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. 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.

JEL Classification Numbers: G32, G33, G34.

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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. We find that rollover risk negatively influences M&A investment and financing decisions.

Debt rollover creates maturity overhang problem, not only because short-term debt can effectively become long-term debt if rolled over but also because rollover induces losses and risk.[1] Influenced by credit market supply and firm decisions, firms maintain stable maturity structures and issue debt to replace maturing debt. However, when rolling over debt at prevailing market prices, firms may experience gains or losses depending on the difference between the market price and the predetermined principal repayments. During adverse market conditions, firms are compelled to issue new debt at a discount, resulting in substantial rollover losses. Short maturity further exacerbates rollover risk. Firms with shorter debt maturity face greater potential losses and encounter more severe debt rollover risk, as they need to reissue debt more frequently to replace maturing debt.

To capture the interaction between rollover risk and short maturity, we introduce a market-based measure of rollover risk, which is the difference between the par value and market value of a bond divided by bond maturity. 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. Furthermore, acquirers with elevated rollover

[1] Myers (1977) advances the classical debt overhang problem: 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.

risk exhibit heightened sensitivity to changes in cash reserves and prefer equity as a payment method over cash. Notably, equity markets respond positively to cash payment choices only when acquirers face low rollover risk.

To explore the economic forces driving these empirical findings, we develop a dynamic model of investment to better understand corporate decisions on investment, financing, and cash management. In this model, 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 continually 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 underscores the significance of rollover risk and precautionary saving in 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 manifestation of 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 work contributes to the existing body of research on mergers and acquisitions (Betton, Eckbo, and Thorburn, 2008). Previous studies. 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 (2003a) 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. Our work highlights the role of rollover risk in determining the payment method and provides the first risk-based explanation by showing markets react positively to cash payment, only when acquirers have a low rollover risk.

Our study contributes to the literature of merger waves (see recent survey by Harford (2022)), 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 (2003b) 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, rollover risk in the debt market 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 suggests that firms in financial distress are hesitant to invest as the returns from investments primarily benefit existing long-term debt holders. One potential solution to this problem 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 exacerbates the rollover problem, depleting cash reserves and leading to underinvestment. Our work complements their study within the context of mergers and acquisitions. However, unlike their study that allows equity financing only, our model allows firms to accumulate cash and choose their payment methods, 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 payments because of the precautionary saving motive, worsening the maturity overhang problem. Moreover, we complement their study 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 presents stylized facts. Section 3 presents the model, followed by model-generated results in Section 4. Finally, Section 5 concludes the paper. Additional robustness tests are relegated to the Appendix.

2 Stylized Facts

We first describe the data and variable construction, and then present our empirical findings using our new measure of rollover risk capturing fluctuations in corporate bond market prices.

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. To ensure data quality and relevance, 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 greater than 1% of the acquirer's book value, (4) acquirers should hold less than 50% of the target's shares before the deal and acquire all shares after the deal, and (5) each deal must have non-missing information on the payment method. Additionally, we winsorize at the top and bottom two percentiles to mitigate the potential impact of outliers for all variables.

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. 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 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. 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.[2]

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.[3]

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

[3]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, because it presents approximately the annual rollover loss. This definition is also consistent with our theoretical definition in the next section. It is worth noting again that short maturities does not captures the fluctuation in bond price, and healthy firms benefit from relatively high bond price and frequent rollovers. Similarly, we use the value-weighted year-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 test M&A behaviors. 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 with a weight of the market value of debt. We include standard macroeconomic variables and Treasury bond interest rates as control variables,[4] 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 15,236 observations.

[Insert Table 2]

Panel A focuses on firm characteristics. 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, indicating that about half of the firms suffer from rollover loss from debt refinancing. In terms of M&A activities, the average acquisition expenditure is 0.035 with a median of zero, suggesting that

NAIC to control for missing Amihud illiquidty measure.

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

most of firms do not make cash acquisitions during the sample period (this is consistent with the general fact that less than 5% of firms are acquirers in the average year). We observe a similar pattern for transaction values.

Panel B 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. After applying the filters, our final sample consists of 1631 deals. The median ratio of deal size relative to acquirer size is approximately 7.4%. 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)). Having observed the significant adverse impact from the rollover risk on merger waves, we proceed to examine the heterogeneous effect of rollover risk on merger activities at the firm-level.

Panel C 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 average rollover risk is the value-weighted average of firm-level rollover risk across all bond-issuing firms. It has a median of –0.002, similar to that in the panel, while its standard deviation is much smaller at 0.6%. 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%.

2.4 Firm-level M&A Investments

To analyze firm-level M&A investments, we utilize two proxies: M&A indicator and cash expenditure. 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.

2.4.1 Likelihood of M&A Investments

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

$$\begin{aligned} \text{Acquisition indicator}_{i,t} = a + b \text{ Rollover risk}_{i,t-1} + c \text{ Price deviation}_{i,t-1} \\ + d \text{ Inverse maturity}_{i,t-1} + f \text{ Controls}_{i,t-1} + e_{i,t}, \end{aligned} \tag{2}$$

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 sale*, *tangibility*, *profitability*, *market-to-book ratio*, *capital expenditure* and *dividend*, and control for year and industry fixed effects in all regressions.

[Insert Table 3]

The results are reported in Table 3. In Column (1), the estimated coefficient of *Rollover risk* is —4.692, which is statistically significant with a t-statistic of —4.14. A one standard deviation increase in *Rollover risk* (0.022) leads to a significant decrease in the probability of acquiring a target by 2.87% (-1.303 $\times$ 0.022). 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 –0.780 (t-statistic = –3.89) for *Price deviation* and –0.317 (t-statistic = –2.01) 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.

In short, we observe a significant, negative impact of rollover risk and its two components on the propensity of M&A investments.

2.4.2 M&A Expenditures

We turn to acquisition expenditures. Because most firms have zero cash expenditures in M&As, there is a truncation problem when examining how rollover risk influences acquisition activities.

To overcome this problem, we run a Tobit model regression by regressing cash expenditure on the rollover risk and control variables as follows:

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

where *Acquisition expenses*$_{i,t}$ measures corporate cash expenses on acquisitions of firm, i, at year t.

[Insert Table 4]

As shown in Column (1) of Table 4, the coefficient of *Rollover risk* is –0.668 with a statistic of –6.28. A one standard deviation increase in *Rollover risk* (0.022) leads to a decrease in *Acquisition expenses* by 0.015 (0.668 × 0.022). This decrease is economically significant, representing a nearly 43% (0.015/0.035) decrease of the average expenses on acquisitions.

Examining the two components of rollover risk, we find a significantly negative impacts. That is, the coefficient is –0.136 (t-statistic = –6.96) in Column (2) and –0.055 (t-statistic = –3.45) in Column (3) for *Price deviation* and *Inverse maturity*, respectively. Those findings align with prior literature and supports the intuitive notion that firms with shorter debt maturity may hold larger cash reserves (e.g., Harford et al. (2014)).

In conclusion, our empirical findings demonstrate that rollover risk hinders acquisitions, and short bond maturity exacerbates its adverse effects. Firms with shorter maturities are particularly susceptible to the impact of rollover risk on their acquisition activities.

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 capital expenditures that includes smaller investments in Table A2. Our results consistently support our main conclusion regarding the role of rollover risk and its induced maturity overhang in shaping M&A dynamics.

2.5 Aggregate M&A Investments

Having examined the impacts of rollover risk on firms' investment decisions, we turn to examine their relation at the aggregate level. We use the fraction of bidder firms to the total public firms as a proxy for aggregate merger activities.

We begin with a visual representation in Figure 1. 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 1]

It is evident from Figure 1 that the fraction of bidder firms to total public firms and aggregate rollover risk are negatively associated. For example, during the onset of the financial crisis in 2008, the fraction of bidder firms, which is a proxy for merger activities, decreased significantly, while our aggregate rollover risk measure increases. A similar decline in merger activities can also be observed during the recent Covid-19 crisis.

To statistically examine the association between the aggregate merger activities and our rollover risk measure, we run time series regressions as follows:

$$\text{Fraction of bidder firms}_t = a + b \text{ Aggregate rollover risk}_{t-1} + c \text{ Controls}_{t-1} + e_t, \quad (4)$$

where *Fraction of bidder firms* represents the number of bidder firms from SDC MA 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.

As shown in Table 5, the univariate regression in Column (1) indicates that the estimated coefficient of aggregate rollover risk is –0.340 (t-statistic = –3.22). The adjusted R-squared value suggests that rollover risk alone explains 8% of the time series variation in the merger activities.

In Columns (2), we consider well-known aggregate variables to explain the merger wave, such as T-bill interest, term structure, inflation, credit spread, consumer sentiment index (Baker and Wurgler, 2006), the change in VIX (Bhagwat et al., 2016), logarithm of S&P index (log(S&P)), and market to book ratio (M/B) (Shleifer and Vishny, 2003b). Regarding the interest rate factors derived from the Treasury bond markets, the real rate (T-bill) has a positive effect, while inflation negatively impacts the merger activities. The credit spread, which is the yield difference between BAA- and AAA-rated bonds, exhibits a strong negative effect with the largest t-statistic of –3.89.

Since our rollover risk measure is derived from corporate bond markets, we conduct a horse-race regression to compare our rollover risk measures with other interest rate factors. The estimated coefficient for aggregate rollover risk in Column (3) increased to –0.505 (t-statistic = –2.74) in absolute terms, remaining both economically and statistically significant. Interestingly, the estimated coefficient of the *credit spread* decreased substantially to –0.019 (t-statistic = –0.09), becoming economically and statistically insignificant despite its previous significance.

The distinction between our rollover risk measure and credit spread, both derived from corporate bond markets, is worth discussing. 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 variations in corporate credit risk, combined with the effect of maturity amplification.

Therefore, our findings suggest that rollover risk plays a crucial role in determining aggregate merger activities, surpassing the impact of standard behavioral, fundamental, and risk factors.

2.6 Investment Financing

The payment method plays a crucial role in determining 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 analyze the market reaction to their chosen payment method.

2.6.1 Method of Payment

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

$$\begin{aligned} \text{Cash financed deal}_i = a + b \text{ Rollover risk}_i + c \text{ Price deviation}_i \\ + d \text{ Inverse maturity}_i + f \text{ Controls}_i + e_i, \end{aligned} \tag{5}$$

where Cash financed deal$_i$ is an indicator variable that equals one if the acquisition deal (i) 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 *acquirer size*, *leverage*, *market-to-book ratio*, *tangibility*, *dividend policy*, *R&D expenses*, and *one-year return before the announcement.* Additionally, we include an indicator for public target firms and the relative ratio of deal to acquirer's size. 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 numbers.

[Insert Table 6]

Table 6 presents the findings. In Column (1), we observe a statistically and economically significant estimated coefficient for total rollover risk. A one standard deviation increase in this interaction term (0.022) leads to a 6.6% significant reduction (–3.008 × 0.022 = –0.066) in the probability of a full-cash payment.

We further analyze the two individual components of rollover risk. In Column (2), the estimated coefficient of *Price deviation* is –1.291 with a t-statistic of –1.93. Conversely, the coefficient of *Inverse maturity* in Column (3) is –0.583, 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.

The estimates for the 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 (2003a). 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. 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.

2.6.2 Market Reaction

Early evidence, such as Travlos (1987) and Fuller, Netter, and Stegemoller (2002), shows that cash payment typically generates higher abnormal return than stock payment. We further examine whether 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 of firm as follows:

$$\text{Announcement return}_i = a + b \text{ Cash payment fraction}_i + c \text{ Controls}_i + e_i, \qquad (6)$$

where *Announcement return* is cumulative abnormal returns (CARs) around the announcement date for acquirers. We choose 3 days, 5 days and 22 days as event window, respectively.

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 equations (5) 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, of *Cash payment fraction*.

[Insert Table 7]

The findings are presented in Table 7. Firstly, in Column (1) and (2), where we use a 3-day event window for the announcement return, we observe a significantly positive coefficient of 0.029 in Column (1) on the *Cash payment fraction* for firms with low rollover risk. The t-statistic of 3.26 indicates the statistical significance of this result. Given a standard deviation of 0.376 of *Cash payment fraction*, an increase of one standard deviation in *Cash payment fraction* corresponds to a 0.97% (0.376 × 0.026) 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 in Column (2), the coefficient on *Cash payment fraction* is only 0.008 (t-statistic = 1.080), which is statistically insignificant. This contrast suggests that cash payment does not elicit a positive market reaction for firms with high rollover risk.

In Columns (3) and (4), where we extend the event window to 5 days for the announcement return, we observe similar patterns. the cash premium increases from 0.018 (0.026 – 0.008) in the 3-day window to 0.028 (0.036 – 0.008) in the 5-day window. In Columns (5) and (6) where we use a 22-day window, both estimated coefficients become statistically insignificant, which is not surprising that the market reaction becomes weaker over a longer period.

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.

2.7 Sensitivity of Equity to Cash

We investigate how rollover risk determines payment choice in acquisitions, via the lens of the equity-cash sensitivities. The rationale behind this exercise is that equity holders are the decision makers in investment and financing. By analyzing the sensitivity of equity value to cash, we gain initial insights into their 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 follow:

$$\begin{aligned} \log(\text{Equity value})_{i,t} &= a + b\ \log(\text{Cash})_{i,t} + c\ \text{Rollover loss}_{i,t} \\ &\quad + d\ \log(\text{Cash}_{i,t}) \times \text{Rollover loss}_{i,t} + f\ \text{Controls}_{i,t-1} + e_{i,t}, \end{aligned} \tag{7}$$

where *equity value* is the market value of equity and *Cash* denotes cash reserve. We include standard control variables, such as *leverage, log sale, 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.[5]

[Insert Table 8]

As shown in Table 8, the estimated coefficient of $log(Cash)$ in Column (1) is 0.210, which is both economically and statistically significant when year- and industry-fixed effects are not

[5]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.

included. However, when both year and industry fixed effects are introduced in Column (2), the estimate decreases to 0.151 with a t-statistic of 6.44.

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 suggests that firms with high rollover risk demonstrate a 54% (0.070/0.129) higher sensitivity to their cash reserves. This result aligns with the findings by Harford et al. (2014) who shows that firms with lower debt maturity value their cash reserve more than their counterparts.[6]

Taken together, the contrast in the equity-cash sensitives suggests that firms with high rollover risk values their cash significantly more than their counterparts. This difference implies that those high rollover risk firms are 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 6 and equity markets react positively to their payment choice in Table 7.

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

- Firms with heighten rollover risk tend not to acquire. If they do, acquirers allocate less capital to acquisitions.
- At the aggregate level, rollover risk is negatively associated with merger activities, beyond existing risk and behavioral factors.
- High-rollover-risk firms prefer equity as a payment method over cash. Stock markets exhibit a positive reaction to cash payment, only when acquirers face low rollover risk.
- Equity values of high-rollover-risk firms are more sensitive to changes in cash reserve.

[6]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.

3 Model

To understand those empirical observations, we develop a dynamic model, which incorporates cash accumulation, lump-sum investments (i.e., M&As), and their payment methods, in the spirit of Bolton, Chen, and Wang (2011) and Della Seta, Morellec, and Zucchi (2020).

3.1 Setup

We consider a representative firm with productive capital, K_s, in stage s, where $s = pre, post$, 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.

$$dY_t = (1-\theta)[K_s^\alpha(\mu dt + \sigma dZ_t) + G(I)dt] \tag{8}$$

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 can choose either cash or stock payment to complete 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 synergy gains 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 the amount of debt, P/M, and issues debt to keep its debt structure stationary, with a proportional cost κ.

The firm accumulates cash, W_t, over time, with a carrying cost, while earning a risk-free rate r from its existing holding 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 holding, W_t evolves as follows:

$$dW_t = (1-\theta)\left[\underbrace{K_s^{\alpha}(\mu dt + \sigma dZ_t) - Cdt}_{\text{Net income}} + \underbrace{(r-\lambda)W_t dt}_{\text{Net interest}} + \underbrace{G(I)dt}_{\text{Synergy gain}}\right] \\ \underbrace{- \frac{1}{M}[P - (1-\kappa)D(W_t)]dt}_{\text{Rollover loss/gain}} . \tag{9}$$

The change in cash holdings, dW_t, has two components. The first component is from operating activities and includes net interest income from carrying the 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 the time interval, *dt*, the firm issues *1/M* fraction 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. This rollover risk could lead them to adopt different M&A decisions and payment methods, *ex ante*.

3.2 Valuation of Assets

We start our analysis by deriving the valuation function of equity and debt. The valuation function of equity, $E_s(W_t) \equiv E(W_t; K_s)$, for pre- and post-merger firm satisfies:

$$rE_s(W_t) = \left[(1-\theta)\left((r-\lambda)W_t + K_s^{\alpha}\mu - C + G(I)\right) - \frac{1}{M}\left(P - (1-\kappa)D_s(W_t)\right)\right]E_s'(W_t) \\ + \frac{\left((1-\theta)\sigma K_s\right)^2}{2}E_s''(W_t) . \tag{10}$$

When cash reserve increases, equity holders make investment decisions. To focus on the investment policy, we assume equity holders do not pay out until cash reserve approaches infinity after the lump-sum investment.[7] Thus, we have the boundary condition as follows:

$$E_s'\left(W_t \to \infty; K_s\right) = 1. \tag{11}$$

When the firm's cash reserve decreases sufficiently, the firm might go bankrupt or issue new equity. We assume the firm has no access to outside equity when in financial difficulties, and is forced into bankruptcy if its cash holding reaches zero, i.e., $W = 0$. At default, the firm has to pay a liquidation cost φ and the remaining liquidation value is denoted as $\iota = 1 - \varphi$. Thus, shareholders receive the residual of the liquidation value as follows:

$$E_s(W_t = 0; K_s) = \max\left(\iota K_s - P, 0\right). \tag{12}$$

Therefore, we solve the equity value function, based on the boundary conditions (11) and (12).

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

$$\begin{aligned}\left(r + \frac{1}{M}\right) D_s\left(W_t\right) =& \left[(1-\theta)\left((r-\lambda)W_t + K_s^{\alpha}\mu - C + G(I)\right) - \frac{1}{M}\left(P - (1-\kappa)D_s\left(W_t\right)\right)\right] D_s'\left(W_t\right) \\ &+ \frac{\left((1-\theta)\sigma K_s\right)^2}{2} D_s''\left(W_t\right) + C + \frac{P}{M}\end{aligned} \tag{13}$$

At default, debt holders receive the minimum of the residual of liquidated asset and the principal:

$$D_s(W_t = 0; K_s) = \min\left(\iota K_s, P\right). \tag{14}$$

Because debt holders do not enjoy the upside benefits when cash holding is sufficiently large, the marginal value of cash to debt holders equals zero as follows:

$$D_s'(W_t \to \infty; K_s) = 0. \tag{15}$$

Thus, the debt value function is obtained, given the above boundary conditions (15) and (14).

[7] The optimal payout policy W_t^* can be foud in Bolton et al. (2011).

3.3 Investment Decisions

The firm has an opportunity to acquire additional capital. Given its debt maturity and current cash holding, the firm makes joint decisions in M&A and payment method. We consider two types of exogenous investment decisions. The first type of investment 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 payment method, given the predetermined investment amount.

3.3.1 Optimal Expenses

We first examine how rollover risk affects firms' cash expenses on acquisitions. We assume that the firm is allowed to conduct an acquisition and choose the size of its acquisition expenses. However, external financing is unavailable, and the firm can only use its internal cash to complete the acquisition. Suppose the size of the acquisition is denoted as I. Then, after the acquisition, its cash holdings decrease by the investment cost $(1+\psi)I$, where ψ is the linear adjustment cost, and its capital will increase from K_{pre} to $K_{\text{post}} = K_{\text{pre}} + I$. We have the value-matching conditions for the firm equity value as followed:

$$E_{\text{pre}}(W_t; K_{\text{pre}}) = \begin{cases} E_{\text{post}}(W_t; K_{\text{post}}); & \text{if no investments} \quad (16a) \\ \max_I E_{\text{post}}(W_t - (1+\psi)I^*; K_{\text{post}}). & \text{if investments} \quad (16b) \end{cases}$$

$E_{\text{post}}(W_t; K_{\text{post}})$ in equation (16a) is the corner solution where no acquisition investment occurs, i.e., $K_{\text{post}} = K_{\text{pre}}$. When cash reserve increases, we have the interior solution in equation (16b), 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 $G(I)$. However, simultaneously, its cash holdings decrease by the amount of $(1+\psi)I$. The firm may choose to forgo large, lump-sum investments due to the direct depletion of cash from its reserves, driven by the precautionary motive.

Moreover, as we have discussed for Equation (9), having a high cash reserve incurs the opportunity cost of carrying excess cash, while lower cash reserves result in losses from debt rollover. Consequently, when having a low cash reserve, the firm has a low market valuation of debt and a high price deviation, therefore less likely making significant acquisition investment. Furthermore, short maturity magnifies the rollover loss, because of frequently rollovers.

Overall, equity holders make optimal investment decision by trading off between potential rollover loss and increased cash flows from this cash-financed acquisition. We solve the model by backward induction. That is, subject to default condition (12), equity holders choose the optimal acquisition expenses to maximize their wealth in equation (16b).

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

$$D_{\text{pre}}(W_t; K_{\text{pre}}) = \begin{cases} D_{\text{post}}(W_t; K_{\text{post}}), & \text{if no investments} \quad (17a) \\ D_{\text{post}}(W_t - (1+\psi)I^*; K_{\text{post}}), & \text{if investments} \quad (17b) \end{cases}$$

where I^* is the size of the acquisition that maximizes equation (16b).

3.3.2 Optimal Payment Choice

The second type of investment decision is to choose the optimal investment and 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 "take it or leave it" decision and completes 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:

$$
E_{\text{pre}}(W_t; K_{\text{pre}}) = \begin{cases} E_{\text{post}}(W_t; K_{\text{post}}), & \text{if no investments} \quad (18a) \\ E_{\text{post}}(W_t - (1+\psi)I; K_{\text{post}}), & \text{if cash payment} \quad (18b) \\ E_{\text{post}}(W_t; K_{\text{post}}) - (1+\psi+\phi)I, & \text{if stock payment} \quad (18c) \end{cases}
$$

Similar to equation (16a), $E_{\text{post}}(W_t; K_{\text{post}})$ in equation (18a) is the corner solution where no acquisition occurs, i.e., $K_{\text{post}} = K_{\text{pre}}$. $E_{\text{post}}(W_t; K_{\text{post}})$ in equation (18a) serve as the benchmark value. M&A investment takes place only if it delivers a positive net present value to equity holders, using either one of the payment methods. That is, $E_{\text{post}}(W_t-(1+\psi)I; K_{\text{post}}) > E_{\text{post}}(W_t; K_{\text{post}})$ for a full cash payment acquisition, or $E_{\text{post}}(W_t; K_{\text{post}}) - (1+\psi+\phi)I > E_{\text{post}}(W_t; K_{\text{post}})$ for a full stock payment acquisition.

Equation (18b) states the condition for all cash payments. The equity value increases from $E_{pre}(W_t; K_{pre})$ to $E_{post}(W_t - (1+\psi)I; K_{post})$, after a total cost $(1+\psi)I$ 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 holding, W_t, by the amount of $(1+\psi)I$. As we have discussed for equation (9), debt retirement and issuance might cause future rollover loss/gain. The decrease in the cash holding due to cash payment might amplify the rollover loss. Therefore, a firm faced with rollover risk is less likely to choose cash payment to complete the M&A transaction, because it anticipates the rollover risk.

Equation (18c) 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 $(1+\psi+\phi)I$. 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. Information asymmetry and adverse information Akerlof (1970) implies that equity issuance is generally costlier than debt issuance. Barclay and Smith Jr (1995) further show that firms issue more short-term debt to mitigate the higher information asymmetry. In this work, we do not model information asymmetry explicitly. Instead, we assume the information symmetry is manifested in the relatively high issuance cost, which impacts the acquirer's preference in the method of payment.

Taken together, the acquiring firm chooses its method of payment, either cash payment (equation (18b)) or stock payment (equation (18c)), to maximize equity value, $E_s(W_t; K_s)$, as follows:

$$\max \left\{ \underbrace{E_{\text{post}}(W_t - (1+\psi)I; K_{\text{post}})}_{\text{Cash payment}}; \underbrace{E_{\text{post}}(W_t; K_{\text{post}}) - (1+\psi+\phi)I}_{\text{Stock payment}}. \right\} \tag{19}$$

The model is solved by backward induction. In anticipating future rollover-induced default risk after the completion of merger, equity holders of the pre-merger firm choose the method of payment *ex ante*. That is, equity holders maximize the pre-merger value in equation (18), subject to the default condition in equations (12).

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:

$$D_{\text{pre}}(W_t, K_{\text{pre}}) = \begin{cases} D_{\text{post}}(W_t; K_{\text{post}}); & \text{if no investments;} \quad (20a) \\ D_{\text{post}}(W_t - (1+\psi)I; K_{\text{post}}); & \text{if cash payment;} \quad (20b) \\ D_{\text{post}}(W_t; K_{\text{post}}). & \text{if stock payment.} \quad (20c) \end{cases}$$

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

4 Model Results

In this section, we use model calibration to understand our empirical results. We start by investigating the impact of rollover risk on cash expenses of acquisitions. Then, we proceed to examine the effects of rollover risk on payment choice in M&A and its implication on 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 mainly 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 1. The proportional transaction cost of the acquisition, ψ, is set to 5%. The acquisition can bring synergy gain, g, is 5% of the increased capital, i.e., $G(I) = 5\% \times I$. All parameter values are listed in Table 9.

[Insert Table 9]

4.1 M&A Investments

We proceed to investigate the role of rollover risk in M&A decisions, specifically focusing on cash-financed acquisitions. Figure 2 provides insight into the optimal expenses on acquisitions for firms with varying 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 the price deviation from the par value (as defined by equation (9)) as well. The lower cash holding implies a larger rollover loss.

[Insert Figure 2]

Figure 2 reveals several noteworthy patterns. When cash holdings are low, all three firms opt for zero expenses on acquisitions. As cash reserves increase, the long-maturity firm initiates acquisitions first, followed by the short-maturity firm at a higher cash holding level. The positive relation between cash reserve and optimal investment amount is largely consistent with our intuition. Furthermore, given the level of cash reserve, 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 presented in Table 4, which indicate that firms experiencing significant rollover losses are less inclined to pursue cash-financed mergers and acquisitions. Moreover, we observe that the impact 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-maturity firms suffer from the debt overhang problem.

4.2 Payment Method and Market Reaction

We proceed to investigate the second type of investment, in which firms choose the optimal investment and payment method given the target size.

We assume that firms have the opportunity to acquire a target, with the relative size of the target to the acquirer set to $I = 0.1$, consistent with 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 3]

Figure 3 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 preferable compared to 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 their 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 payment 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 (9) and (10). 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 prudently choose to issue equity to finance their M&A investments, particularly when their firm's financial condition is deteriorating.[8]

Furthermore, equation (15) and Figure 3 indicate 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 7, confirming the importance of rollover risk in payment method, which is different from the traditional signaling theory.

In summary, these findings reinforce the empirical evidence from Table 6, 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

[8]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 lower 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 the signaling, our model predicts a new role of debt maturity.

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 7. We emphasize that the precautionary saving motive in choosing payment method worsens the overhang problem in the context of mergers and acquisitions.

4.3 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, because equity holders make decision on payment choice (cash vs. equity) and care about the changes in cash reserves.

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

$$Sensitivity_E = \frac{\partial \log E(W)}{\partial \log W} = \frac{\partial E(W)}{\partial W}\frac{W}{E(W)}, \tag{21a}$$

$$Sensitivity_D = \frac{\partial \log D(W)}{\partial \log W} = \frac{\partial D(W)}{\partial W}\frac{W}{D(W)}. \tag{21b}$$

The sensitivity of equity in equation (21a) 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 (21b). 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.

4.3.1 Equity-cash Sensitivity

Figure 4 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 4]

Two observations follow from Panel A of Figure 4. Firstly, 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 concerns about repayment from deteriorating financial conditions.

Secondly, 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 reserve. 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 in order 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 provide theoretical support for our empirical finding in Table 8 that equity values are more sensitive to cash reserve among firms with larger price deviation, shorter maturity and higher rollover risk.

4.3.2 Debt-cash Sensitivity

Panel B depicts debt-cash sensitivities. Firstly, 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. Secondly, similar to equity, debt-cash sensitivities are higher if firms have a low level of cash reserves. Thirdly, in contrast to their equity couterparts 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. Firstly, 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. Secondly, 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. When considering these factors together, it becomes evident that debt holders in short-maturity firms are less sensitive to cash compared to those in long-maturity firms, particularly when cash reserve is low.

In summary, our calibration exercise demonstrates that shortening debt maturity amplifies the sensitivities of equity value to cash reserves due to the frequent rollovers. In an interesting contrast, short-maturity debt serves to mitigate the debt-cash sensitivities, particularly when cash reserves decrease. This interesting contrast also suggests theoretically that short maturity might be a perfect proxy for rollover risk.

5 Conclusion

This paper shows how short maturity magnifies rollover risk, resulting in the 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.

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.

Accumulated cash holding does not resolve the maturity overhang problem. High-rollover risk firms carefully manage their cash reserves, while making investment and payment method choices. Because of precautionary saving motive, 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 motive might worsen the maturity overhang problem. Therefore, this finding contrasts with traditional debt overhang problems (Myers, 1977) and extends recent research on the short-maturity overhang problem (Diamond and He, 2014) in the context of M&A investments.

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 to cash are likely to use cash as their payment in acquisitions.

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

References

Akerlof, G., 1970, The market for lemons: Quality uncertainty and the market mechanism, *Quarterly Journal of Economics* 84, 488–500.

Amihud, Yakov, 2002, Illiquidity and stock returns: cross-section and time-series effects, *Journal of financial markets* 5, 31–56.

Baker, Malcolm, and Jeffrey Wurgler, 2006, Investor sentiment and the cross-section of stock returns, *The journal of Finance* 61, 1645–1680.

Barclay, Michael J, and Clifford W Smith Jr, 1995, The maturity structure of corporate debt, *the Journal of Finance* 50, 609–631.

Betton, Sandra, B Espen Eckbo, and Karin S Thorburn, 2008, Corporate takeovers, *Handbook of empirical corporate finance* 291–429.

Bhagwat, Vineet, Robert Dam, and Jarrad Harford, 2016, The real effects of uncertainty on merger activity, *The Review of Financial Studies* 29, 3000–3034.

Bolton, P., H. Chen, and N. Wang, 2011, A unified theory of tobin's q, corporate investment, financing, and risk management, *The Journal of Finance* 66, 1545–1578.

Chen, H., Z. Chen, and J. Li, 2022, The debt-equity spread, MIT working paper. Available at SSRN 3944082.

Choi, J., D. Hackbarth, and J. Zechner, 2018, Corporate debt maturity profiles, *Journal of Financial Economics* 130, 484–502.

Custódio, C., M. A. Ferreira, and L. Laureano, 2013, Why are us firms using more short-term debt?, *Journal of Financial Economics* 108, 182–212.

Dasgupta, Sudipto, Jarrad Harford, and Fangyuan Ma, 2023, Eps-sensitivity and mergers, *Journal of Financial and Quantitative Analysis* 1–61.

de Bodt, E., J. G. Cousin, and R. Roll, 2018, Full-stock-payment marginalization in merger and acquisition transactions, *Management Science* 64, 760–783.

Della Seta, M., E. Morellec, and F. Zucchi, 2020, Short-term debt and incentives for risk-taking, *Journal of Financial Economics* 137, 179–203.

Diamond, D., and Z. He, 2014, A theory of debt maturity: the long and short of debt overhang, *Journal of Finance* 719–762.

Diamond, Douglas W, 1991, Debt maturity structure and liquidity risk, *the Quarterly Journal of economics* 106, 709–737.

Dick-Nielsen, Jens, 2014, How to clean enhanced trace data, *Available at SSRN 2337908* .

Dittmar, A., and J. Mahrt-Smith, 2007, Corporate governance and the value of cash holdings, *Journal of Financial Economics* 83, 599–634.

Faulkender, M., and R. Wang, 2006, Corporate financial policy and the value of cash, *The Journal of Finance* 61, 1957–1990.

Flannery, M., 1986, Asymmetric information and risky debt maturity choice, *Journal of Finance* 19–37.

Fu, F., L. Lin, and M. S. Officer, 2013, Acquisitions driven by stock overvaluation: are they good deals?, *Journal of Financial Economics* 109, 24–39.

Fu, X., and T. Tang, 2016, Corporate debt maturity and acquisition decisions, *Financial Management* 45, 737–768.

Fuller, K., J. Netter, and M. Stegemoller, 2002, What do returns to acquiring firms tell us? evidence from firms that make many acquisitions, *The Journal of Finance* 57, 1763–1793.

Gort, Michael, 1969, An economic disturbance theory of mergers, *The Quarterly Journal of Economics* 624–642.

Hackbarth, D., J. Miao, and E. Morellec, 2006, Capital structure, credit risk, and macroeconomic conditions, *Journal of Financial Economics* 82, 519–550.

Hackbarth, Dirk, and Erwan Morellec, 2008, Stock returns in mergers and acquisitions, *The Journal of Finance* 63, 1213–1252.

Harford, J., 1999, Corporate cash reserves and acquisitions, *The Journal of Finance* 54, 1969–1997.

Harford, J., S. Klasa, and W. F. Maxwell, 2014, Refinancing risk and cash holdings, *The Journal of Finance* 69, 975–1012.

Harford, J., S. Klasa, and N. Walcott, 2009, Do firms have leverage targets? evidence from acquisitions, *Journal of Financial Economics* 93, 1–14.

Harford, J., S. A. Mansi, and W. F. Maxwell, 2008, Corporate governance and firm cash holdings in the us, *Journal of Financial Economics* 87, 535–555.

Harford, Jarrad, 2005, What drives merger waves?, *Journal of financial economics* 77, 529–560.

Harford, Jarrad, 2022, Merger waves: A survey of the literature, *Available at SSRN 4244184* .

Jensen, M. C., 1986, Agency costs of free cash flow, corporate finance, and takeovers, *The American Economic Review* 76, 323–329.

Leland, H. E., 1998, Agency costs, risk management, and capital structure, *The Journal of Finance* 53, 1213–1243.

Loughran, T., and A. M. Vijh, 1997, Do long-term shareholders benefit from corporate acquisitions?, *The Journal of Finance* 52, 1765–1790.

Ma, Y., 2019, Nonfinancial firms as cross-market arbitrageurs, *The Journal of Finance* 74, 3041–3087.

Mitchell, Mark L, and J Harold Mulherin, 1996, The impact of industry shocks on takeover and restructuring activity, *Journal of financial economics* 41, 193–229.

Moeller, S. B., F. P. Schlingemann, and R. M. Stulz, 2004, Firm size and the gains from acquisitions, *Journal of Financial Economics* 73, 201–228.

Myers, Stewart C, 1977, Determinants of corporate borrowing, *Journal of financial economics* 5, 147–175.

Rau, P. R., and T. Vermaelen, 1998, Glamour, value and the post-acquisition performance of acquiring firms, *Journal of Financial Economics* 49, 223–253.

Rhodes-Kropf, Matthew, and Steven Viswanathan, 2004, Market valuation and merger waves, *The Journal of Finance* 59, 2685–2718.

Shleifer, A., and R. W. Vishny, 2003a, Stock market driven acquisitions, *Journal of Financial Economics* 70, 295–311.

Shleifer, Andrei, and Robert W Vishny, 2003b, Stock market driven acquisitions, *Journal of financial Economics* 70, 295–311.

Travlos, N. G., 1987, Corporate takeover bids, methods of payment, and bidding firms' stock returns, *The Journal of Finance* 42, 943–963.

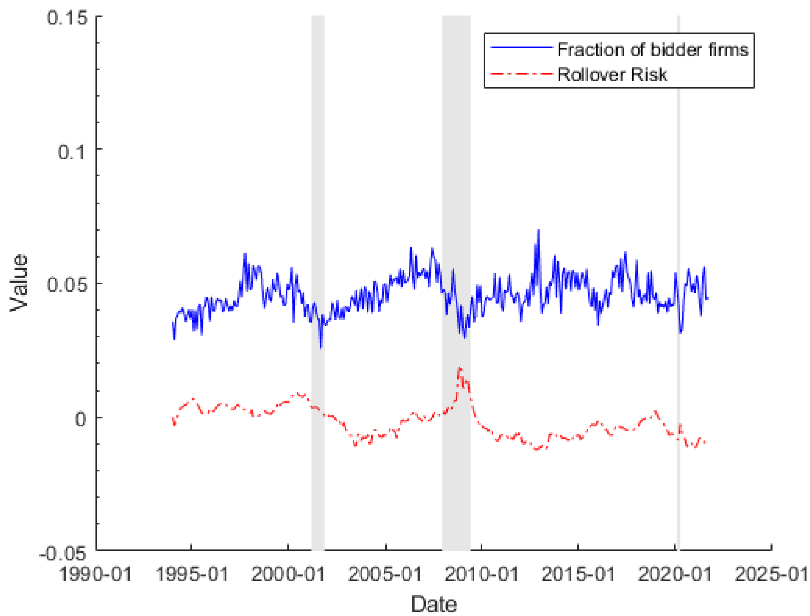

Figure 1: **Aggregate rollover risk and merger waves**
This figure illustrates the relationship between merger waves and aggregate rollover risk. The solid and dotted lines correspond to the fraction of bidder firms to the number of public firms and rollover risk measure, respectively. The gray areas are for NBER recession dates.

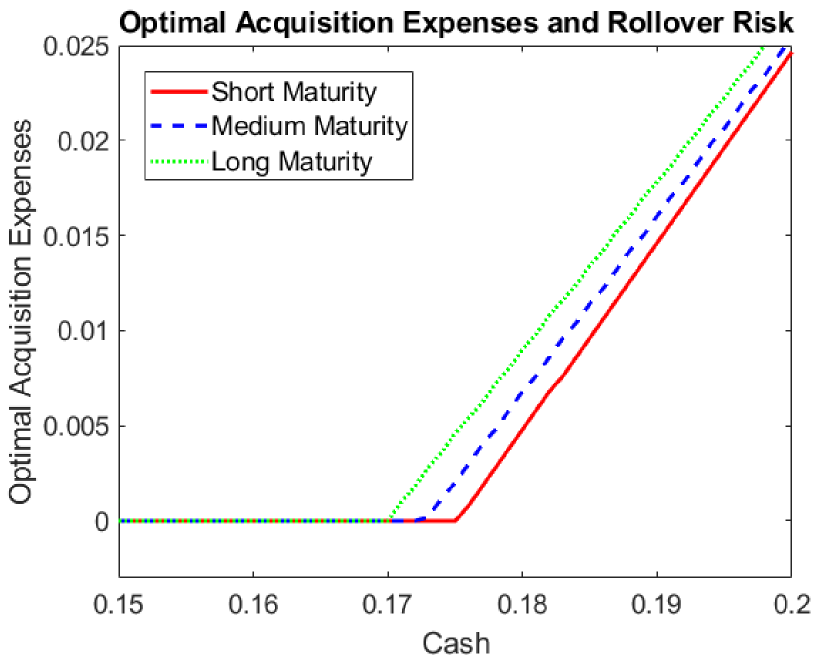

Figure 2: **Optimal acquisition expenses and rollover risk**
This figure illustrates the relationship between optimal acquisition expenses and rollover risk. The x-axis variable represents cash holdings. The y-axis variable represents the optimal size of the target firms that should be acquired. The 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.

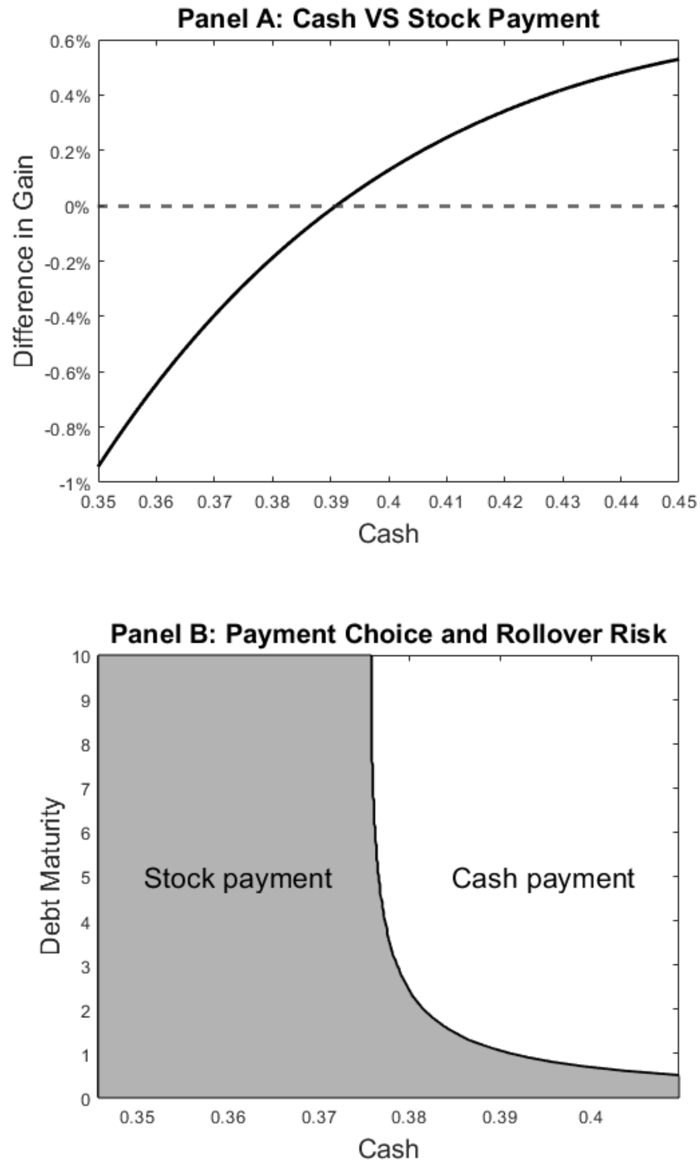

Figure 3: **Acquisition policy and rollover risk.**
This figure illustrates how rollover risk affects the payment choice mergers and acquisitions. In both panels, the x-axis variable represents cash holdings, which signifies the price deviation of debt faced by firms. Panel A focuses on the effect of 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.

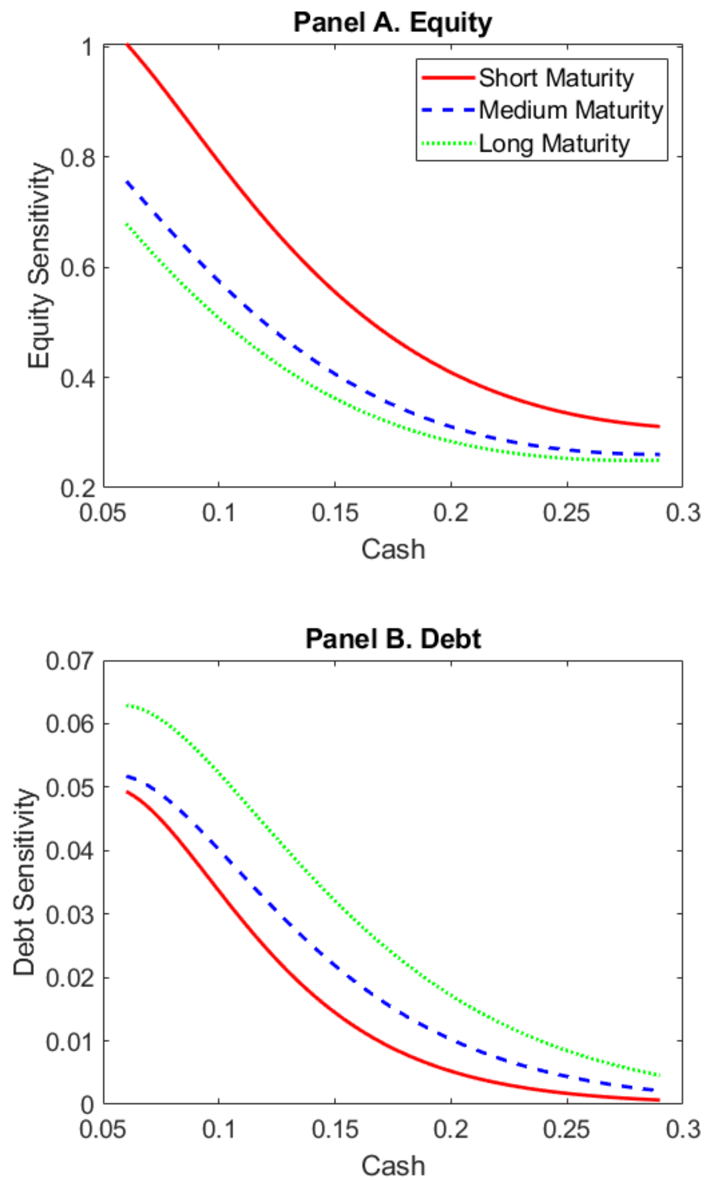

Figure 4: **Sensitivities and rollover risk**
This figure illustrates the relationship between rollover risk and the sensitivity to cash holding of equity value in Panel A and debt value in Panel B, across three levels of debt maturity. The solid, dashed, and dotted lines correspond to low (1) for short maturity, 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**

Variable	**Definition**
	Panel A: firm characteristics
Price deviation	value-weighted difference between market value and par value of a bonds 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)
Amihud illiquidity	measure the illiquidity of 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 equity (PRCC×CSHO + DLC + DLTT) (Source: Compustat)
Log(sale)	logarithm of total sales (Sale) (Source: Compustat)
Tangibility	net property, plants and equipments (PPENT) divided by total assets (AT) (Source: Compustat)
Profit	operating incomes (OIBDP) divided by total assets of the previous year (AT) (Source: Compustat)
Market-to-book ratio	The ratio of the market value of asset (PRCC×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	investment (CAPX) divided by total assets (AT) (Source: Compustat)
R&D expenses	research and development expenses (RD) divided by total assets (AT) (Source: SDC M&A and Compustat)
Dividend ratio	dividend (DVC) divided by total assets (AT) (Source: Compustat)

Panel B: deal characteristics	
Cash payment fraction (%)	percentage of cash payment in the total transaction value. (Source: SDC MA)
Transaction value	total value of an acquisition deal. (Source: SDC MA)
Relative size	Deal valuation/book value of acquirer. (Source: SDC MA)
Completion time	time to complete the acquisition. (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)
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: Firm characteristics

	N	Mean	SD	P10	P25	Median	P75	P90
Bond maturity	15,236	8.060	4.701	3.425	4.977	6.930	9.593	14.479
Inverse maturity	15,236	0.172	0.118	0.069	0.104	0.144	0.201	0.292
Price deviation	15,236	-0.005	0.118	-0.108	-0.067	-0.023	0.020	0.103
Rollover risk	15,236	0.000	0.022	-0.016	-0.009	-0.003	0.003	0.017
Cash	15,231	0.087	0.104	0.007	0.018	0.051	0.116	0.207
Log sale	15,236	8.072	1.498	6.111	7.085	8.128	9.167	9.966
Market-to-book ratio	15,236	1.404	0.965	0.670	0.848	1.128	1.628	2.418
Leverage	15,236	0.369	0.187	0.157	0.232	0.337	0.478	0.640
Tangibility	15,236	0.339	0.244	0.064	0.136	0.278	0.510	0.724
Profit	15,204	0.129	0.094	0.052	0.091	0.130	0.173	0.223
Dividend ratio	15,236	0.013	0.018	0.000	0.000	0.005	0.019	0.037
Capital expenditures	15,236	0.059	0.060	0.011	0.022	0.040	0.073	0.133
Acquisition dummy	15,236	0.222	0.416	0.000	0.000	0.000	0.000	1.000
Transaction value	15,204	0.041	0.147	0.000	0.000	0.000	0.000	0.091
Acquisition expenses	15,204	0.035	0.088	0.000	0.000	0.000	0.022	0.104

Panel B: Deal characteristics

	N	Mean	SD	P10	P25	Median	P75	P90
Cash-financed deal	1,631	0.722	0.448	0.000	0.000	1.000	1.000	1.000
Cash payment fraction (%)	1,631	79.031	37.616	0.000	74.080	100.000	100.000	100.000
Relative size	1,631	0.205	0.418	0.017	0.030	0.074	0.195	0.464
Public target	1,631	0.353	0.478	0.000	0.000	0.000	1.000	1.000
Horizontal	1,631	0.592	0.492	0.000	0.000	1.000	1.000	1.000
Bidder return	1,629	0.146	0.749	-0.305	-0.140	0.037	0.249	0.565

Panel C: Aggregate variables

	N	Mean	SD	P10	P25	Median	P75	P90
Fraction of bidder firms to total public firms	333	0.046	0.007	0.037	0.041	0.045	0.050	0.055
Aggregate rollover risk	332	-0.002	0.006	-0.009	-0.007	-0.002	0.002	0.005
T-bill	332	0.022	0.021	0.000	0.001	0.017	0.046	0.051
Term structure	332	0.021	0.013	0.005	0.010	0.020	0.033	0.040
Credit spread	332	0.010	0.004	0.006	0.007	0.009	0.011	0.013
Inflation	332	0.023	0.041	-0.020	0.000	0.023	0.048	0.070
log of S&P index	332	7.212	0.499	6.559	6.957	7.165	7.576	7.923
Market-to-book ratio	332	4.014	1.268	2.861	3.099	3.603	4.351	6.109
VIX change	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

Table 3: **Propensity to acquire and rollover risk**

This table reports results of probit 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 price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par value of a bond scaled by its par value, and inverse maturity is the reciprocal value 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	Acquisition dummy		
	(1)	(2)	(3)
Rollover risk	-4.692***		
	(-4.14)		
Price deviation		-0.780***	
		(-3.98)	
Inverse maturity			-0.317**
			(-2.01)
Leverage	-0.528***	-0.537***	-0.623***
	(-4.60)	(-4.71)	(-5.51)
Log sale	0.051***	0.048***	0.049***
	(3.13)	(2.90)	(2.97)
Tangibility	-0.613***	-0.615***	-0.625***
	(-4.46)	(-4.48)	(-4.56)
Profit	0.395*	0.409*	0.577**
	(1.67)	(1.74)	(2.52)
Cash	-0.160	-0.155	-0.190
	(-0.77)	(-0.75)	(-0.91)
Market-to-book ratio	0.100***	0.100***	0.104***
	(4.34)	(4.34)	(4.43)
Capital expenditures	-0.174	-0.152	-0.247
	(-0.42)	(-0.37)	(-0.60)
Dividend ratio	-0.562	-0.669	-0.722
	(-0.47)	(-0.56)	(-0.60)
Amihud liquidity	-0.036	-0.042	-0.050
	(-0.77)	(-0.89)	(-1.05)
NAIC dummy	0.125	0.126	0.110
	(0.64)	(0.64)	(0.56)
Observations	12,940	12,940	12,940
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table 4: **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 analysis 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 price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par 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	Acquisition expenses		
	(1)	(2)	(3)
Rollover risk	-0.668***		
	(-6.28)		
Price deviation		-0.136***	
		(-6.96)	
Inverse maturity			-0.055***
			(-3.45)
Leverage	-0.035***	-0.033***	-0.049***
	(-2.77)	(-2.69)	(-3.98)
Log sale	-0.006***	-0.006***	-0.006***
	(-3.17)	(-3.56)	(-3.34)
Tangibility	-0.098***	-0.098***	-0.100***
	(-6.55)	(-6.59)	(-6.67)
Profit	0.189***	0.186***	0.213***
	(6.24)	(6.17)	(7.05)
Cash	-0.024	-0.022	-0.028
	(-1.08)	(-1.00)	(-1.26)
Market-to-book ratio	0.000	0.000	0.001
	(0.12)	(0.10)	(0.40)
Capital expenditures	-0.162***	-0.155***	-0.170***
	(-3.09)	(-2.96)	(-3.24)
Dividend ratio	-0.071	-0.089	-0.098
	(-0.56)	(-0.69)	(-0.76)
Amihud liquidity	0.004	0.003	0.002
	(1.11)	(0.90)	(0.55)
NAIC dummy	-0.005	-0.005	-0.006
	(-0.34)	(-0.32)	(-0.42)
Observations	12,969	12,969	12,969
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table 5: **Aggregated rollover risk and merger wave**

This table examines the relation between rollover risk and acquisition activities at the aggregate level. The dependent variable is the monthly fraction of bidder firms to total public firms at the aggregate level. 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	-0.340***		-0.505***
	(-3.22)		(-2.74)
T-bill		0.260**	0.465***
		(2.31)	(4.24)
Term structure		0.176	0.300***
		(1.39)	(2.63)
Credit spread		-0.499***	-0.019
		(-3.89)	(-0.09)
Inflation		-0.014*	-0.019**
		(-1.95)	(-2.39)
log of S&P index		0.012***	0.015***
		(3.19)	(4.55)
Market-to-book ratio		-0.002***	-0.002***
		(-3.03)	(-3.53)
VIX change		0.009	0.009
		(1.23)	(1.28)
Consumer sentiment index		-0.009	-0.010*
		(-1.50)	(-1.67)
Observations	332	325	324
Adjusted R-squared	0.08	0.32	0.35

Table 6: **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, 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 price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par 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	-9.911**		
	(-2.44)		
Price deviation		-1.291*	
		(-1.93)	
Inverse maturity			-0.583
			(-1.31)
Cash	-0.659	-0.710	-0.855*
	(-1.45)	(-1.55)	(-1.82)
Leverage	-0.151	-0.195	-0.369
	(-0.42)	(-0.55)	(-1.03)
Log sale	-0.056	-0.061	-0.062
	(-1.02)	(-1.09)	(-1.11)
Market-to-book ratio	-0.040	-0.033	-0.020
	(-0.82)	(-0.68)	(-0.40)
Tangibility	-0.298	-0.332	-0.447
	(-0.90)	(-1.00)	(-1.34)
Dividend	10.010***	9.982***	10.171***
	(3.17)	(3.14)	(3.22)
R&D expenses	3.229	3.099	2.933
	(0.56)	(0.53)	(0.49)
Relative size	-1.701***	-1.707***	-1.696***
	(-7.76)	(-7.80)	(-7.76)
Horizontal	0.002	0.005	0.018
	(0.02)	(0.05)	(0.19)
Public target	-0.841***	-0.841***	-0.841***
	(-7.89)	(-7.91)	(-7.91)
10-year interest rate	-0.043	-0.045	-0.050
	(-0.38)	(-0.40)	(-0.44)
Bidder return	-0.337***	-0.340***	-0.344***
	(-3.24)	(-3.35)	(-3.69)
Amihud liquidity	-0.018	-0.030	-0.068
	(-0.12)	(-0.21)	(-0.45)
NAIC dummy	-0.482	-0.472	-0.507
	(-0.72)	(-0.70)	(-0.72)
Observations	1,575	1,575	1,575
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table 7: **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, and in columns (5) and (6), it spans 22 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, 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 price deviation from bond par value multiplied by inverse 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		22 days	
Rollover Risk	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
Cash payment fraction	0.026***	0.008	0.036***	0.008	0.022	-0.007
	(3.26)	(1.08)	(3.47)	(0.84)	(1.26)	(-0.44)
Cash	0.032	0.014	0.033	0.031	0.013	0.024
	(1.10)	(0.49)	(1.06)	(0.81)	(0.28)	(0.33)
Leverage	0.019	0.050***	0.014	0.068***	0.046	0.111**
	(1.10)	(2.70)	(0.71)	(3.09)	(1.59)	(2.50)
Log sale	-0.001	-0.000	-0.003	0.001	-0.001	-0.002
	(-0.59)	(-0.18)	(-1.14)	(0.31)	(-0.22)	(-0.31)
Market-to-book ratio	-0.002	-0.001	-0.006**	-0.004	-0.011***	0.001
	(-0.93)	(-0.38)	(-2.18)	(-1.36)	(-2.77)	(0.17)
Tangibility	0.007	-0.009	0.011	0.021	-0.033	0.040
	(0.37)	(-0.49)	(0.49)	(0.79)	(-1.14)	(1.03)
Dividend	-0.043	-0.293**	0.054	-0.270*	0.184	-0.380
	(-0.35)	(-2.46)	(0.38)	(-1.95)	(0.86)	(-1.44)
R&D expenses	0.449	0.647***	0.406	0.690**	0.731	1.245
	(1.17)	(2.82)	(0.80)	(2.47)	(1.03)	(1.60)
Relative size	0.022***	-0.035***	0.031***	-0.038***	0.028***	-0.059***
	(2.63)	(-3.02)	(3.43)	(-2.93)	(3.16)	(-3.65)
Horizontal	0.003	0.008	0.002	0.008	0.001	0.009
	(0.70)	(1.37)	(0.34)	(1.08)	(0.06)	(0.80)
Public target	-0.008	-0.010*	-0.010*	-0.011*	-0.011	0.009
	(-1.59)	(-1.77)	(-1.82)	(-1.71)	(-1.27)	(0.73)
10-year interest rate	-0.014*	0.001	-0.009	0.005	-0.008	0.009
	(-1.95)	(0.19)	(-1.14)	(0.66)	(-0.61)	(0.54)
Bidder return	0.001	0.007*	0.003	0.003	0.009	-0.002
	(0.17)	(1.92)	(0.40)	(0.55)	(0.93)	(-0.17)
Amihud liquidity	0.000	0.004	0.006	-0.000	-0.011	-0.016
	(0.03)	(0.33)	(0.83)	(-0.04)	(-0.98)	(-0.95)
NAIC dummy	0.004	0.024	0.007	0.011	-0.007	0.017
	(0.26)	(1.32)	(0.30)	(0.54)	(-0.23)	(0.46)
Observations	810	769	785	759	784	753
Adjusted R-squared	0.19	0.20	0.20	0.17	0.16	0.14
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: **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)	(6.44)	(8.13)	(5.34)
Rollover loss			-0.615***	-0.624***
			(-3.31)	(-3.77)
Log(cash) × Rollover loss			0.053*	0.070***
			(1.79)	(2.63)
Leverage	-0.368**	-0.700***	-0.319*	-0.641***
	(-2.00)	(-3.54)	(-1.79)	(-3.32)
Log sale	0.648***	0.717***	0.646***	0.717***
	(19.96)	(21.87)	(20.96)	(22.82)
Tangibility	0.219	-0.067	0.213	-0.090
	(1.05)	(-0.26)	(1.06)	(-0.36)
Profit	-1.206***	-0.907**	-1.384***	-1.076***
	(-2.78)	(-2.33)	(-3.30)	(-2.82)
Market-to-book ratio	0.356***	0.341***	0.361***	0.339***
	(7.84)	(8.01)	(8.14)	(7.98)
Capital expenditures	1.071	0.071	1.308*	0.205
	(1.37)	(0.08)	(1.74)	(0.25)
Dividend	4.506***	4.284***	4.254***	4.271***
	(3.12)	(2.98)	(3.02)	(3.06)
Observations	1,628	1,618	1,628	1,618
Adjusted R-squared	0.79	0.85	0.80	0.86
Year FE	No	Yes	No	Yes
Industry FE	No	Yes	No	Yes

Table 9: **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 1. The proportional transaction cost of the acquisition, ψ, is set to 5%. The acquisition can bring synergy gain, g, is 5% of the increased capital, i.e., $G(I) = 5\% \times I$.

Parameter	Symbol	Value
Mean cash flow rate	μ	0.09
Cash flow volatility	σ	0.1
Risk-free rate	r	0.04
Carry cost of cash	λ	0.01
Liquidation cost	φ	0.33
Tax rate	θ	0.20
Coupon on debt	C	0.036
Principal on debt	P	0.75
Average debt maturity	M	1.3
Debt issuance cost	κ	0.01
Production scale	α	0.7
Transaction cost	ψ	0.05
Equity issuance cost	ϕ	0.06
Initial capital	K_{pre}	1
Target size	I	0.1
Post-merger capital	K_{post}	1.1
Synergy gain	g	1%

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. A similar 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 –1.612. A one standard deviation increase in *Rollover risk* causes a significant decrease in *Transaction Value* of 2.9% (1.304 × 0.022), which is nearly 70% of the average transaction costs of 4.1%.

We turn to the two components of our rollover risk measure. The estimated coefficient of *Price deviation* in Column (2) is –0.289 (t-statistic = –4.53). A one standard deviation increase in *Price deviation* induces a significant decrease in *Transaction Value* of 2.6% (0.217 × 0.118), compared to the effect from the rollover risk. In Column (3), we observe a statistically significant coefficient of —0.119 (t-statistic = –2.55) for *Inverse maturity.*

Taken together, our findings using transaction values are consistent with those in Table 4 where we use cash acquisitions to proxy for M&A investments.

A.2 Capital Expenditure

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

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 –0.181, which is statistically significant with a t-statistic of –5.59. When turning to its two components of rollover risk in Columns (2) and (3), we also observe a significant, negative coefficient of —0.029 (t-statistic = –4.83) and –0.011 (t-statistic = –2.32) for *Price deviation* and *Inverse maturity*, respectively. This finding is consistent with what we obtain in Table 4 where we use cash expenses on acquisitions to proxy M&A investment.

Overall, we find the adverse impacts from rollover risk are not limited to large M&A investments. It has significant adverse in broader types of investments.

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 the robustness test on the effect of rollover risk on payment choice. Using the same specification in equation (5), we employ linear regressions instead of Probit models.

These results closely align with those presented in Table 6. In Column (1) where we include *Rollover risk*, we observe a significantly negative coefficient. A one standard deviation increase in this interaction term (0.022) leads to a 5.4% reduction ($—2.446 \times 0.022 = —0.054$) in the probability of a full-cash payment. The estimated coefficient of *Price deviation* in Column (2) shows a marginally significant negative coefficient of –0.325 (t-statistic = –1.83). 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 6 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.

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 price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par 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	-1.612***		
	(-4.43)		
Price deviation		-0.289***	
		(-4.53)	
Inverse maturity			-0.119**
			(-2.55)
Leverage	-0.136***	-0.138***	-0.169***
	(-3.64)	(-3.71)	(-4.62)
Log sale	0.002	0.000	0.001
	(0.36)	(0.05)	(0.14)
Tangibility	-0.173***	-0.173***	-0.177***
	(-4.00)	(-4.02)	(-4.11)
Profit	0.140*	0.141*	0.202***
	(1.88)	(1.91)	(2.79)
Cash	-0.043	-0.040	-0.054
	(-0.68)	(-0.64)	(-0.86)
Market-to-book ratio	0.040***	0.040***	0.041***
	(5.07)	(5.06)	(5.13)
Capital expenditures	-0.094	-0.085	-0.121
	(-0.70)	(-0.64)	(-0.90)
Dividend ratio	-0.371	-0.410	-0.427
	(-1.01)	(-1.11)	(-1.15)
Amihud liquidity	-0.012	-0.014	-0.017
	(-0.90)	(-1.05)	(-1.24)
NAIC dummy	0.048	0.049	0.043
	(0.87)	(0.87)	(0.76)
Observations	12,969	12,969	12,969
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table A2: **Capital expenditures and rollover risk**

This table reports results from Probit 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 price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par 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	-0.181***		
	(-5.59)		
Price deviation		-0.029***	
		(-4.83)	
Inverse maturity			-0.011**
			(-2.32)
Leverage	-0.004	-0.004	-0.008*
	(-0.88)	(-0.99)	(-1.81)
Log sale	-0.002***	-0.002***	-0.002***
	(-2.86)	(-3.00)	(-2.84)
Tangibility	0.126***	0.126***	0.125***
	(22.16)	(22.08)	(22.02)
Profit	0.046***	0.047***	0.054***
	(4.97)	(5.13)	(6.03)
Cash	0.034***	0.034***	0.033***
	(5.18)	(5.20)	(5.03)
Market-to-book ratio	0.006***	0.006***	0.006***
	(6.10)	(6.10)	(6.20)
Dividend ratio	-0.188***	-0.193***	-0.195***
	(-5.08)	(-5.21)	(-5.22)
Amihud liquidity	-0.002	-0.002*	-0.002**
	(-1.57)	(-1.79)	(-2.12)
NAIC dummy	0.004	0.004	0.004
	(1.25)	(1.25)	(1.10)
Observations	12,969	12,969	12,969
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, which have observations in TRACE and NAIC. The dependent variable is an indicator variable if the acquisition is 100% cash financed. Rollover risk is price deviation multiplied by inverse maturity. Price deviation is defined as the difference between market value and par 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	-2.446**		
	(-2.44)		
Price deviation		-0.325*	
		(-1.83)	
Inverse maturity			-0.115
			(-1.23)
Cash	-0.122	-0.131	-0.164
	(-1.17)	(-1.25)	(-1.53)
Leverage	0.016	0.003	-0.035
	(0.19)	(0.03)	(-0.40)
Log sale	0.001	-0.000	-0.000
	(0.11)	(-0.01)	(-0.01)
Market-to-book ratio	-0.005	-0.003	-0.000
	(-0.40)	(-0.24)	(-0.03)
Tangibility	-0.122	-0.128	-0.148*
	(-1.42)	(-1.49)	(-1.70)
Dividend	1.545**	1.514**	1.557**
	(2.56)	(2.48)	(2.54)
R&D expenses	1.800	1.793	1.818
	(1.07)	(1.06)	(1.08)
Relative size	-0.276***	-0.277***	-0.275***
	(-7.63)	(-7.58)	(-7.46)
Horizontal	-0.000	-0.000	0.003
	(-0.01)	(-0.01)	(0.11)
Public target	-0.236***	-0.236***	-0.235***
	(-8.86)	(-8.86)	(-8.81)
10-year interest rate	-0.021	-0.022	-0.023
	(-0.73)	(-0.75)	(-0.77)
Bidder return	-0.056***	-0.058***	-0.063***
	(-3.64)	(-3.81)	(-4.53)
Amihud liquidity	-0.012	-0.015	-0.021
	(-0.38)	(-0.48)	(-0.62)
NAIC dummy	-0.122	-0.124	-0.133
	(-0.62)	(-0.64)	(-0.67)
Observations	1,617	1,617	1,617
Adjusted R-squared	0.34	0.34	0.34
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes