties and the market value of newly issued debt $D_s(W_t)$ is low. These *ex post* rollover problems *ex ante* lead to different M&A decisions and payment methods.

[10] As shown in Figure 1, the maturity structure is relatively stable in recent years even during the crisis.

4.2 Valuation of Assets

We start our analysis by deriving the valuation function of equity and debt. Equity value, $E_s(W_t) \equiv E_s(W_t; K_s)$, during the pre- and post-merger stages $s \in \{pre, post\}$ satisfies:

$$\begin{aligned} rE_s\left(W_t\right) \; = \; & \left[(1-\theta)\left((r-\lambda)W_t + K_s^{\alpha}\mu - C + G(I)\right) - m\left(P - (1-\kappa)D_s\left(W_t\right)\right)\right] E_s'\left(W_t\right) \\ & + \frac{\left((1-\theta)\sigma K_s\right)^2}{2} E_s''\left(W_t\right). \end{aligned} \tag{12}$$

When cash reserves increase, equity holders make investment decisions. To focus on the investment policy, we assume equity holders do not pay out until cash reserves approach infinity after the lump-sum investment.Thus, we have the boundary condition as follows:

$$E_s'\left(W_t \to \infty; K_s\right) = 1. \tag{13}$$

When the firm's cash reserves decrease sufficiently, the firm might go bankrupt or issue new equity. We assume the firm has no access to outside equity when in financial difficulty, and is forced into bankruptcy if its cash holdings reach zero, i.e., $W = 0$. At default, the firm has to pay a liquidation cost and the remaining liquidation value is denoted as ι. Thus, shareholders receive the residual of the liquidation value as follows:

$$E_s(W_t = 0; K_s) = \max\left(\iota K_s - P, 0\right). \tag{14}$$

Therefore, we determine equity value, based on the boundary conditions (13) and (14).

Similarly, the debt value function, $D_s(W_t) \equiv D_s(W_t; K_s)$, is given as follows:

$$\begin{aligned} (r+m)\,D_s\left(W_t\right) \; = \; & \left[(1-\theta)\left((r-\lambda)W_t + K_s^{\alpha}\mu - C + G(I)\right) - m\left(P - (1-\kappa)D_s\left(W_t\right)\right)\right] D_s'\left(W_t\right) \\ & + \frac{\left((1-\theta)\sigma K_s\right)^2}{2} D_s''\left(W_t\right) + C + mP. \end{aligned} \tag{15}$$

Debt value also satisfies the boundary conditions, namely (16) and (17). First, debt holders receive the minimum of liquidated asset or principal value if the firm defaults:

$$D_s(W_t = 0; K_s) = \min(\iota K_s, P). \tag{16}$$

Second, because debt holders do not enjoy any upside benefits when cash holdings are sufficiently large, the marginal value of cash to debt holders goes to zero:

$$D'_s(W_t \to \infty; K_s) = 0. \tag{17}$$

4.3 Investment Decisions

The firm has an opportunity to acquire additional capital. Given its debt maturity and current cash holdings, the firm makes joint decisions in M&A and payment method. We consider two types of investment decisions. The first type is to determine the optimal expense, given cash as the payment choice. We focus on cash payment because more than 70% of deals (see Table 2) in our sample are cash-financed. The second type is to choose the optimal payment method (i.e., cash vs. stock payment), given the predetermined investment amount.

4.3.1 Optimal Expenses

We first examine how rollover risk affects firms' cash expenses on acquisitions, if the firm is allowed to conduct an acquisition and choose the size of its acquisition expense. However, external financing is unavailable, and the firm can only use its internal funds for acquisitions. Wet denote the size of the acquisition by I. Then, after the acquisition, its cash holdings decrease by the investment cost $I + \psi(I, K)$, where $\psi(.)$ is the adjustment cost of capital and it takes the quadratic form $\psi(I, K) = \psi I^2/K$. Its capital will increase from K_{pre} to $K_{\text{post}} = K_{\text{pre}} + I$. The value-matching conditions for equity value are as follows:

$$E_{\text{pre}}(W_t; K_{\text{pre}}) = \begin{cases} E_{\text{post}}(W_t; K_{\text{post}}) & \text{if no investments,} \quad (18a) \\ \max\limits_{I^*} E_{\text{post}}(W_t - I^* - \psi(I^*, K_{pre}); K_{\text{post}}) & \text{if investments.} \quad (18b) \end{cases}$$

$E_{\text{post}}(W_t; K_{\text{post}})$ in equation (18a) is the corner solution where no acquisition investment occurs, i.e., $K_{\text{post}} = K_{\text{pre}}$. When cash reserves increase, we have the interior solution in equation (18b), where the firm chooses the optimal amount, i.e., I^*.

When the acquisition is completed, the acquirer benefits from increased cash flows due to the expanded capital K_{post} and the synergy gain $G(I)$. At the same time, its cash holdings decrease by the amount of $I + \psi(I, K_{pre})$. Hence the firm may forgo large-scale investments due to the direct depletion of cash from its reserves, driven by the precautionary motive.

Furthermore, as we have discussed for Equation (11), higher cash reserves incur the opportunity cost of carrying excess cash, while lower cash reserves result in losses from debt rollover. Consequently, when having low cash reserves, the firm has a low market valuation of debt and a high price deviation, making a significant acquisition investment less likely. Moreover, short maturity magnifies the rollover loss due to frequent rollovers.

Overall, equity holders make optimal investment decisions by trading off between potential rollover losses and increased cash flows from cash-financed acquisitions. We solve the model by backward induction. That is, subject to the default condition (14), equity holders choose the optimal acquisition expenses to maximize their wealth in equation (18b).

Debtholders do not make the acquisition decision. The post-acquisition debt value, or the boundary condition for the debt value, is given as follows:

$$D(W_t; K_{\text{pre}}) = \begin{cases} D_{\text{pre}}(W_t; K_{\text{pre}}) & \text{if no investment,} \quad (19a) \\ D_{\text{post}}(W_t - I^* - \psi(I^*, K_{\text{pre}}) K_{\text{post}}) & \text{if investment.} \quad (19b) \end{cases}$$

where I^* is the size of the acquisition that maximizes equation (18b).

4.3.2 Optimal Payment Choice

The second decision is to choose the optimal payment method, given the exogenous investment, I. Suppose the M&A opportunity arrives exogenously when cash holdings are at W_t. The acquirer faces a payment decision to complete the deal with either all cash or all stock payment. After the M&A investment, I, the firm's capital increases from K_{pre} to K_{post} with a synergy gain G. Accordingly, we have value-matching conditions as follows:

$$E_{\text{pre}}(W_t; K_{\text{pre}}) = \begin{cases} E_{\text{post}}(W_t - I - \psi(I, K_{pre}); K_{\text{post}}) & \text{if cash payment,} \quad (20a) \\ E_{\text{post}}(W_t; K_{\text{post}}) - I - \psi(I, K_{pre}) - \phi E_{pay} & \text{if stock payment.} \quad (20b) \end{cases}$$

Equation (20b) states the condition for cash payments. The equity value increases from $E_{pre}(W_t; K_{pre})$ to $E_{post}(W_t - I - \psi(I, K_{pre}); K_{post})$, after a total cost $I + \psi(I, K_{pre})$ in the form of cash, where ψ is the capital adjustment cost. The acquirer enjoys capital expansion and synergy gain G. It is worth noting that the cash payment drains cash holdings, W_t, by the amount of $I + \psi(I, K_{pre})$. As we have discussed for Equation (11), debt retirement and issuance might cause future rollover loss/gain. Decreases in cash holdings due to cash payment might amplify rollover risk. Therefore, a firm faced with rollover risk is less likely to choose cash payment to complete the M&A transaction (precautionary savings motive).

Equation (20b) states the condition for acquisition for all equity payment. The equity value increases from $E_{pre}(W_t; K_{pre})$ to $E_{post}(W_t; K_{post})$, after the total payment $I + \psi(I, K_{pre}) + \phi E_{pay}$. Different from the cash payment that lowers cash holding, equity payment does not alter the state variable cash holding, W_t. In addition to the adjustment cost, ψ, equity financing incurs additional issuance cost, ϕ, paid to investment banks as underwriting costs. Asymmetric information and adverse selection make equity issuance costlier than debt issuance. Additionally, Barclay and Smith (1995) show that firms issue more short-term debt to mitigate higher informational asymmetries. While we do not model information explicitly, equity issuance cost could reflect informational problems, which also affect acquirers' preferences for the method of payment.

Taken together, the acquiring firm chooses its method of payment, either cash payment (Equation (20a)) or stock payment (Equation (20b)), to maximize equity value, $E_s(W_t; K_s)$:

$$\max\left\{ \underbrace{E_{\text{post}}(W_t - I - \psi(I, K_{pre}); K_{\text{post}})}_{\text{Cash payment}}, \underbrace{E_{\text{post}}(W_t; K_{\text{post}}) - I - \psi(I, K_{pre}) - \phi I}_{\text{Stock payment}} \right\} \tag{21}$$

Based on backward induction, equity holders of the pre-merger firm choose the method of payment *ex ante* (anticipating future rollover-induced default risk after the completion of merger). That is, equity holders maximize the pre-merger value Equation (20), subject to the default condition in Equation (14).

In contrast, existing debt holders do not make investment decisions. Because they do not benefit from the expansion investment, the post-merger debt value is the same as the pre-merger value, irrespective to the payment method, as follows:

$$D_{\text{pre}}(W_t, K_{\text{pre}}) = \begin{cases} D_{\text{post}}(W_t - I - \psi(I, K_{pre}); K_{\text{post}}) & \text{if cash payment,} \quad (22a) \\ D_{\text{post}}(W_t; K_{\text{post}}) & \text{if stock payment.} \quad (22b) \end{cases}$$

Given the boundary conditions and investment policies, we numerically solve the model, and obtain the value functions of equity and debt.

5 Model Results

In this section, we calibrate the model to understand our empirical results. We start by investigating the impact of rollover risk on cash acquisition expenses. Then, we proceed to examine the effects of rollover risk on payment choice in M&A and its implications for the market reaction. Finally, we examine the relation between equity/debt-cash sensitivity and rollover risk because their sensitivities have direct implications for the firm's M&A policies.

We follow the literature (e.g., Bolton et al. (2011), and Della Seta et al. (2020)) in selecting parameter values. Additionally, we normalize the pre-merger capital K_{pre} to 10. The acquisition cost, ψ, equals 1.5, and the acquisition gain (synergy), g, is 10% of the increased capital, i.e., $G(I) = 10\% \times I$. Table 11 reports all parameter values.

[Insert Table 11]

5.1 M&A Investments

We proceed to investigate the role of rollover risk in M&A decisions, specifically focusing on cash-financed acquisitions. Figure 3 provides insight into the optimal expenses on acquisitions for firms with varying debt maturities. We consider three maturity levels: short maturity (M=1), medium maturity (M=3), and long maturity (M=10). The x-axis represents the cash holdings of firms, which serves as an indicator of price deviation from par value (as defined by equation (11)) as well. Lower cash holdings imply larger rollover losses.

[Insert Figure 3]

Figure 3 reveals that when cash holdings are low, all three firms opt for zero expenses for acquisitions. As cash reserves increase, the long-maturity firm initiates acquisitions first, followed by the medium- and short-maturity firms at progressively higher cash levels. The positive relation between cash reserves and optimal investment is consistent with our intuition. Furthermore, given a level of cash reserves, we observe that short-maturity firms invest less than long-maturity ones, a manifestation of the short-maturity overhang problem.

These findings substantiate the empirical results of Table 5, which indicate that firms experiencing significant rollover losses are less inclined to pursue cash-financed mergers and acquisitions. Moreover, the effect of rollover risk is particularly prominent among firms with shorter maturity, giving rise to the phenomenon of short-maturity overhang, which is in contrast to the conventional view that long-term risky debt causes debt overhang.

5.2 Payment Method and Market Reaction

We next study the firm's decision to choose optimal investment and payment method for a given target size. We consider an opportunity to acquire a target with the relative size of the target to the acquirer set to $I/K_{pre} = 5\%$, consistent with the median of relative target size in our sample and empirical evidence from Moeller et al. (2004). Firms are given the option to pay using internal funds or by issuing equity to finance the acquisition. When issuing equity, the acquirer incurs additional costs from equity issuance. Firms select the payment choice that maximizes their equity value.

[Insert Figure 4]

Figure 4 illustrates the relationship between rollover risk and the payment choice. In Panel A, we examine the payment choice of a short-maturity firm. The y-axis represents the difference in gains between cash and stock payment. A negative (positive) difference indicates that cash payment is less (more) preferable than stock payment. The x-axis represents cash holdings, which reflects the low market value of debt faced by the firm. When cash holdings are low, cash payment is less preferred than equity payment because the gain difference between the two payment methods is negative. As cash holdings increase, the difference gradually becomes positive, indicating that cash becomes a preferred choice over stock.

In Panel B, we explore how rollover risk and debt maturity jointly influence payment choice. We plot firms' payment choice against maturity and cash holdings. In the gray area, firms choose to pay with stock, while in the white area, firms opt for cash payment. When cash holdings are sufficiently low, all the firms choose stock payment due to the potential rollover loss. As cash reserves increase, firms with higher maturity first transition from stock to cash payment, while low-maturity firms continue to use equity payment. Thus, the effect of rollover risk on payment choices is more significant among firms with shorter maturity.

These observations align with our previous discussion of Equations (11) and (12). When deciding between cash and stock payment, equity holders take into account the future rollover-induced default risk. Specifically, when firms face rollover risk and have short maturity, equity holders choose to issue equity to finance their M&A investments, particularly when their firm's financial condition is deteriorating.[11]

Furthermore, Figure 4 indicates that equity holders, in their pursuit of maximizing equity value, should expect firms with lower rollover risk to experience a greater increase in equity value when they choose cash payment. Conversely, for firms facing high rollover risk, they should not anticipate a positive market reaction from cash payment. These implications align with our empirical findings presented in Table 9, confirming the importance of rollover risk for payment method, which is different from the traditional signaling theory.

In summary, these findings reinforce the empirical evidence from Table 8, demonstrating that firms with high rollover risk exhibit a preference for equity payment over cash payment in mergers and acquisitions. Moreover, this preference for equity payment is particularly pronounced among firms with shorter maturity. Notably, following the announcement of their acquisitions, firms with lower rollover risk that opt for cash payment experience higher positive equity returns compared to those facing high rollover risk, consistent with the results presented in Table 9. We emphasize that the precautionary saving motive in choosing payment method worsens the overhang problem in the context of mergers and acquisitions.

5.3 Sensitivities of Equity and Debt Values to Cash

To better understand the model mechanism and payment choice, we further examine the sensitivity of equity or debt value to cash reserves prior to the M&A investment, because equity holders make the decision on payment choice (cash vs. equity) and care about the changes in cash reserves.

[11] An alternative role played by debt maturity is related to signaling a firm's future credit worthiness or profitability (see, e.g., Diamond (1991), and Flannery (1986)). Intuitively, higher quality firms, on the margin, choose shorter maturity debt as a costly signal to distinguish themselves from lower quality firms, which would not be able to bear the larger (rollover) risk. By the same logic, we would expect firms with shorter debt maturity to use cash as a method of payment to signal their higher quality in a costly way that lower quality firms cannot easily implement. In contrast to such signaling, our model predicts a new role of debt maturity.

The sensitivities (or elasticities) of equity and debt to cash are expressed as follows:

$$Sensitivity_E = \frac{\partial \log E(W)}{\partial \log W} = \frac{\partial E(W)}{\partial W}\frac{W}{E(W)}, \tag{23a}$$

$$Sensitivity_D = \frac{\partial \log D(W)}{\partial \log W} = \frac{\partial D(W)}{\partial W}\frac{W}{D(W)}. \tag{23b}$$

The sensitivity of equity in equation (23a) is the marginal value of cash, $\partial E(W)/dW$, divided by the average value of cash, *E(W)/W*, and analogously for the sensitivity of debt in equation (23b). Our discussions of the equity/debt sensitivities focus on the firms immediately prior to the merger because their sensitivity affects their future M&A investment and financing decisions.

5.3.1 Equity-cash Sensitivity

Figure 5 depicts the relationship between cash (W) and the sensitivity of asset value to cash holdings across three maturity levels. The solid, dashed, and dotted lines represent short maturity (M = 1), medium maturity (M = 3), and long maturity (M = 10), respectively, in both figures. In our model, the level of cash reserves determines the market value of debt. Therefore, a low (high) level of cash reserves implies a low (high) market value of debt and a high (low) price deviation.

[Insert Figure 5]

Two observations follow from Panel A of Figure 5. First, equity-cash sensitivities are higher when firms have a low level of cash reserves, indicating that the sensitivities increase as firms face more severe price deviation. This observation aligns with our intuition. When firms are cash-strapped and closer to bankruptcy, both equity and debt holders become more sensitive to the level of the firm's cash reserves due to repayment concerns driven by deteriorating financial conditions.

Second, the sensitivities in short-maturity firms (red solid line) are greater than those in long-maturity firms (green dotted line), given a level of cash reserves. The difference in equity-cash sensitivities is more pronounced among firms with short maturity. These results align with our intuition. Equity holders have an incentive to issue new debt to roll over existing debt to maintain the stability of the firm and preserve investment opportunities, such as mergers and acquisitions. Short-maturity debt implies more frequent rollovers and greater rollover risk. Consequently, the frequent rollovers in short-maturity firms lead to a greater transfer of wealth from equity holders to debt holders, making equity holders more sensitive to corporate cash holdings.

Therefore, this result provides theoretical support for our empirical finding in Table 10 that equity values are more sensitive to cash reserve among firms with a larger price deviation, shorter maturity and higher rollover risk.

5.3.2 Debt-cash Sensitivity

Panel B depicts debt-cash sensitivities. First, the debt-cash sensitivities are smaller than the equity-cash sensitivities. This difference is expected because bondholders receive fixed income payments prior to bankruptcy and have a claim on the liquidation value of assets during bankruptcy. Second, similar to equity, debt-cash sensitivities are higher if firms have a low level of cash reserves. Third, in contrast to their equity counterparts in Panel A, the debt-cash sensitivities in short-maturity firms (in red solid line) are smaller than those in long-maturity firms (in green dotted line) across all levels of cash, with a smaller difference in the high level of cash.

The contrasting behavior between debt and equity in relation to cash sensitivities is worth discussing. First, consistent with the explanation provided for equity-cash sensitivities, debt holders in short-maturity firms benefit from the wealth transferred from equity holders. As a result, they are less sensitive to changes in cash reserves. Second, in long-maturity firms, debt holders receive the remaining wealth after the short-maturity debt holders. Consequently, debt holders of long-maturity firms are more sensitive to the level of cash reserves, particularly when firms are close to bankruptcy and have low levels of cash. Given these factors together, debt holders in short-maturity firms are less sensitive to cash compared to those in long-maturity firms, particularly when cash reserves are low.

In sum, our calibrated model demonstrates that shortening debt maturity amplifies the sensitivities of equity to cash due to frequent rollovers. In an interesting contrast, short-maturity debt mitigates the debt-cash sensitivities, particularly when cash reserves decrease. As argued earlier, this suggests that short maturity alone is not a good proxy for rollover risk.

6 Conclusion

We study how fluctuations in corporate bond prices contribute to rollover risk, and how this risk distorts corporate investment and financing activities – a maturity overhang problem. Using bond transaction data, we develop a novel market-based measure of rollover risk and uncover important insights. Our empirical results reveal the adverse effect of rollover risk on merger activities at the firm and aggregate levels. Acquirers facing higher rollover risk are more sensitive to changes in cash reserves and prefer equity as a payment method over cash. Furthermore, equity holders react positively when those acquirers use less cash for payment.

Specifically, we find that a one standard deviation increase in rollover risk leads to a significant 1.5% decrease in the cash acquisition rate, representing a nearly 43% decrease of the average acquisition rate, and a 19.4% reduction in the probability of an all-cash payment. In contrast, debt maturity, a typical proxy for rollover risk, has a much weaker effect on M&A investments, and no effect at all on the payment method. Those contrasts demonstrate the importance of our market-based measure in empirical studies.

To shed light on the underlying economic drivers, we build a dynamic investment model incorporating cash accumulation, rollover risk, and financing methods. Our model illustrates the importance of rollover risk and precautionary saving in shaping corporate investments. During debt rollovers at market prices, firms face potential rollover gains or losses. In particular, firms with shorter debt maturity face more severe rollover risk because of frequent rollovers, resulting in the short-maturity overhang problem. Cash hoarding does not resolve maturity overhang. High-rollover risk firms carefully manage their cash reserves, while making investment and payment method choices. For precautionary reasons, those firms are less incentivized to make significant M&A investments. If they do, they tend to choose equity as a payment method over cash, anticipating potential defaults induced by rollover risk. Therefore, precautionary motives might worsen the maturity overhang.

We further explore payment choice in M&A, by studying the sensitivities of equity to cash reserves. Equity values are highly sensitive to changes in cash holdings, when firms have low levels of cash reserves or are close to bankruptcy. Short maturity amplifies the sensitivities of equity value to cash reserves. We empirically and theoretically show that equity holders who place a high marginal value on cash are likely to use cash as their payment in acquisitions.

To conclude, our study contributes to our understanding of M&A decision-making by considering the influence of corporate bond market conditions and rollover risk. Our findings have implications for cash management, debt maturity structure, and payment methods in M&A. Future studies could extend this work by investigating the interaction between risk management and rollover risk, and their implications for M&A activities.

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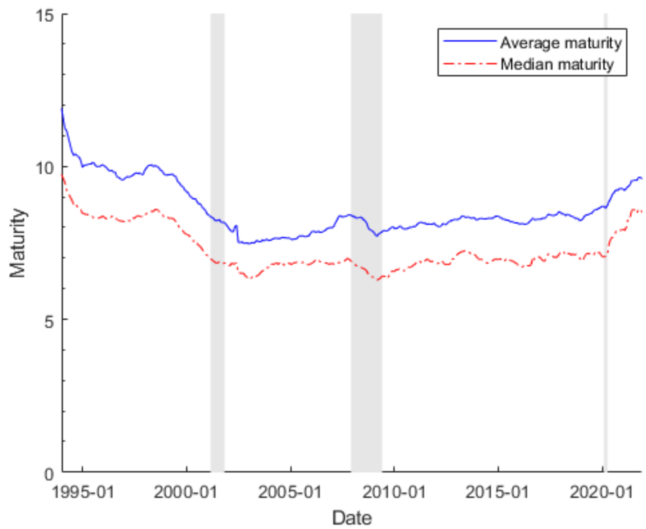


Figure 1. Maturity over time

This figure shows the average and median maturity of firms in our sample over time. The solid and dotted lines correspond to the average and median maturity, respectively. The gray areas are for NBER recession dates.

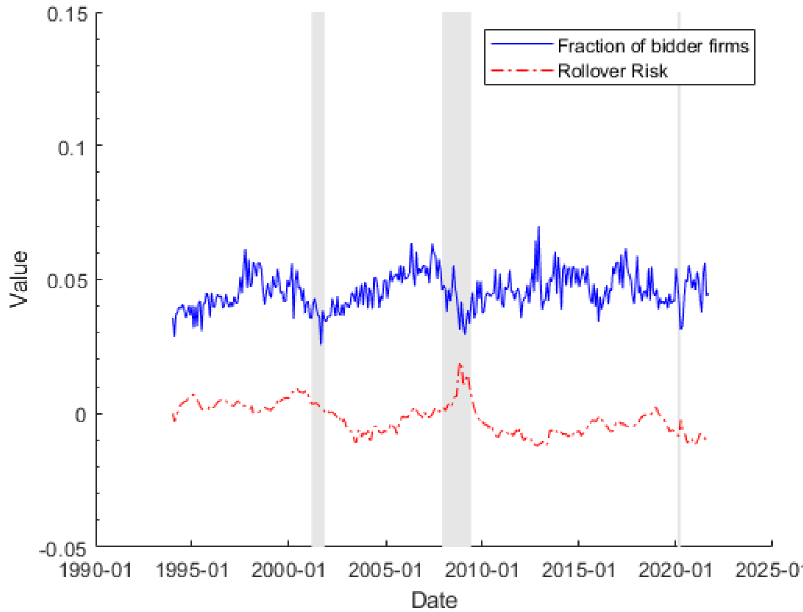


Figure 2. Aggregate rollover risk and merger waves
This figure illustrates the relationship between merger waves and aggregate rollover risk. The solid and dotted lines correspond to the fraction of bidder firms to the number of public firms and rollover risk measure, respectively. The gray areas are for NBER recession dates.

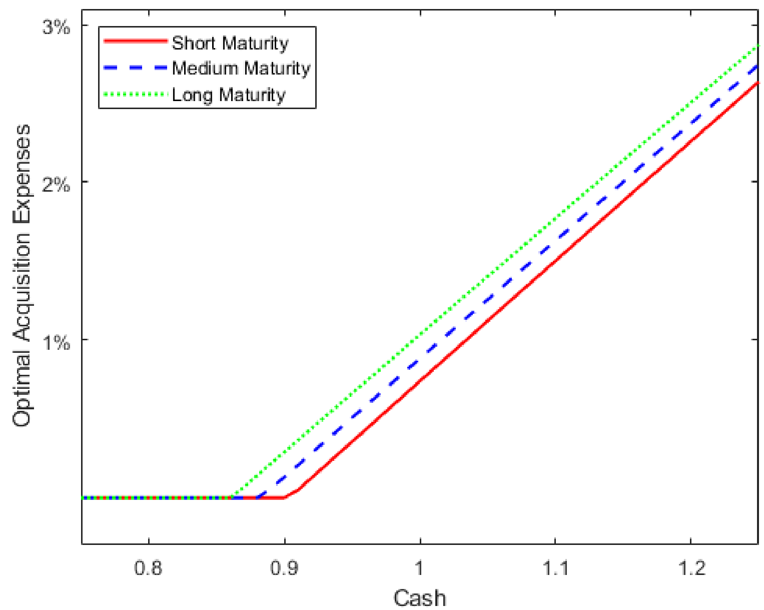


Figure 3. Optimal acquisition expenses and rollover risk

This figure illustrates the relationship between optimal acquisition expenses and rollover risk. The x-axis variable represents cash holdings. The y-axis variable represents the optimal relative size of the target firms that should be acquired. The solid, dashed, and dotted lines correspond to short maturity (1), medium maturity (3), and long maturity (10) respectively. A zero-acquisition expense indicates no acquisition.

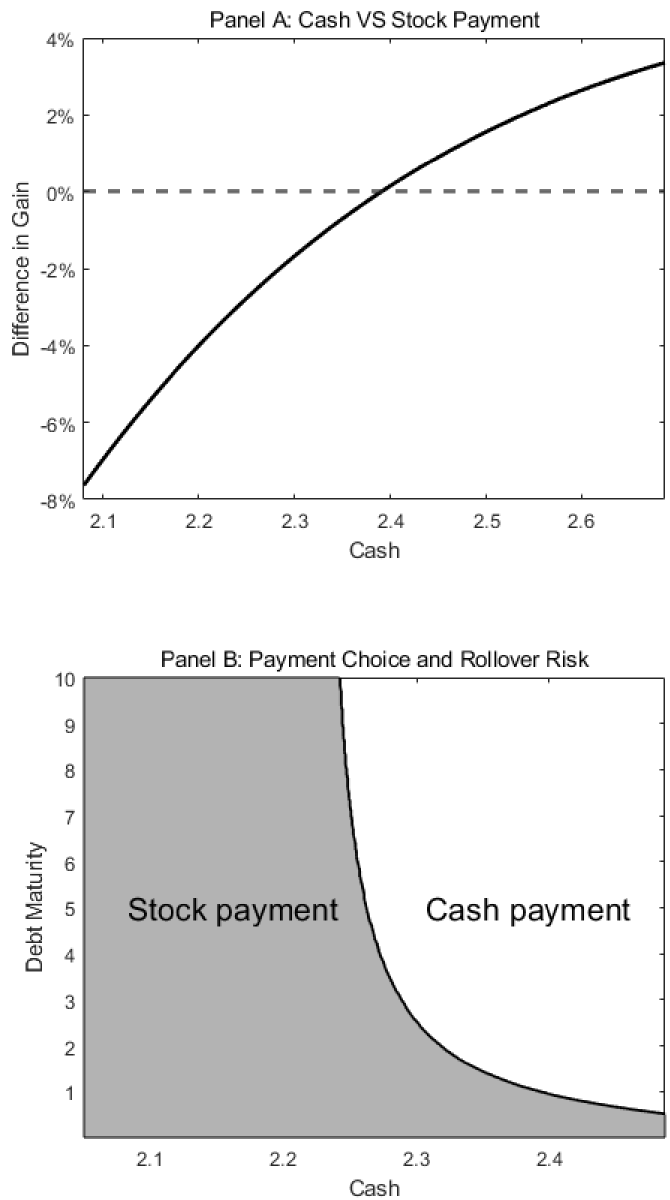


Figure 4. Acquisition policy and rollover risk.
This figure illustrates how rollover risk affects the payment choice in mergers and acquisitions. In both panels, the x-axis variable represents cash holdings, which signifies the price deviation of debt faced by firms. Panel A focuses on the effect of price deviation on payment choice. The y-axis variable represents the difference between the gains from cash payment and stock payment for the short-maturity firm (M=1). Panel B demonstrates how rollover risk (joint with maturity) influences payment choice. The grey area indicates that stock payment is preferred, while the white area indicates that cash payment is preferred.

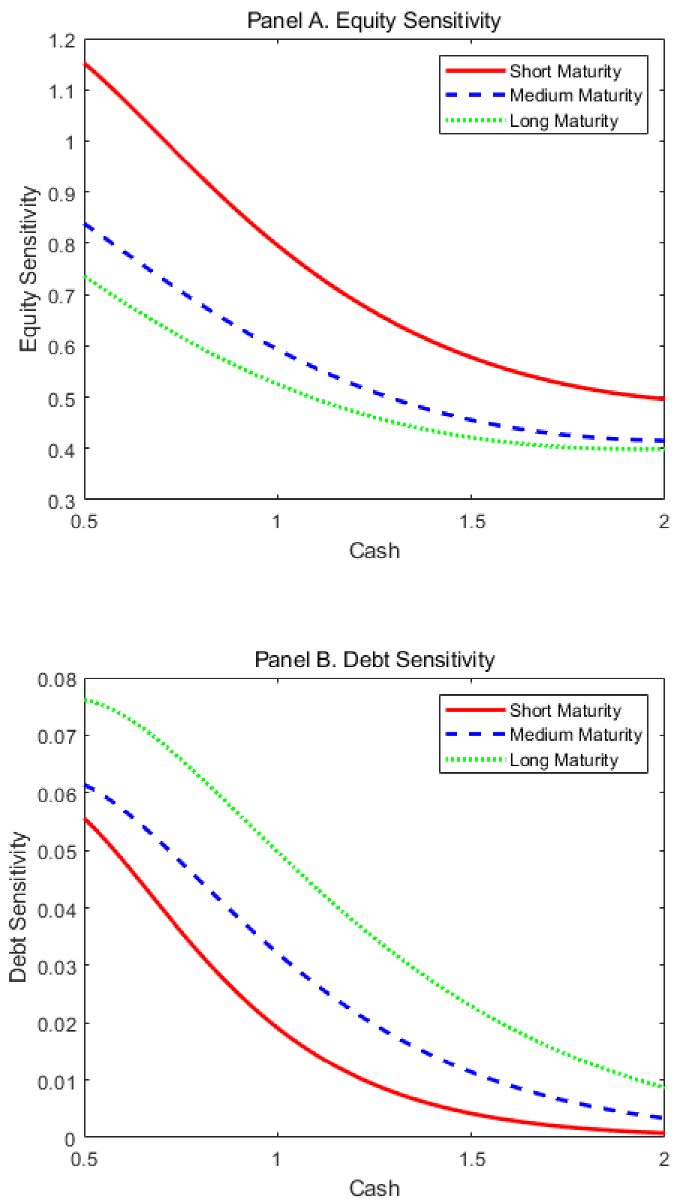


Figure 5. Sensitivities and rollover risk
This figure illustrates the relationship between rollover risk and the sensitivity to cash holding of equity value in Panel A and debt value in Panel B, across three levels of debt maturity. The solid, dashed, and dotted lines correspond to for short maturity (1), medium maturity (3), and long maturity (10) respectively. The x-axis variable represents cash reserve, which serves as an indicator of debt price deviation faced by firms.

Table 1. Empirical variable definitions

Panel A: firm characteristics	
Variable	**Definition**
Price deviation	value-weighted difference between market value and par value of a bond scaled by its par value (Source: NAIC and TRACE)
Inverse maturity	reciprocal of the value-weighted maturities of bonds of a firm (Source: NAIC and TRACE)
Rollover risk	price deviation multiplied by inverse maturity at the firm level (Source: NAIC and TRACE)
Acquisition dummy	an indicator that equals to one if the firm acquires at least one target in the given period. (Source: SDC MA)
Acquisition expenses	cash expenses on acquisitions (AQC) scaled by book value (AT). (Source: Compustat)
Transaction value	total value of acquisition completed in the given period scaled by book value (AT). (Source: SDC MA and Compustat)
Amihud illiquidity	a measure of the illiquidity of the bonds using the definition of Amihud (2002) (Source: NAIC and TRACE)
NAIC dummy	an indicator that equals one for bond prices from NAIC, for which the Amihud illiquidity measure is not calculated. (Source: NAIC)
Log(equity value)	logarithm of equity value (PRCC_F×CSHO) (Source: Compustat)
Log(cash)	logarithm of cash (CHE) (Source: Compustat)
Leverage	total book debt (DLC + DLTT) divided by the sum of book debt and market equity (PRCC×CSHO + DLC + DLTT) (Source: Compustat)
Log sales	logarithm of total sales (Sale) (Source: Compustat)
Tangibility	net property, plants and equipments (PPENT) divided by total assets (AT) (Source: Compustat)

Table 1 – continued from previous page

Variable	**Definition**
Profit	operating income (OIBDP) divided by total assets of the previous year (AT) (Source: Compustat)
Market-to-book ratio	The ratio of the market value of assets (PRCC$\times$CSHO + DLC + DLTT) to its book value (AT) (Source: Compustat)
Cash	cash and short term investments (CHE), divided by total assets (AT) of the previous year (Source: Compustat)
Capital expenditures	capital investment (CAPX) divided by total assets (AT) (Source: Compustat)
R&D expenses	research and development expenses (XRD) divided by total assets (AT) (Source: SDC M&A and Compustat)
Dividend ratio	dividend (DVC) divided by total assets (AT) (Source: Compustat)
Whited-Wu index	index measuring financial constraint (Whited and Wu, 2006): -0.091$\times$Profit - 0.062$\times\mathbf{1}_A$(Issuing dividend) + 0.021$\times$DLTT/AT - 0.044$\times$log(1 + AT) - 0.035$\times$Sale growth + 0.102$\times$ Median Sale Growth (Source: Compustat)

Panel B: deal characteristics	
Variable	**Definition**
Cash payment fraction (%)	percentage of cash payment in the total transaction value. (Source: SDC MA)
Log of target size	log of the transaction value in the acquisition deal. (Source: SDC MA)
Relative size	transaction value/market value of acquirer. (Source: SDC MA)
Horizontal	an indicator that equals to one if the acquirer and the target are in the same industry (i.e., same first two-digit SIC codes). (Source: SDC MA)
Friendly deal	an indicator that equals to one if the deal attitude is friendly. (Source: SDC MA)
Public target	an indicator that equals to one if the target is a public firm. (Source: SDC MA)
Bidder return	one-year excess return before acquisition announcement. The benchmark is 25 Fama and French portfolios formed on size and book-to-market. (Source: CRSP)

Table 2. Summary statistics

This table reports summary statistics of firm and acquisition samples. Panel A is for the firm-year CRSP/Compustat sample from 1990 to 2021. Panel B is for the acquisition deal sample from SDC Mergers and Acquisitions data over the same period. Panel C shows our aggregate variables.

Panel A: Aggregate variables								
	N	Mean	SD	P10	P25	Median	P75	P90
Fraction of bidder firms to total public firms	336	0.046	0.007	0.037	0.041	0.045	0.050	0.055
Aggregate rollover risk	335	-0.003	0.006	-0.009	-0.007	-0.003	0.002	0.005
T-bill rate	335	0.022	0.021	0.000	0.001	0.017	0.046	0.051
Term structure	335	0.021	0.013	0.005	0.011	0.020	0.033	0.040
Credit spread	335	0.010	0.004	0.006	0.007	0.009	0.011	0.013
Inflation	335	0.023	0.041	-0.020	0.000	0.023	0.049	0.070
log of S&P index	335	7.223	0.510	6.559	6.957	7.172	7.587	7.946
Market-to-book ratio	335	4.027	1.269	2.861	3.107	3.610	4.471	6.109
Change in VIX	332	0.000	0.048	-0.044	-0.023	-0.001	0.019	0.051
Consumer sentiment index	325	0.885	0.124	0.708	0.806	0.912	0.968	1.045

Panel B: Firm characteristics								
	N	Mean	SD	P10	P25	Median	P75	P90
Bond maturity	15,502	8.081	4.721	3.435	4.983	6.941	9.630	14.478
Inverse maturity	15,502	0.171	0.118	0.069	0.104	0.144	0.201	0.291
Price deviation	15,502	-0.006	0.118	-0.109	-0.068	-0.024	0.018	0.101
Rollover risk	15,502	-0.000	0.021	-0.016	-0.010	-0.003	0.003	0.017
Cash	15,497	0.087	0.104	0.007	0.019	0.052	0.117	0.207
Log sales	15,502	8.092	1.498	6.128	7.108	8.157	9.190	9.971
Market-to-book ratio	15,502	1.416	0.993	0.672	0.850	1.132	1.638	2.445
Leverage	15,502	0.369	0.187	0.157	0.233	0.337	0.479	0.639
Tangibility	15,502	0.337	0.244	0.063	0.134	0.277	0.509	0.723
Profit	15,470	0.129	0.093	0.052	0.091	0.130	0.173	0.224
Dividend ratio	15,502	0.013	0.018	0.000	0.000	0.005	0.019	0.037
Capital expenditures	15,502	0.059	0.059	0.011	0.022	0.040	0.072	0.131
Acquisition dummy	15,502	0.222	0.416	0.000	0.000	0.000	0.000	1.000
Transaction value	15,468	0.040	0.146	0.000	0.000	0.000	0.000	0.091
Acquisition expenses	15,468	0.035	0.088	0.000	0.000	0.000	0.022	0.104

Panel C: Deal and target characteristics								
	N	Mean	SD	P10	P25	Median	P75	P90
Cash-financed deal	1,629	0.722	0.448	0.000	0.000	1.000	1.000	1.000
Cash payment fraction (%)	1,629	79.067	37.584	0.000	74.550	100.000	100.000	100.000
Log of target size	1,629	6.025	1.778	3.689	4.838	5.956	7.242	8.305
Relative size	1,629	0.139	0.258	0.011	0.020	0.053	0.138	0.354
Public target	1,629	0.352	0.478	0.000	0.000	0.000	1.000	1.000
Horizontal	1,629	0.592	0.492	0.000	0.000	1.000	1.000	1.000
Friendly deal	1,629	0.990	0.102	1.000	1.000	1.000	1.000	1.000
Bidder return	1,627	0.156	0.757	-0.310	-0.134	0.041	0.264	0.561

Table 3. Aggregated rollover risk and acquisition activity

This table examines the relation between rollover risk and acquisition activity at the aggregate level. The dependent variable is the monthly fraction of bidder firms to total public firms. The aggregated rollover risk is the monthly value-weighted average of firm-level rollover risk, which measures the price deviation from bond par value multiplied by inverse maturity. We adjust the standard errors using the Newey-West method with 12 lags. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Fraction of bidder firms to total public firms		
	(1)	(2)	(3)
Aggregate rollover risk	-0.407***		-0.539***
	(-4.14)		(-3.36)
T-bill rate		0.260**	0.446***
		(2.31)	(4.80)
Term structure		0.176	0.298***
		(1.39)	(2.71)
Credit spread		-0.499***	0.005
		(-3.89)	(0.02)
Inflation		-0.014*	-0.019**
		(-1.95)	(-2.47)
log of S&P index		0.012***	0.014***
		(3.19)	(4.81)
Market-to-book ratio		-0.002***	-0.002***
		(-3.03)	(-3.37)
Change in VIX		0.009	0.009
		(1.23)	(1.29)
Consumer sentiment index		-0.009	-0.008
		(-1.50)	(-1.47)
Observations	335	325	324
Adjusted R-squared	0.11	0.32	0.37

Table 4. Propensity to acquire and rollover risk

This table reports results of Probit regressions to examine the relationship between bond rollover risk, maturity, and propensity to acquire. The sample includes firms from the CRSP and Compustat databases covering the period from 1990 to 2021, excluding financial and utility firms, which have observations in TRACE and NAIC. The dependent variable is a dummy variable that equals one if the firm acquires at least one target in a given year. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. Columns (1) to (3) include the full sample, while columns (4) to (6) restrict the sample to firms experiencing rollover loss (where the bond's market value is lower than its par value). We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Acquisition dummy					
Sample	All			Rollover loss		
	(1)	(2)	(3)	(4)	(5)	(6)
Rollover risk	-4.729***			-5.293***		
	(-4.24)			(-3.16)		
Price deviation		-0.762***			-0.809***	
		(-3.99)			(-2.75)	
Inverse maturity			-0.346**			-0.993***
			(-2.19)			(-3.37)
Leverage	-0.515***	-0.527***	-0.611***	-0.554***	-0.568***	-0.634***
	(-4.56)	(-4.70)	(-5.49)	(-3.06)	(-3.17)	(-3.50)
Log sales	0.049***	0.046***	0.046***	0.092***	0.097***	0.088***
	(3.03)	(2.80)	(2.85)	(3.69)	(3.90)	(3.53)
Tangibility	-0.601***	-0.602***	-0.613***	-0.688***	-0.692***	-0.722***
	(-4.42)	(-4.44)	(-4.51)	(-2.98)	(-3.02)	(-3.14)
Profit	0.424*	0.441*	0.607***	0.195	0.224	0.382
	(1.82)	(1.90)	(2.67)	(0.70)	(0.82)	(1.42)
Cash	-0.160	-0.156	-0.188	0.357	0.362	0.320
	(-0.77)	(-0.76)	(-0.91)	(1.24)	(1.27)	(1.09)
Market-to-book ratio	0.094***	0.095***	0.098***	0.106***	0.105***	0.109***
	(4.37)	(4.39)	(4.47)	(3.52)	(3.52)	(3.55)
Capital expenditures	-0.172	-0.159	-0.249	0.447	0.485	0.377
	(-0.42)	(-0.38)	(-0.60)	(0.76)	(0.83)	(0.64)
Dividend ratio	-0.531	-0.657	-0.709	-2.266	-2.219	-2.209
	(-0.45)	(-0.56)	(-0.60)	(-1.09)	(-1.07)	(-1.07)
Amihud liquidity	-0.036	-0.043	-0.050	0.027	0.024	0.009
	(-0.77)	(-0.90)	(-1.06)	(0.45)	(0.40)	(0.15)
NAIC dummy	0.128	0.128	0.113	0.032	0.034	0.072
	(0.65)	(0.65)	(0.57)	(0.09)	(0.09)	(0.19)
Observations	13,204	13,204	13,204	4,341	4,341	4,341
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 5. Acquisition expenses, maturity, and rollover risk

This table reports results of Tobit regressions to examining the relationship between rollover risk, maturity, and acquisition expenses. The sample includes firms from the CRSP and Compustat databases covering the period from 1990 to 2021, excluding financial and utility firms, which have observations in TRACE and NAIC. The dependent variable is acquisition expenses scaled by total assets. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. Columns (1) to (3) include the full sample, while columns (4) to (6) restrict the sample to firms experiencing rollover loss (where the bond's market value is lower than its par value). We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Acquisition expenses					
Sample	All			Rollover loss		
	(1)	(2)	(3)	(4)	(5)	(6)
Rollover risk	-0.667***			-0.724***		
	(-6.37)			(-5.20)		
Price deviation		-0.135***			-0.139***	
		(-6.98)			(-5.40)	
Inverse maturity			-0.057***			-0.073**
			(-3.54)			(-2.47)
Leverage	-0.037***	-0.036***	-0.051***	-0.041**	-0.040**	-0.053***
	(-2.95)	(-2.88)	(-4.15)	(-2.39)	(-2.37)	(-3.12)
Log sales	-0.006***	-0.007***	-0.006***	-0.005**	-0.005*	-0.005*
	(-3.24)	(-3.64)	(-3.42)	(-2.04)	(-1.89)	(-1.89)
Tangibility	-0.096***	-0.096***	-0.098***	-0.095***	-0.096***	-0.100***
	(-6.45)	(-6.47)	(-6.55)	(-4.61)	(-4.65)	(-4.82)
Profit	0.190***	0.188***	0.215***	0.133***	0.130***	0.158***
	(6.28)	(6.21)	(7.12)	(3.61)	(3.60)	(4.27)
Cash	-0.025	-0.023	-0.028	-0.039	-0.037	-0.046
	(-1.12)	(-1.04)	(-1.28)	(-1.21)	(-1.15)	(-1.43)
Market-to-book ratio	0.000	0.000	0.001	0.003	0.003	0.004
	(0.10)	(0.10)	(0.37)	(0.95)	(0.90)	(1.16)
Capital expenditures	-0.169***	-0.164***	-0.178***	-0.080	-0.070	-0.082
	(-3.23)	(-3.13)	(-3.39)	(-1.09)	(-0.96)	(-1.12)
Dividend ratio	-0.074	-0.095	-0.103	0.115	0.121	0.124
	(-0.59)	(-0.74)	(-0.80)	(0.55)	(0.58)	(0.58)
Amihud liquidity	0.003	0.002	0.001	0.005	0.005	0.004
	(0.95)	(0.72)	(0.39)	(1.24)	(1.29)	(0.95)
NAIC dummy	-0.005	-0.005	-0.006	-0.045	-0.046	-0.035
	(-0.33)	(-0.32)	(-0.41)	(-1.55)	(-1.57)	(-1.19)
Observations	13,227	13,227	13,227	4,380	4,380	4,380
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6. Rollover risk, financial crisis, and M&A

This table reports the relationship between rollover risk and merger and acquisitions during the financial crisis. The sample includes firms from the CRSP and Compustat databases covering the period from 2005 January to 2010 December, excluding financial and utility firms, which have observations in TRACE. The dependent variable is a dummy variable that equals one if the firm acquires at least one target in each month in Columns (1) and (2), and acquisition transaction value scaled by the book asset in each month in Columns (3) and (4). *Crisis* is an indicator variable that equals to one for the time period of 2007 December to 2010 December. *Rollover loss* is an indicator variable that equals to one if debt rollover causes a loss (i.e., rollover risk > 0). Firms are assigned to the short-maturity group each month if their maturity is below the median, and the indicator variable, *Short maturity*, equals one for the short-maturity firms and zero otherwise. We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Acquisition dummy		Transaction value	
	(1)	(2)	(3)	(4)
Rollover loss	-0.055		-0.023	
	(-1.21)		(-0.92)	
Rollover loss × Crisis	-0.138**		-0.081**	
	(-2.14)		(-2.26)	
Short maturity		-0.044		-0.014
		(-0.93)		(-0.57)
Short maturity × Crisis		-0.060		-0.037
		(-0.93)		(-1.07)
Leverage	-0.235*	-0.268**	-0.120*	-0.138**
	(-1.88)	(-2.17)	(-1.78)	(-2.06)
Log sales	0.062***	0.061***	0.027***	0.027***
	(3.21)	(3.00)	(2.73)	(2.60)
Tangibility	-0.320	-0.321	-0.134	-0.134
	(-1.54)	(-1.51)	(-1.24)	(-1.22)
Profit	0.455*	0.519*	0.170	0.200
	(1.66)	(1.88)	(1.01)	(1.17)
Cash	-0.138	-0.143	-0.094	-0.097
	(-0.60)	(-0.62)	(-0.78)	(-0.81)
Market-to-book ratio	0.092***	0.094***	0.061***	0.062***
	(3.04)	(3.04)	(3.24)	(3.23)
Capital expenditures	-0.247	-0.307	-0.134	-0.162
	(-0.37)	(-0.47)	(-0.39)	(-0.48)
Dividend ratio	-0.694	-0.721	-0.247	-0.251
	(-0.44)	(-0.46)	(-0.31)	(-0.31)
Amihud liquidity	-0.000	-0.001	-0.000	-0.000
	(-0.39)	(-0.28)	(-0.29)	(-0.34)
Observations	38,679	38,679	39,431	39,431
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

Table 7. Rollover risk, M&A and financial constraint

This table reports the relationship between rollover risk, M&A and financial constraint. The sample includes firms from the CRSP and Compustat databases covering the period from 1994 to 2021, excluding financial and utility firms, which have observations in TRACE. The dependent variable is a dummy variable that equals one if the firm acquires at least one target in a given year in Columns (1) and (2), acquisition expenses scaled by book value in Columns (3) and (4), and acquisition transaction value scaled by book assets in Columns (5) and (6). *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. Using on the Whited-Wu index (Whited and Wu, 2006), we classify firms each year into financially constrained (C) and unconstrained (U) groups. We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Acquisition dummy		Acquisition expense		Transaction value	
Constrained/Unconstrained	C	U	C	U	C	U
	(1)	(2)	(3)	(4)	(5)	(6)
Rollover risk	-6.300***	-1.111	-0.810***	-0.263	-2.473***	0.064
	(-4.57)	(-0.52)	(-5.72)	(-1.55)	(-4.81)	(0.11)
Leverage	-0.334**	-0.852***	-0.035*	-0.043***	-0.079	-0.218***
	(-2.38)	(-4.99)	(-1.88)	(-2.84)	(-1.53)	(-4.39)
Log sales	0.014	0.067**	0.001	-0.008***	-0.005	-0.002
	(0.57)	(2.48)	(0.39)	(-3.27)	(-0.56)	(-0.24)
Tangibility	-0.747***	-0.537***	-0.149***	-0.096***	-0.223***	-0.156***
	(-4.66)	(-3.08)	(-7.66)	(-5.66)	(-3.88)	(-3.40)
Profit	0.233	0.731*	0.135***	0.242***	0.072	0.265**
	(0.91)	(1.76)	(3.62)	(6.17)	(0.78)	(2.15)
Cash	-0.675**	0.406	-0.090***	0.041	-0.196**	0.095
	(-2.55)	(1.41)	(-2.87)	(1.46)	(-2.01)	(1.29)
Market-to-book ratio	0.115***	0.059*	0.004	-0.006**	0.051***	0.022**
	(4.25)	(1.80)	(1.05)	(-2.06)	(4.72)	(2.17)
Dividend ratio	1.012	-0.500	0.602**	-0.231	0.174	-0.318
	(0.54)	(-0.33)	(2.44)	(-1.64)	(0.27)	(-0.76)
Amihud liquidity	-0.034	-0.010	0.002	0.002	-0.006	-0.008
	(-0.49)	(-0.16)	(0.39)	(0.57)	(-0.28)	(-0.55)
NAIC dummy	0.150	0.040	0.008	-0.020	0.068	0.012
	(0.47)	(0.16)	(0.29)	(-1.43)	(0.66)	(0.19)
Observations	6,273	6,832	6,342	6,865	6,342	6,865
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 8. Payment method and rollover risk

This table reports results from Probit regressions for the relation between rollover risk and payment method in mergers and acquisitions. The sample includes completed deals in SDC from 1990 to 2021, excluding financial and utility acquirers, which have observations in TRACE and NAIC. The dependent variable is an indicator variable that equals one if the acquisition is 100% cash financed, and zero otherwise. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. We include control variables of acquirers' characteristics, industry-and year-fixed effects, and cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Cash-financed deals		
	(1)	(2)	(3)
Rollover risk	-9.049**		
	(-2.24)		
Price deviation		-1.130*	
		(-1.69)	
Inverse maturity			-0.648
			(-1.53)
Cash	-0.792*	-0.844*	-0.946**
	(-1.69)	(-1.78)	(-1.97)
Leverage	-0.282	-0.329	-0.492
	(-0.79)	(-0.92)	(-1.37)
Log sales	-0.058	-0.063	-0.066
	(-1.07)	(-1.13)	(-1.17)
Market-to-book ratio	-0.147***	-0.141***	-0.125***
	(-3.02)	(-2.93)	(-2.68)
Tangibility	-0.219	-0.253	-0.362
	(-0.65)	(-0.75)	(-1.06)
Dividend	7.543**	7.569**	7.717**
	(2.51)	(2.51)	(2.57)
R&D expenses	0.320	0.319	-0.012
	(0.18)	(0.18)	(-0.01)
Relative size	-2.575***	-2.577***	-2.571***
	(-8.03)	(-8.05)	(-8.06)
Horizontal	0.015	0.019	0.034
	(0.15)	(0.19)	(0.34)
Friendly deal	-0.110	-0.116	-0.112
	(-0.28)	(-0.30)	(-0.29)
Public target	-0.850***	-0.851***	-0.848***
	(-7.87)	(-7.89)	(-7.87)
10-year interest rate	-0.050	-0.053	-0.059
	(-0.44)	(-0.46)	(-0.52)
Bidder return	-0.366***	-0.369***	-0.371***
	(-3.42)	(-3.54)	(-3.84)
Amihud liquidity	0.026	0.010	-0.026
	(0.17)	(0.07)	(-0.17)
NAIC dummy	-0.521	-0.514	-0.550
	(-0.79)	(-0.77)	(-0.79)
Observations	1,573	1,573	1,573
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table 9. Market reaction, payment method and rollover risk

This table presents the market reaction to acquirers' payment method in mergers and acquisitions. In columns (1) and (2), the dependent variable is the 3-day cumulative abnormal returns (CARs) around the announcement date for acquirers. In columns (3) and (4), the return horizon extends to 5 days. The baseline return is calculated based on portfolios formed by size and book-to-market ratio, consisting of 25 portfolios. The sample consists of completed deals sourced from the SDC database spanning the period from 1990 to 2021, excluding financial and utility acquirers, which have observations in TRACE and NAIC. Acquirers are sorted into large and small groups based on the median of rollover risk. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. We include control variables, defined in the appendix, industry-and year-fixed effects, and cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * $p<0.10$, ** $p<0.05$, and *** $p<0.01$.

Return Horizon	3 days		5 days	
Rollover Risk	Low	High	Low	High
	(1)	(2)	(3)	(4)
Cash payment fraction	0.027***	0.010	0.037***	0.009
	(3.14)	(1.37)	(3.44)	(1.01)
Cash	0.032	0.020	0.031	0.030
	(1.02)	(0.67)	(0.90)	(0.72)
Leverage	0.019	0.039**	0.016	0.062***
	(1.11)	(2.02)	(0.77)	(2.78)
Log sales	-0.001	0.001	-0.003	0.002
	(-0.50)	(0.27)	(-0.89)	(0.57)
Market-to-book ratio	-0.000	-0.003	-0.002	-0.007**
	(-0.18)	(-1.59)	(-0.76)	(-2.21)
Tangibility	0.008	0.001	0.011	0.030
	(0.40)	(0.07)	(0.47)	(1.09)
Dividend	-0.044	-0.300**	0.022	-0.263*
	(-0.37)	(-2.28)	(0.16)	(-1.78)
R&D expenses	0.012	-0.089	-0.014	-0.021
	(0.18)	(-0.89)	(-0.16)	(-0.19)
Relative size	0.044***	-0.028**	0.064***	-0.026*
	(3.20)	(-2.31)	(4.26)	(-1.84)
Horizontal	0.004	0.004	0.003	0.004
	(0.93)	(0.77)	(0.58)	(0.59)
Friendly deal	-0.015	0.015	-0.011	-0.005
	(-0.60)	(0.91)	(-0.45)	(-0.33)
Public target	-0.009*	-0.015**	-0.012**	-0.019***
	(-1.78)	(-2.58)	(-1.99)	(-2.80)
10-year interest rate	-0.016**	-0.000	-0.013	0.006
	(-2.14)	(-0.01)	(-1.52)	(0.67)
Bidder return	0.001	0.007*	0.002	0.002
	(0.11)	(1.80)	(0.28)	(0.44)
Amihud liquidity	0.000	0.003	0.005	-0.003
	(0.00)	(0.22)	(0.84)	(-0.21)
NAIC dummy	0.014	0.036**	0.016	0.018
	(0.86)	(2.18)	(0.76)	(0.99)
Observations	806	771	781	761
Adjusted R-squared	0.20	0.18	0.20	0.16
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

Table 10. Sensitivity of equity value to cash and rollover risk

This table reports the relation between rollover risk and sensitivity of equity value to cash among acquirers. We estimate the sensitivity of equity to cash by regressing the logarithm of equity value on the logarithm of cash and control variables. The sample includes acquirers in SDC M&A from 1994 to 2021, excluding financial and utility firms, which have observations in TRACE and NAIC. *Rollover loss* is an indicator variable that equals one if the acquirer makes losses from debt rollover. We include control variables, defined in the appendix, industry-and year-fixed effects, and cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Log(equity value)			
	(1)	(2)	(3)	(4)
Log(cash)	0.210***	0.151***	0.189***	0.129***
	(9.30)	(6.45)	(8.12)	(5.35)
Rollover loss			-0.612***	-0.620***
			(-3.30)	(-3.75)
Log(cash) × Rollover loss			0.053*	0.070***
			(1.80)	(2.63)
Leverage	-0.369**	-0.701***	-0.320*	-0.644***
	(-2.00)	(-3.54)	(-1.79)	(-3.33)
Log sales	0.648***	0.718***	0.646***	0.718***
	(19.94)	(21.86)	(20.93)	(22.80)
Tangibility	0.219	-0.063	0.212	-0.086
	(1.04)	(-0.24)	(1.05)	(-0.34)
Profit	-1.207***	-0.905**	-1.384***	-1.072***
	(-2.78)	(-2.33)	(-3.30)	(-2.81)
Market-to-book ratio	0.356***	0.341***	0.361***	0.339***
	(7.84)	(8.01)	(8.14)	(7.97)
Capital expenditures	1.068	0.071	1.303*	0.202
	(1.36)	(0.08)	(1.74)	(0.25)
Dividend	4.496***	4.299***	4.251***	4.294***
	(3.11)	(2.99)	(3.02)	(3.07)
Observations	1,626	1,616	1,626	1,616
Adjusted R-squared	0.79	0.85	0.80	0.86
Year FE	No	Yes	No	Yes
Industry FE	No	Yes	No	Yes

Table 11. Parameter values

This table lists parameter values for model calibration. They are chosen based on the literature. Additionally, we normalize the pre-merger capital K_{pre} to 10. The adjustment cost of the acquisition, ψ, is set to 1.5. The acquisition can bring synergy gain, g, is 10% of the increased capital, i.e., $G(I) = 10\% \times I$.

Parameter	Symbol	Value
Mean cash flow rate	μ	0.08
Cash flow volatility	σ	0.12
Risk-free rate	r	0.04
Carry cost of cash	λ	0.01
Liquidation value	ι	0.35
Tax rate	θ	0.20
Coupon on debt	C	0.2
Principal on debt	P	4
Debt maturity	M	1,3,10
Debt issuance cost	κ	0.01
Production scale	α	0.7
Adjustment cost	ψ	1.5
Equity issuance cost	ϕ	0.1
Initial capital	K_{pre}	10
Relative target size	I/K_{pre}	5%
Post-merger capital	K_{post}	10.5
Synergy gain	g	10%

A Robustness Tests

A.1 Alternative M&A Investment Measure

In this section, we aim to further confirm the effect of rollover risk on M&A investments by using an alternative measure, namely, transaction value from SDC. The regression specification is as follows:

$$\begin{aligned} \text{Transaction value}_{it} = a + b \text{ Rollover risk}_{i,t-1} + c \text{ Price deviation}_{i,t-1} \\ + d \text{ Inverse maturity}_{i,t-1} + f \text{ Controls}_{i,t-1} + e_{i,t} \end{aligned} \tag{A1}$$

where *Transaction value* measures the total expenses incurred by firms on acquisitions, including both cash and stock payments.

[Insert Table A1]

As shown in Column (1) of Table A1, the estimated coefficient of *Rollover risk* is –1.597. A one standard deviation increase in *Rollover risk* causes a significant decrease in *Transaction Value* of 3.4% (1.597 × 0.021), which is over 80% of the average transaction costs of 4.0%.

We turn to the two components of our rollover risk measure. The estimated coefficient of *Price deviation* in Column (2) is –0.278 (t-statistic = –4.51). In Column (3), we observe a statistically significant coefficient of —0.125 (t-statistic = –2.67) for *Inverse maturity.*

Taken together, our findings using transaction values are consistent with those in Table 5 where we use cash acquisitions to proxy for M&A investments.

A.2 Capital Expenditures

While in the main text we examine the effect of rollover risk on M&A, observable large investments, we consider broader investments that include smaller investments, proxied by capital expenditures.

We run panel regressions of capital expenditures on price deviation, inverse maturity and rollover risk, with fixed firm and year effects as follows:

$$\begin{aligned}\text{Cap expenditure}_{it} = a &+ b \text{ Rollover risk}_{i,t-1} + c \text{ Price deviation}_{i,t-1} \\ &+ d \text{ Inverse maturity}_{i,t-1} + f \text{ Controls}_{i,t-1} + e_{i,t}\end{aligned} \tag{A2}$$

where *Cap expenditure* denotes capital expenditure, scaled by total assets (Compustat item Capx/AT).

[Insert Table A2]

As shown in Column (1) of Table A2, the estimated coefficient of *Rollover risk* is –0.178, which is statistically significant with a t-statistic of –5.56. When turning to its two components of rollover risk in Columns (2) and (3), we also observe a significant, negative coefficient of –0.030 (t-statistic = –4.96) and –0.012 (t-statistic = –2.47) for *Price deviation* and *Inverse maturity*, respectively. This finding is consistent with what we obtain in Table 5 where we use cash expenses on acquisitions to measure M&A investment.

Overall, we find the role of rollover risk are not limited to large M&A investments. Our measure has significant adverse effects on broader types of investments too.

A.3 Alternative Specification for Payment Choice Regressions

Furthermore, we explore whether different specifications can alter our conclusion regarding the relationship between rollover risk and payment choice.

[Insert Table A3]

Table A3 presents a robustness test on the effect of rollover risk on payment choice. Using the same specification in equation (7), we employ linear regressions instead of Probit models.

These results closely align with those presented in Table 8. In Column (1) where we include *Rollover risk*, we observe a significantly negative coefficient. A one standard deviation increase in this interaction term (0.021) leads to a 3.8% reduction ($-1.801 \times 0.021 = -0.038$) in the probability of a full-cash payment. The estimated coefficient of *Price deviation* in Column (2) shows an insignificant negative coefficient of –0.242 (t-statistic = –1.37). The coefficient of *Inverse Maturity* in Column (3) is statistically insignificant.

Taken together, our findings remain consistent across different specifications when examining the effect of rollover risk on payment choice. They are consistent with our results in Table 8 that short maturity does not impact payment choice significantly. It is rollover risk that significantly influences payment choice, because it includes the information of bond price deviation.

B Model extension

In this section, we extend our model to incorporate both the optimal choice of acquisition size and payment method. In addition to equity issuance, we allow firms to issue debt for financing acquisitions, given the prevalent use of debt financing in mergers and acquisitions (Faccio and Masulis, 2005; Bharadwaj and Shivdasani, 2003).

B.1 Setup

We allow the firm to raise additional capital and choose the optimal acquisition size, denoted by I. Following the acquisition, the firm's capital increases from K_{pre} to $K_{post} = K_{pre} + I$. The total investment cost comprises the acquisition size I and the capital adjustment cost, $\psi(I, K_{pre})$.

As another extension to the baseline model, we assume that the acquisition is financed through a combination of debt and equity issuance, without drawing down its cash reserves. When financing with debt, the firm repays the outstanding principal, P, which remains constant prior to the lump-sum investment, and issues new debt with a principal of P_{post}. The proceeds from this debt issuance represent the market value of the newly issued debt net of its issuance cost κ, i.e., $D_{post}(W_t; K_{post}, P_{post})(1 - \kappa)$. If the net debt proceeds, $D_{post}(W_t; K_{post}, P_{post})(1-\kappa) - P$, are insufficient to cover the investment cost, the firm raises external equity, E_{issue}, incurring an issuance cost of ϕE_{issue}.

Taken together, the acquirer chooses the optimal post-acquisition capital level, K_{post}, to maximize post-merger equity value, $E(W_t; K_{post}, P_{post})$, net of newly issued equity payable to target, E_{issue}, as follows:

$$\max_{K_{post}} E(W_t; K_{post}, P_{post}) - E_{issue}, \tag{A3}$$

subject to:

$$\max_{P_{post}} \underbrace{E(W_t; K_{post}, P_{post}) - (1+\phi)E_{issue}}_{\text{Net equity issue gain}} + \underbrace{[D_{post}(W_t; K_{post}, P_{post})(1-\kappa) - P]}_{\text{Net debt issue gain}}, \tag{A4}$$

and

$$I + \psi(I, K_{pre}) = [D_{post}(W_t; K_{post}, P_{post})(1-\kappa) - P] + E_{issue}(1-\phi). \tag{A5}$$

Equation (A4) states that the acquirer chooses the optimal debt issuance P_{post} to maximize the change in firm value, and equation (A5) represents a feasibility constraint to ensure the total investment cost can be financed by net gain in debt issuance plus equity issuance.

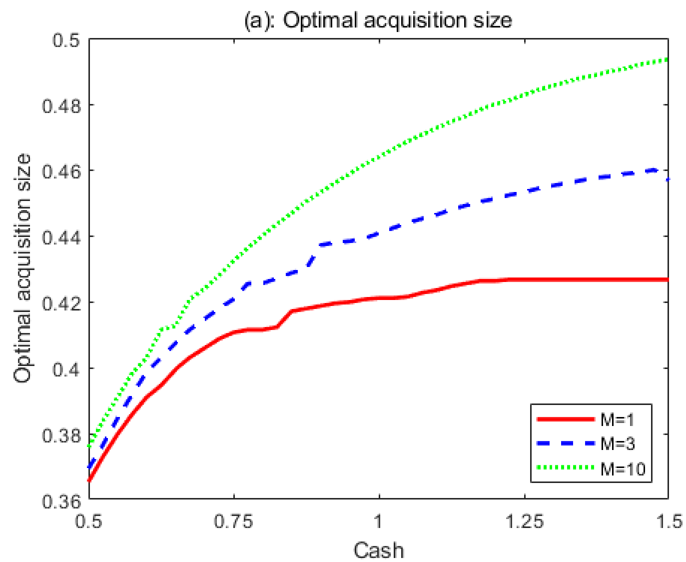
B.2 Results

Figure B1 shows how rollover risk affects acquisition size and payment choice under the extended model. In both panels, the solid, dashed and dotted lines represent short maturity (M=1), medium maturity (M=3), and long maturity (M=10), respectively. We plot relative size of the target firm to the acquirer's size against cash reserve.

We analyze the joint effects of debt maturity and cash holdings on the optimal acquisition size. As shown in Panel A, firms with high cash holding pursue larger acquisitions, consistent with the intuition that cash-rich firms possess greater investment capacity. Furthermore, firms with long maturities tend to acquire larger targets compared to those with short maturities, as they aim to mitigate rollover risk. Consequently, firms experiencing high rollover risk allocate less to acquisitions, even when permitted to finance through both debt and equity. These findings reinforce the predictions from our previous model in Figure 3 and align with the empirical results presented in Table 4 and Table 5.

Panel B examines how rollover risk influences payment choices of acquisitions. The y-axis indicates the fraction of the acquisition financed through debt. Notably, firms with low cash holdings exhibit a reduced reliance on debt financing. Additionally, firms with long maturities tend to utilize more debt for financing acquisitions, whereas those with short maturities favor equity payments. These observations align with the predictions from our prior model in Figure 4. As demonstrated in equations (11) and (12), firms with low cash reserves and short debt maturities face heightened rollover risk, making them less inclined to utilize debt for acquisitions, as increased leverage could exacerbate potential losses from debt rollover. These findings also correspond with the empirical results in Table 8 and Table 9, confirming that firms take into account rollover risk when determining payment methods in acquisitions.

In summary, the extended model allows firms to optimally choose acquisition size and issue both debt and equity for financing acquisition expenditures. Its predictions are consistent with our baseline framework and our empirical findings. Hence the results in this appendix reinforce our conclusion that rollover risk negatively impacts firms' acquisition strategies across diverse scenarios. Firms facing higher rollover risk tend to acquire smaller targets compared to those with lower rollover risk. Moreover, firms with higher rollover risk are more likely to utilize debt financing for acquisitions, whereas those with lower rollover rely more on equity financing.



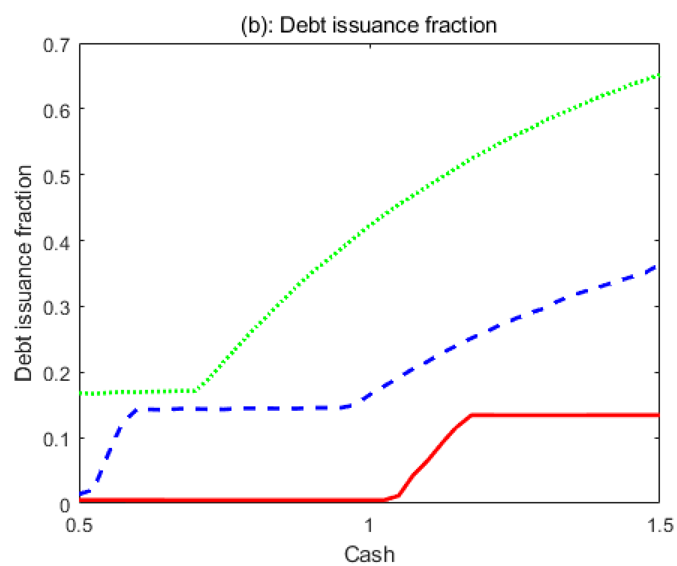


Figure B1. Rollover risk, optimal acquisition, and debt financing
This figure illustrates the relationship between rollover risk and optimal acquisition size in Panel A and payment choice in Panel B. The x-axis variable represents cash reserve, which serves as an indicator of debt price deviation faced by firms. The solid, dashed, and dotted lines correspond to low (1) for short maturity, medium maturity (3), and long maturity (10) respectively. In Panel A, the y-axis variable represents the optimal relative size of the target firms that should be acquired and in Panel B, the y-axis represents the fraction of the acquisition financed through debt.

Table A1. Transaction value and rollover risk

This table reports results of Tobit regressions to examine the relationship between transaction values and rollover risk. The sample includes firms from the CRSP and Compustat databases covering the period from 1990 to 2021, excluding financial and utility firms, which have observations in TRACE and NAIC. The dependent variable is acquisition transaction value scaled by the book asset in the given year. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Transaction value		
	(1)	(2)	(3)
Rollover risk	-1.597***		
	(-4.49)		
Price deviation		-0.278***	
		(-4.51)	
Inverse maturity			-0.125***
			(-2.67)
Leverage	-0.133***	-0.135***	-0.165***
	(-3.62)	(-3.70)	(-4.59)
Log sales	0.001	-0.000	-0.000
	(0.22)	(-0.08)	(-0.02)
Tangibility	-0.171***	-0.171***	-0.175***
	(-4.01)	(-4.02)	(-4.11)
Profit	0.143*	0.145**	0.204***
	(1.95)	(1.99)	(2.85)
Cash	-0.044	-0.041	-0.053
	(-0.70)	(-0.66)	(-0.86)
Market-to-book ratio	0.037***	0.037***	0.039***
	(5.13)	(5.15)	(5.21)
Capital expenditures	-0.093	-0.087	-0.120
	(-0.70)	(-0.65)	(-0.90)
Dividend ratio	-0.351	-0.394	-0.412
	(-0.98)	(-1.10)	(-1.14)
Amihud liquidity	-0.012	-0.015	-0.017
	(-0.94)	(-1.10)	(-1.28)
NAIC dummy	0.049	0.049	0.044
	(0.88)	(0.88)	(0.78)
Observations	13,227	13,227	13,227
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table A2. Capital expenditures and rollover risk

This table reports results from linear regressions to examine the relationship between capital expenditures and rollover risk. The sample includes firms in CRSP and Compustat from 1990 to 2021, excluding financial and utility firms, which have observations in TRACE and NAIC. The dependent variable is a capital expenses scaled by book value. *Rollover risk* is the product of *price deviation* and *inverse maturity. Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. We control for acquirers' characteristics, industry and year fixed effects, and employ cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * p<0.10, ** p<0.05, and *** p<0.01.

Dependent variable	Capital Expenditures		
	(1)	(2)	(3)
Rollover risk	-0.178***		
	(-5.56)		
Price deviation		-0.030***	
		(-4.96)	
Inverse maturity			-0.012**
			(-2.47)
Leverage	-0.004	-0.004	-0.008*
	(-0.81)	(-0.90)	(-1.74)
Log sales	-0.002***	-0.002***	-0.002***
	(-2.81)	(-2.97)	(-2.81)
Tangibility	0.126***	0.126***	0.125***
	(22.30)	(22.22)	(22.15)
Profit	0.047***	0.048***	0.055***
	(5.09)	(5.22)	(6.13)
Cash	0.034***	0.034***	0.033***
	(5.22)	(5.24)	(5.09)
Market-to-book ratio	0.005***	0.005***	0.005***
	(6.00)	(6.02)	(6.13)
Dividend ratio	-0.181***	-0.186***	-0.188***
	(-4.92)	(-5.07)	(-5.08)
Amihud liquidity	-0.002	-0.002*	-0.002**
	(-1.64)	(-1.86)	(-2.20)
NAIC dummy	0.004	0.004	0.004
	(1.24)	(1.24)	(1.12)
Observations	13,227	13,227	13,227
Adjusted R-squared	0.61	0.61	0.61
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table A3. Payment method and rollover risk

This table reports results from linear regressions for the relation between bond rollover risk, maturity and payment method in mergers and acquisitions. The sample includes completed deals in SDC from 1990 to 2021, excluding financial and utility acquirers, which have observations in TRACE and NAIC. The dependent variable is an indicator variable if the acquisition is 100% cash financed. *Rollover risk* is the product of *price deviation* and *inverse maturity*. *Price deviation* is defined as the difference between par value and market value of a bond scaled by its par value, and *inverse maturity* is the reciprocal of firm-level bond maturity. We include control variables of acquirers' characteristics, industry-and year-fixed effects, and cluster standard errors at the firm level. t-statistics are in parentheses. Significance levels are denoted as * $p<0.10$, ** $p<0.05$, and *** $p<0.01$.

Dependent variable	Cash-financed deals		
	(1)	(2)	(3)
Rollover risk	-1.801*		
	(-1.77)		
Price deviation		-0.242	
		(-1.37)	
Inverse maturity			-0.126
			(-1.42)
Cash	-0.122	-0.128	-0.151
	(-1.13)	(-1.18)	(-1.36)
Leverage	-0.020	-0.030	-0.062
	(-0.23)	(-0.34)	(-0.70)
Log sales	-0.002	-0.003	-0.004
	(-0.16)	(-0.26)	(-0.31)
Market-to-book ratio	-0.038***	-0.037***	-0.034***
	(-3.16)	(-3.06)	(-2.87)
Tangibility	-0.104	-0.109	-0.125
	(-1.18)	(-1.24)	(-1.40)
Dividend	1.634***	1.611***	1.629***
	(2.79)	(2.73)	(2.75)
R&D expenses	0.073	0.074	0.025
	(0.17)	(0.18)	(0.06)
Relative size	-0.475***	-0.478***	-0.480***
	(-7.47)	(-7.54)	(-7.57)
Horizontal	0.003	0.003	0.005
	(0.12)	(0.12)	(0.22)
Friendly deal	-0.044	-0.046	-0.052
	(-0.48)	(-0.51)	(-0.56)
Public target	-0.232***	-0.232***	-0.231***
	(-8.69)	(-8.70)	(-8.64)
10-year interest rate	-0.024	-0.025	-0.025
	(-0.81)	(-0.83)	(-0.86)
Bidder return	-0.058***	-0.060***	-0.064***
	(-3.61)	(-3.70)	(-4.23)
Amihud liquidity	-0.009	-0.011	-0.016
	(-0.29)	(-0.37)	(-0.52)
NAIC dummy	-0.109	-0.111	-0.120
	(-0.57)	(-0.57)	(-0.62)
Observations	1,615	1,615	1,615
Adjusted R-squared	0.35	0.35	0.35
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes