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NO NEWS IS NEWS:
DO MARKETS UNDERREACT TO NOTHING?

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ABSTRACT

As illustrated in the tale of “the dog that did not bark,” the absence of news and the passage of time often contain information. We test whether markets fully incorporate this information using the empirical context of mergers. During the year after merger announcement, the passage of time is informative about the probability that the merger will ultimately complete. We show that the variation in hazard rates of completion after announcement strongly predicts returns. This pattern is consistent with a behavioral model of underreaction to the passage of time and cannot be explained by changes in risk or frictions.

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1 Introduction

“The dog did nothing in the night time ... that was the curious incident.”

- Sir Arthur Conan Doyle

The absence of news reports and the passage of time often contain important information. For example, a citizen who lives through a sustained period without terrorist attacks should update positively on the effectiveness of the government’s anti-terrorism programs. A manager who observes that an employee has executed a difficult task without incident should update positively on the employee’s quality.

“No news” is also news in many financial contexts. For example, if a firm does not lay off workers or declare bankruptcy after a macroeconomic shock, investors should update positively on the firm’s underlying strength. On the other hand, if a firm repeatedly fails to announce new investment projects, investors may be justified in updating negatively on the firm’s growth prospects. Finally, investment returns that seldom display newsworthy variation can reveal information about the underlying investment decisions. Overly-consistent returns may be suggestive of fraud, as in the case of Bernie Madoff’s investment fund.

In this paper, we study the extent to which markets incorporate the information content of “no news”, i.e. the passage of time. We focus on a financial context in which we can easily quantify the information contained the passage of time: mergers. Mergers offer a convenient empirical setting for several reasons. First, each merger has a clear starting point: the announcement of the intention to merge. Second, the returns of merger investment strategies depend heavily on a well-defined and stochastic ending point: the merger either completes, or the parties withdraw for reasons such as loss of financing, antitrust rulings, or target shareholder resistance. To best capture this uncertainty, we focus on mergers without known expiration dates, so that both the timing and outcome of merger resolution are stochastic. Between merger announcement and resolution, there exists an interim period which usually lasts several months to a year. We show empirically that the passage of time during this interim period contains information about whether the deal will ultimately complete. We then compute how prices should move during this interim period if markets fully incorporated the information tied to the passage of time.

Using a sample of over 5000 mergers, we estimate the hazard rate of merger completion, defined as the probability that a merger will complete in event week n conditional on it not completing or withdrawing prior to week n . If the hazard rate of completion is non-constant over the event life of a merger, then the passage of time contains information about merger completion. We find that hazard rates of completion do indeed vary strongly over event time and are hump-shaped. Hazard rates rise from zero in the first weeks after announcement, peak around event week 25, and then decline to zero one year after announcement. In contrast, hazard rates of withdrawal are essentially flat. These patterns hold throughout the calendar time period of our sample, 1970 to 2010. They also hold after accounting for potential heterogeneity, such as the form of merger financing or the size of the target.

Rational markets should incorporate all available information, including predictable variation in hazard rates tied to the passage of time. For example, if the market believes the merger is likely to complete tomorrow, the price of the target should be high today, so that the mean return between today and tomorrow should be the risk free rate plus compensation for risk. When we look empirically at returns, we find a strong positive correlation between hazard rates and returns in the event year following merger announcement. This relationship is robust and holds even when we estimate hazard rates using an earlier sample and mean returns using a later sample.¹ In other words, returns are predictable and they move with the hump-shaped hazard rates. For example, a strategy that invests in cash financed mergers earns a mean return of 20bp per week in the first few weeks after merger announcement. Returns peak at above 40bp per week around event week 25 and then decline sharply as more time passes after announcement.

What explains the strong predictability of returns by hazard rates? We explore two possible explanations: underreaction to the passage of time (the behavioral explanation) and changes in risk or trading frictions over the event lives of mergers (the rational explanation).

First, we examine the behavioral explanation, motivated by a large literature showing that agents tend to underreact to less vivid and salient sources of information.² The passage of

¹For cash financed mergers, the relevant return is the return from holding the target. For equity financed mergers, the relevant return is that from a strategy in which one takes a long position in the target and a short position in the acquirer.

²See for example Gabaix et al. (2006), Gifford (2005), Kahneman (1973), Pashler, ed (1998), Radner and Rothschild (1975), Sargent (1993), Simon (1955), and Tversky and Kahneman (1973) for general theories, and

time after merger announcement is likely to be less vivid than explicit news stories covered by either formal media outlets or rumors. Media outlets typically choose to cover the more attention-grabbing news stories to increase readership while rumors tend to anticipate the same explicit news covered by media outlets (we discuss explicit news in detail in Section 5.3). Information tied to the passage of time that is not covered by explicit news is then likely to be endogenously less able to grab people’s attention. Therefore, boundedly rational agents may not fully update on the passage of time. We develop a simple model showing that this underreaction can explain the observed returns predictability.

The model links movements in the target’s price to market beliefs about event time variation in hazard rates. If agents correctly update using the passage of time and systematic risk does not change over the event lives of mergers, then mean weekly returns should be constant in event time. Returns should not vary systematically with the passage of time and they should not be predicted by the hazard rate.

However, if agents underreact to the information contained in the passage of time, they will behave as though they believe that the hazard rate of completion does not vary over event time as much as the true hazard rate. This implies that agents will tend to *underestimate* the hazard rate when hazard rates are high and *overestimate* it when hazard rates are low.

Underreaction to the passage of time further implies that mean returns should be high when hazard rates are high (since markets underestimate merger completion probabilities and receive positive surprises on average) and low when hazard rates are low (since markets overestimate merger completion probabilities and are disappointed on average). In other words, hazard rates and mean returns should be positively correlated. This matches the data: mean returns are significantly non-constant over the event lives of mergers and the pattern in mean returns is aligned with movements in aggregate hazard rates.

Importantly, these predictions hold even if investors observe explicit news in the interim period between merger announcement and resolution. For example, investors may be exposed to news reports of target shareholder voting results or insider information leaks about merger completion probability. By “no news”, we do not refer to the situation in which no explicit news is released. Rather, we define “no news” to be the information content tied to the passage

Merton (1987), Peng (2005), and Peng and Xiong (2006) for applications to financial markets.

of time, i.e. what market participants should know by observing the passage of time *even if they are unable to observe explicit news*.

The release of explicit news is not a threat to our methodology because rational investors should update on *both* explicit news and the passage of time; the passage of time should still not predict returns. We do not rule out the possibility that markets underreact to explicit news. However, we show that, at a minimum, markets underreact to the passage of time. In fact, any release of explicit news about merger completion probability should be a bias against our findings that aggregate hazard rates tied to the passage of time predict returns. If agents receive explicit news, they should estimate merger completion probability with less error, and therefore aggregate historical hazard rates should be less predictive of returns. This intuition is discussed in detail in Section 5.3.

Using our simple model, we estimate the market’s beliefs about completion hazard rates that would generate the observed average returns in each event week. The implied beliefs track the empirically measured hazard rates but display approximately 25 percent less variation over time. This is consistent with an underreaction hypothesis in which agents only partially incorporate the information content of the passage of time when setting prices.

While our results are consistent with the behavioral model of underreaction, the positive relationship between returns and hazard rates could also reflect compensation for risk or frictions (the rational explanation). We begin by noting that the correlation between hazard rates and returns is a phenomenon measured over the event life of the merger, and therefore cannot be explained by changes in risk or risk premia over calendar time.³ Next, we test whether our results can be explained by event time variation in three types of risk: (1) systematic risk as captured by the Fama French factors, (2) downside risk, in which returns covary more with the market during market downturns, and (3) idiosyncratic risk. To measure risk, we examine the returns of trading strategies that modify the common merger arbitrage strategy described in Mitchell and Pulvino (2001): for each calendar month we invest in all mergers active between certain event windows. We test whether a trading strategy that invests

³Because mergers occur in waves, we may be concerned that event time is correlated with calendar time, and therefore changes in risk or risk premia over calendar time may matter. However, in a regression of returns on hazard rates, the results remain similar after we control for calendar time (year x month) fixed effects, which removes calendar year-month variation in risk and risk premia.

in deals active in event weeks when hazard rates are high (estimated from the aggregate sample of mergers in a *preceding* period) delivers a higher alpha than a strategy that invests in deals in event weeks when hazard rates are low.

Our High Hazard strategy delivers a significant monthly alpha (relative to the three Fama French factors) of 64bp for cash deals and 146bp for equity deals. This is significantly higher than the -6bp and 17bp for cash and equity deals, respectively, of strategies that buy deals in the Low Hazard weeks. This is also significantly higher than the 38bp and 109bp respectively of the traditional Buy and Hold strategy which invests in deals for their entire event lives. These alphas represent the economic magnitude of potential mispricing: event time variation in hazard rates predicts a substantial difference in alpha of approximately 100bp per month between the High and Low Hazard strategies for cash and equity mergers.

We also find that all risk exposures (Fama French betas, momentum beta, downside beta, beta with respect to the option factors of Agarwal and Naik (2004), and idiosyncratic risk) do not vary significantly in event time. Therefore, while risk is a potential contributor to the positive returns in the traditional Buy and Hold merger arbitrage strategy, it cannot explain why returns covary with hazard rates over the event lives of mergers.

Finally, we consider alternative rational explanations based on event-time-varying frictions and asymmetric information. For example, large institutional investors tend to sell the target immediately after announcement to lock in capital gains. If not enough arbitrage capital takes the other side of the deal, the downward price pressure could result in low returns immediately after announcement, followed by rising returns as arbitrage capital enters. It is also possible that the degree of asymmetric information changes in event time, such that the buyer's required compensation for the asymmetric information also changes. These explanations predict that mean returns should be correlated in event time with proxies for market liquidity and asymmetric information. Instead, we show that almost all the event time variation in these market conditions is concentrated in the first two weeks after announcement, while the event time variation in returns that we document occurs on a different time scale, in the *months* following announcement. Further, we show that potential "last day effects," frictions associated with the last day of trading before merger completion, cannot generate our returns patterns.

We conclude that changes in risk, frictions, and asymmetric information in event time are

unlikely to drive the relationship between hazard rates and returns. Rather, the empirical evidence supports the behavioral hypothesis that markets fail to incorporate all information contained in the passage of time while waiting for merger resolution.

Given that sophisticated investors are likely to exist in these markets, we explore why these returns patterns are not arbitrated away. We study how the High Hazard strategy performs when executed on subsamples of mergers for which arbitrage is likely to be more difficult due to higher transaction costs. We find that the alphas of our High Hazard strategy are significantly larger for smaller deals, for deals with lower volume and turnover, and for deals with higher bid-ask spreads. Next, we simulate realistic trading strategies that limit the total exposure to each deal and account for direct and indirect transaction costs following the procedure developed in Mitchell and Pulvino (2001). Accounting for trading costs and limitations in the size of the positions pushes our alphas toward zero, although we still find significant differences in the alphas between our High and Low Hazard strategies. This is consistent with a limits to arbitrage view in which boundedly rational retail investors generate the mispricing and sophisticated investors are unable to fully arbitrage away mispricing in the subset of deals for which transaction costs are particularly high.

To the best of our knowledge, this is the first paper to empirically investigate underreaction to the passage of time. However, our findings build upon and complement related findings in behavioral finance. For example, Da, Gurn and Warachka (2012) show that markets underreact to the slow release of news. Corwin and Coughenour (2008) and Barber and Odean (2008) show that investors focus on familiar or attention-grabbing stocks, while Hirshleifer and Teoh (2003), Hirshleifer et al. (2004), and DellaVigna and Pollet (2009) study limited attention with respect to firm disclosure. Cohen and Frazzini (2008) and Menzly and Ozbas (2010) find evidence of limited attention with regard to firms' economic linkages. Chan (2003), Gilbert et al. (2012), Hirshleifer, Lim and Teoh (2009), Huberman and Regev (2001), and Tetlock (2011) study under- and over-reaction to explicit news in different financial settings. Overall, the existing literature argues that investors underreact to less salient news when sifting through a set of explicit news stories. This paper shows that investors also underreact to the absence of news, which itself can contain valuable information.

Our research also relates to several recent papers that present rational explanations for

price movements in the absence of activity. For example, Marin and Olivier (2008) and Gao and Ma (2012) find that markets incorporate part of the information tied to the absence of insider trading. Bagnoli, Kross and Watts (2002) show that prices drop following delays in earnings reports because delays convey negative information.⁴ Compared to these papers which argue that price drift in the absence of news reflects rational updating by the market, we quantify the extent to which markets underreact to the information content of the passage of time.

Understanding how agents process the absence of news is economically important because the passage of time often contains valuable information that can reduce asymmetric information problems (for example, between voters and politicians, employers and employees, and investors and insiders). Underreaction to no news can therefore lead to misallocation of resources in a variety of contexts. In addition, the distortionary effects of underreaction to no news can be amplified by the fact that no news tends to be slow-moving and persistent.

2 Data

We combine data on merger activity from two sources. The first data source, generously shared by Mark Mitchell and Todd Pulvino (MP), covers merger activity from 1970 to 2005. It is an updated version of the data described in Mitchell and Pulvino (2001). The second data source is Thomson One (TO), formerly known as the SDC, which covers merger activity from 1985 to 2010. Because MP covers a longer time series while TO offers more comprehensive coverage of recent years, we combine the two datasets as follows: we use the MP dataset for years up to and including 1995 and the TO dataset afterward. The exact year of the split is determined by a comparison of the relative coverage of the two datasets in each year. Our results are robust to using only MP or TO data.

We define the takeover premium for cash deals as the ratio of the initial offer price at deal announcement to the price of the target two days before deal announcement. For equity

⁴A related theory literature includes Campbell and Hentschel (1992), who show that the absence of major price movements predicts low future volatility; Galai et al. (2007), who model the relationship between time spent in distress and liquidation; and Jung and Kwon (1988), who model the information content of the absence of disclosures.

financed deals, the takeover premium is defined as $\Delta * P_{t=-2}^A / P_{t=-2}^T$, where Δ is the exchange ratio, defined as the number of acquirer shares offered for each share of the target, and P^A and P^T are the acquirer's and target's share prices, respectively.

We apply the following filters to our initial sample of mergers.

1. The merger is all cash financed or all equity financed. We exclude hybrid forms of financing or deals with contingency terms (e.g. collar agreements) because they are more difficult to price using the available data on equity prices. For equity financed deals, we require that there exists data on the exchange ratio for the deal.
2. The merger takes the form of a simple one-step merger without a known expiration date for investors to tender shares. We exclude tender offers, which have known expiration dates, because the information content of the passage of time near and beyond the expiration date is likely to be obvious to market participants.⁵
3. For cash financed mergers, equity price data is available for the target from the Center for Research in Security Prices (CRSP). For equity financed mergers, equity price data for both the target and acquirer is available from CRSP.
4. We exclude deals for which the typical hazard rates of completion or withdrawal are less applicable. First, we exclude deals that compete with a previous bid for the same target that was announced within the past three years because competing bids are relatively more likely to withdraw and follow more deal-specific heterogeneity in timing. Second, we exclude deals in which the initial takeover premium is less than one. As we execute our trading strategies (see Section 6), we also exit out of a deal if the target price rises above the acquirer offer price (or, for equity financed mergers, the exchange ratio multiplied by the acquirer stock price). In these cases, the market expects either a competing offer or a favorable revision of deal terms and deal completion is less likely to be the primary form of uncertainty.

⁵Note that in some cases, one-step mergers have projected completion dates (as opposed to expiration dates) that are disclosed at merger announcement. Our historical panel of data does not contain information about projected completion dates. However, discussions with M&A lawyers suggest that these date projections have limited informativeness because of the many uncertain steps involved in the merger process which can greatly affect the timing and probability of completion. Therefore, we keep all one-step mergers in the sample.

Note that these filters only exclude deals from the sample or investment strategy based upon information that was publicly available at the time of the deal. After applying these filters, we are left with 3414 cash financed deals and 1963 equity financed deals, which are summarized in Table 1. If a deal does not complete, it can either be formally withdrawn on a particular date or remain pending. 70 percent of cash financed deals complete, with a median time to completion of 83 days. 77 percent of equity financed deals complete, with a median time to completion of 97 days.

3 Hazard Rates

In this section, we document how the hazard rate of completion varies over the event lives of mergers. Variation in hazard rates represents one important reason why the passage of time after merger announcement should contain information about whether the deal will ultimately complete. Other reasons why the passage of time may contain information are discussed in Section 5.4.

3.1 Empirical Hazard Rates

Let t refer to the number of weeks after the merger announcement. Note that t measures event time rather than calendar time. Let $S(t)$ be the probability that the merger survives until time t , i.e. it does not complete or withdraw prior to t . Let $h(t)$ be the hazard rate of completion at time t , i.e. the probability that the merger completes during period t conditional on surviving up to t . We also estimate a separate hazard rate of withdrawal $w(t)$, although we will show that this hazard rate remains roughly constant over event time.

We use the standard Kaplan-Meier estimator of competing hazard rates. We estimate the hazard rates of completion (withdrawal) as the fraction of deals that complete (withdraw) during each period t among those that have survived until time t , taking into account that once a deal has completed it cannot withdraw, and vice versa. The Kaplan-Meier estimator assumes that all merger completion and withdrawal events are drawn from the *same* underlying distribution and provides an estimate of this distribution at each point in event time. In reality, it is possible that deal completions and withdrawals follow different hazard pro-

cesses depending on the observable or unobservable characteristics of each deal. For example, mergers in regulated utilities are known to take longer on average because of the additional regulatory hurdles. We explicitly account for one major source of heterogeneity: the financing of the deal. A large literature has explored the differences between cash and equity financed deals. Therefore, we allow the two types of mergers to have different hazard rates curves for completion and withdrawal. We leave a discussion of other potential sources of heterogeneity for the next subsection.

Figures 1 and 2 show the estimated hazard rates of completion and withdrawal for cash and equity mergers. We report estimates using the full sample of mergers (1970-2010), and separately over the early and late parts of the sample (1970-1990 and 1991-2010).

Three main results emerge from these figures. First, the hazard rates of completion are strongly non-constant. For cash deals, they start at around zero during the first weeks, then rise to about 7 percent per week around week 20, and gradually decline to zero by the end of the first year after announcement. A similar pattern is observed for equity deals, for which the hazard rate reaches 8 percent per week at the peak in week 25. Second, hazard rates of withdrawal are essentially constant for both cash and equity deals. Third, hazard rate patterns estimated using the early and late calendar time samples are similar, suggesting that hazard rate patterns have not changed significantly over the past several decades.

3.2 Heterogeneity in Hazard Rates

Within the categories of cash and equity mergers, the hazard rate for any specific merger may differ from the hazard rate we estimate using aggregate data because of other observed and unobserved heterogeneity. While it is impossible to fully account for heterogeneity in hazard rates, our results are robust to unobserved heterogeneity for two reasons.

First, we will test a behavioral hypothesis that predicts a positive relationship between each individual merger's latent hazard rate and returns. To the extent that our measured hazard rate approximates each merger's individual hazard rate with noise, this is a bias *against* our empirical findings in support of the behavioral hypothesis.

Second, we prove that, under commonly used assumptions (such as those used in the proportional hazard models) about the nature of the unobserved heterogeneity, the mean

individual latent hazard rate must be non-constant over a merger’s event life if the *measured* hazard rate (which ignores the heterogeneity) is non-constant. In other words, given that our measured hazard rate is strongly hump-shaped, the true hazard rate will necessarily display even more time variation. This implies that even if unobserved heterogeneity is present, there is information content in the passage of time. In particular, we prove the following proposition in the Appendix:

Proposition 1. *Suppose that the true hazard rate for merger i is $h_i(t) = \alpha_i h(t)$, where $h(t)$ is an unobserved common component and α_i is a merger-specific unobservable parameter distributed in the cross-section according to the distribution function $G(\alpha)$ with mean normalized to 1. Then, we have*

$$h(t) \geq h_\theta(t) \quad \forall t,$$

where $h_\theta(t)$ is the measured hazard rates that ignores the unobserved heterogeneity.

Proposition 1 shows that the mean of the latent individual hazard rates must always lie weakly above the estimated hazard rate. Based upon conversations with M&A lawyers, we also assume that individual hazard rates are close to zero at the very beginning of event time (because a merger cannot complete immediately after announcement due to regulatory restrictions) and at the very end of event time (some period T). This, combined with Proposition 1, shows that the mean individual latent hazard rates must have at least as much time variation as the estimated hazard rate $h_\theta(t)$, and therefore, the passage of time contains information about merger resolution.

In Appendix Figure 11, we account for another explicit source of observed heterogeneity: the merger arbitrage spread, as measured by the relative difference between the effective offer price and the target price two days *after* merger announcement. A large merger arbitrage spread usually reflects market beliefs that the merger is unlikely to complete. As expected, we find that a larger merger arbitrage spread tends to shift the overall hazard rate curve down proportionally, but the overall hump shape of the hazard rate curve remains similar. Since our analysis focuses on event time variation in hazard rates rather than the mean level of hazard rates, we abstract away from this source of heterogeneity in future analysis. In unreported results, we also check for heterogeneity by size of the target, and find similarly shaped hazard

curves across size categories.

Armed with the result that hazard rates of completion vary significantly over the event lives of mergers, we now study the implications for returns.

4 Returns and Hazard Rates

In this section, we document a surprising positive correlation between hazard rates and average weekly returns over event time. Further, this relationship continues to hold when we estimate hazard rates using an aggregate sample in a previous period and returns in a later period. For cash mergers, the relevant return is the weekly return from investing in the target. For equity mergers, the relevant return is the weekly return from going long the target and shorting Δ shares of the acquirer. Each event week's return includes the gains from any delisting, i.e. the upside from attaining the acquirer's offer price if the merger completes in that week. Note that we use actual returns for each event week, and do not scale any daily return to a weekly horizon for deals that complete in the middle of a week.⁶

We start by plotting average returns across deals in event time for cash and equity mergers. Because very few deals survive until one full year after announcement, and returns are noisy, we focus on event weeks 1 through 45 in all subsequent analysis.⁷

Figure 3 plots completion and withdrawal hazard rates in the top panel and mean weekly returns in the bottom panel. Because of noise in the returns data, we plot returns over event time by fitting a smoothed local mean to the panel series of returns for each deal in each event week. The figure shows smoothed returns using the optimal bandwidth. In unreported results, we also plot the curve using 0.5 and 1.5 times the optimal bandwidth, as well as fitting a local linear regression, and find qualitatively similar results. The figures show that the hazard rate of completion and mean weekly returns tend to move together. In the first weeks after announcement and towards the end of the first year after announcement, completion hazard

⁶We test our underreaction hypothesis using stock prices as opposed to option prices. In theory, option prices may offer insights into the market's perceptions of completion probabilities, as well as beliefs about downside and jump risk. Unfortunately, less than 10 percent of our sample consists of deals in which options for the target are traded. In addition, the options subsample tends to exclude small stocks, for which we find the greatest degree of underreaction.

⁷All results in this paper are substantively unchanged if we include returns after week 45, although the confidence intervals for average returns (as plotted in Figure 3) are very wide for all weeks after week 45.

rates are below the average and returns are below the average as well. In the intermediate weeks, hazard rates are high and returns are high as well. Finally, returns revert to the average by the end of the last event week (week 45). This nuance is discussed in detail in Section 5.2

In Figure 3, we also plot 90 percent pointwise confidence bands for each point in the returns curve. These confidence bands grow wider as we approach one year after merger announcement because fewer deals survive as time passes after announcement. We also conduct a more formal test of whether returns are constant over event time. We estimate a regression of returns on indicators for each event week following deal announcement, with controls for calendar year-month fixed effects and with standard errors double-clustered by merger and calendar year-month. We can reject that returns are constant across event weeks with p-values of 0.08 and 0.002 respectively for cash and equity deals.

Next, we test the strength of the relationship between returns and completion hazard rates. In Table 2, we regress weekly returns on hazard rates, with and without controls for calendar year-month fixed effects. Observations are at the merger by event week level. The fixed effects control for possible calendar time variation in unobservables that might affect returns, e.g. calendar-time variation in risk or risk premia. We allow standard errors to be double clustered at both the the calendar year-month level and at the merger level. For both cash and equity deals, we find that hazard rates (estimated from the aggregate sample) significantly predict returns over event time. The relationship continues to hold when we adopt a split-sample approach that is free of “look-ahead” bias. In column (3) we show that hazard rates estimated using the first half of our sample (pre-1991) predict returns in the second half of the sample.

Overall, we find that returns following merger announcement are predictable using aggregate hazard rates. This is surprising because we expect rational markets to incorporate all available information, including predictable variation in hazard rates. For example, if the market understands that the merger is likely to complete tomorrow, the price of the target should be high today, such that the mean return only reflects compensation for risk. What explains this return predictability? In the remainder of this paper, we explore two possible explanations: underreaction to the passage of time (the behavioral explanation) and changes in risk or frictions over the event lives of mergers (the rational explanation).

5 A Simple Behavioral Model of Underreaction

To understand what time variation in hazard rates implies for returns when markets imperfectly update on the passage of time, consider the following parsimonious pricing model for the returns of the target of a cash merger after the announcement of the intention to merge.

5.1 The Model

Let t represent event time after merger announcement. Let r be the constant risk free rate. Let $\hat{P}(t)$ be the price of the target's shares after merger announcement, but before the deal has completed or withdrawn. If at any point the deal completes, the value of the target jumps to P_C , the amount of cash per share promised to the target's equity holders. If at any point the deal is withdrawn, the price jumps to $P_0(t)$, where $P_0(t)$ is some latent process.⁸ We model $P_0(t)$ as:

$$dP_0(t) = \mu P_0(t)dt + \sigma P_0(t)dZ(t), \quad (1)$$

where $Z(t)$ is a standard Brownian motion. We assume that there is an end time, T , such that any deal that does not complete by time T is assumed to never complete (in accordance with the empirical evidence that shows that hazard rates of completion fall to zero approximately one year after merger announcement).

If the merger has not completed or withdrawn prior to time t , the price of the target is:

$$\begin{aligned} \hat{P}(t) &= E_t \left\{ \int_t^T e^{-r(z-t)} e^{-\int_t^z [\hat{h}(k) + \hat{w}(k)] dk} \hat{h}(z) P_C dz \right. \\ &+ \int_t^T e^{-r(z-t)} e^{-\int_t^z [\hat{h}(k) + \hat{w}(k)] dk} \hat{w}(z) P_0(z) dz \\ &+ \left. e^{-r(T-t)} e^{-\int_t^T [\hat{h}(k) + \hat{w}(k)] dk} P_0(T) \right\}, \end{aligned} \quad (2)$$

where $\hat{h}(t)$ and $\hat{w}(t)$ are risk-neutral hazard rates.

To focus on a possible behavioral explanation, assume for now that all risk is idiosyncratic and the market believes that all risk is idiosyncratic. This means that we can interpret $\hat{h}(t)$ and $\hat{w}(t)$ as market beliefs about the true hazard rates, as opposed to the risk-neutral hazard

⁸Using insights from Malmendier, Opp and Saidi (2011), which shows that merger announcement can change the underlying value of the target even if the merger never completes, we do not constrain $P_0(t)$ to represent the value of the target if the merger had never been announced. Rather, $P_0(t)$ represents the value that the target share price would revert to if the acquirer were to withdraw at time t .

rates that also reflect the risk attitude of the market (we postpone a thorough discussion of risk to a later section).

Let $h(t)$ and $w(t)$ be the *true* hazard rates, as opposed to the market beliefs represented by $\hat{h}(t)$ and $\hat{w}(t)$. Note that $\hat{P}(t)$ in equation (2) above is a function of market beliefs about hazard rates while the average realized one period return from holding the target is a function of both $\hat{P}(t)$ and the true hazard rates:

$$E[ret_t] = \left(\frac{P_C}{\hat{P}(t)} - 1 \right) h(t)dt + \left(\frac{P_0(t)}{\hat{P}(t)} - 1 \right) w(t)dt + \left(\frac{d\hat{P}(t)}{\hat{P}(t)} \right) [1 - h(t) - w(t)] dt. \quad (3)$$

Combining equations (2) and (3), we can decompose the expected one-period return as:

$$\begin{aligned} E[ret_t] &= rdt \\ &+ \left(\frac{P_C}{\hat{P}(t)} - 1 \right) [h(t) - \hat{h}(t)] dt \\ &+ \left(\frac{P_0(t)}{\hat{P}(t)} - 1 \right) [w(t) - \hat{w}(t)] dt. \end{aligned} \quad (4)$$

Note that

$$\left(\frac{P_C}{\hat{P}(t)} - 1 \right) \geq 0 \quad \text{and} \quad \left(\frac{P_0(t)}{\hat{P}(t)} - 1 \right) \leq 0.$$

The model generates simple testable predictions concerning the relationship between hazard rates and mean returns at each event time t . First, if markets have correct beliefs about hazard rates ($h(t) = \hat{h}(t)$, $w(t) = \hat{w}(t)$), the mean target return will always equal the risk free rate r (since all risk is assumed to be idiosyncratic). Second, if the market underestimates completion hazard rates ($\hat{h}(t) < h(t)$), mean returns will be higher than the risk free rate r . This occurs because the market, underestimating the probability of completion, will receive positive surprises on average, generating abnormally high returns. Finally, if the market overestimates the completion probability ($\hat{h}(t) > h(t)$), the target's stock will be overvalued at time t and experience a return that is lower than the risk free rate. Incorrect beliefs about the withdrawal hazard rate would similarly lead to deviations from the risk free rate, following equation (4). Note that returns in each period will deviate from the risk free rate only if beliefs

differ from the true hazard rate in the current period (future differences between beliefs and true hazard rates do not matter except in affecting the second and third terms through $\hat{P}(t)$).

These predictions directly map to the behavioral hypothesis of market underreaction to no news. Suppose that markets fail to use the passage of time to update on changes to the hazard rate, but have correct beliefs on average over the event life of a merger. In other words, the market believes that $\hat{h}(t) = \bar{h}$ and $\hat{w}(t) = \bar{w}$, where \bar{h} and \bar{w} represent the average of the *true* hazard rates. This implies that the market will have approximately correct beliefs about the hazard rate of withdrawal because $w(t)$ is approximately constant over time. However, the market will underestimate the completion hazard rate during event weeks in which the true hazard rate is high. During these times, the model predicts that we should observe particularly high returns for the target's stock. In contrast, in event periods in which the true completion hazard rate is low, markets will overestimate the hazard rate, and the model tells us that we should expect to see particularly low average returns for the target. In other words, underreaction to the passage of time implies that mean returns should be positively correlated with true hazard rates, exactly as we observe in the data.

Figure 4 shows an example of how the relationship between hazard rates and returns varies depending on whether beliefs are correct. The top panel shows the completion and withdrawals hazard rates, estimated for cash deals. It also plots a sample set of beliefs (for illustrative purposes only) in which the market holds correct beliefs about hazard rates for the first several weeks after deal announcement (the dotted line and the solid lines coincide). After a certain number of weeks, and up to a year after announcement, agents fail to use the passage of time to update on changes in the hazard rate. The beliefs about the completion hazard rate are constant but correct on average. As a consequence, in this example, markets underestimate the true completion hazard rate between weeks 10 and 37 and overestimate the hazard rate from week 37 onwards.

The lower panel of Figure 4 shows the model predictions for average excess returns over the risk free rate in each event week among the set of deals that have not yet completed or withdrawn. During event periods in which beliefs are correct, mean excess returns are zero (the return is equal to the risk free rate). When markets underreact to no news but have correct beliefs on average about hazard rates, the returns curve follows the shape of the

hazard rate of completion: returns are positively correlated with hazard rates.

These predictions extend to a model in which merger returns contain risk that is systematic and in which risk and risk premia are allowed to be non-constant in calendar time. As long as risk and risk premia do not vary systematically over event time, rational updating on the passage of time implies that merger returns should be constant over the event life of the merger (although mean returns may exceed the risk free rate). Underreaction to no news still implies a positive relationship between hazard rates and returns. These predictions also extend to a model of equity mergers; returns for these deals are those from a portfolio in which investors long the target and short the acquirer. Finally, these predictions hold even if agents *also* have incorrect beliefs about the average completion rate over the merger’s event life. As long as hazard rate beliefs exhibit *flatter* event time variation than true hazard rates, the model predicts a positive relationship between hazard rates and mean returns.

5.2 Estimating Market Beliefs about Hazard Rates

We can also use the model to estimate the market’s beliefs with regard to completion hazard rates that are implied by the observed returns. We parameterize the model using the main sample moments of the data: $P_c = 1.3P_0(0)$, corresponding to an approximately 30 percent takeover premium as shown in Table 1, and $r = 2\%$ per year.⁹ Using Equation (4), we numerically estimate the values for beliefs $\hat{h}(t)$ such that the model-implied returns match the observed average return in each event week. To focus on implied beliefs concerning the completion hazard rate, we also impose that beliefs about the withdrawal hazard rate are correct, $\hat{w}(t) = w(t)$. Given that $w(t)$ is approximately constant, the results are robust to assuming that beliefs about withdrawal hazard rates are flat and equal to the mean of $w(t)$.¹⁰ Since the model assumes that all risk is idiosyncratic, we also adjust the average return across

⁹Of course, $P_0(0)$ need not equal the price of the target prior to merger announcement, as noted in Malmendier, Opp and Saidi (2011). Our model calibration yields similar results if we instead assume that $P_c = 1.2P_0(0)$ or that $P_c = 1.4P_0(0)$.

¹⁰In theory, the positive correlation between hazard rates of completion and returns may also be driven by incorrect beliefs about the hazard rate of withdrawal. However, the true hazard rate of withdrawal is flat over event time, so agents will have approximately correct beliefs about the hazard rate of withdrawal even if they ignore the passage of time. To generate the observed returns pattern only through incorrect beliefs about withdrawal, the market must believe that withdrawal rates are hump shaped even though they are flat over event time.

all event weeks to be equal to the risk free rate. In practice, as shown by Mitchell and Pulvino (2001), the average return across all events weeks exceeds the risk free rate mainly due to transaction costs in operating the arbitrage strategy – we show later that these are approximately constant in the event windows that are relevant for our findings.

Figure 5 compares the estimates of true hazard rates with the beliefs implied by fitting the model to the observed returns. Consistent with an underreaction hypothesis, we find that implied beliefs of completion hazard rates are flatter than the estimates of true hazard rates for both cash and equity deals. Hazard rates are overestimated at the beginning and the end of the event period, and underestimated in the intermediate period. We can also estimate the extent of the underreaction: the implied beliefs display 26 and 27 percent less variation over event time than the estimates of true hazard rates for cash and equity mergers, respectively.¹¹ In other words, markets only partially incorporate the information content of the passage of time.

A striking implication of Figure 5 is that agents overestimate the hazard rate of completion during the first two months following merger announcement. This may seem surprising if we consider that most deals cannot legally complete so soon after announcement due to regulatory barriers, a fact that should be obvious to many market participants. However, the market may anticipate that positive explicit news about merger completion probability will be released in the period immediately following the announcement, which would lead the target’s price to converge upwards toward the offer price. From the point of view of an agent holding the target, the release of definitive news about future completion will have the same effect on target prices as if the actual completion event occurs. Therefore, the overestimation of hazard rates observed in the first two months could be explained by the agents being overly optimistic about the probability of obtaining good explicit news about future completion. If agents overestimate the probability of receiving good news in the next period, they will set prices too high in the current period, and receive negative surprises (lack of good news) in the next period, leading to low returns in the first weeks after announcement.

¹¹We measure the total variation in true hazard rates as $TV = \sum_{t=1}^T (h(t) - \bar{h})^2$. The sum of squared errors between the true hazard rate and implied beliefs is $SE = \sum_{t=1}^T (h(t) - \hat{h}(t))^2$. Therefore, SE/TV offers an estimate of the event time variation in true hazard rates that is not captured by implied beliefs. If beliefs are correct, $SE/TV = 0$, and if beliefs are completely flat, then $SE/TV = 1$.

Figure 5 also shows an interesting convergence between beliefs and true hazard rates as the time after merger announcement approaches one year. While returns one year after announcement are noisy, this is consistent with a story in which agents are slow to react to changes in the hazard rate. However, after sufficient time has passed, agents eventually hold correct beliefs and realize that the merger is unlikely to ever complete. Once agents hold correct beliefs, returns revert to zero (in the model) or to their mean (once we account for systematic risk that is constant in event time). This explains why returns display a small upward swing toward the mean near the end of the event year as shown in Figure 3.

5.3 No News vs. Explicit News

During the interim period between merger announcement and resolution, investors may observe explicit news. For example, investors may see news coverage of shareholder voting results or insider information leaks about merger completion probability.¹² By “no news”, we do not refer to the situation in which no explicit news is released. Rather, we define “no news” to be the information content tied to the passage of time, i.e. what the market should know by observing the passage of time *even if agents are unable to observe explicit news*.

In this section we show that the release of explicit news is not a problem for our methodology; rather it is a bias against our findings. While we cannot rule out the possibility that markets underreact to explicit news, we can show that, at a minimum, markets underreact to the passage of time.

The key insight is that it is possible to underreact to multiple sources of information at the same time. If multiple signals observed by the market convey the same information and this information is not reflected in prices, then the market must be underreacting to all signals. “No news,” defined as the passage of time, is one public signal that the market should observe. If the passage of time predicts returns, then the market must be underreacting to that signal and possibly to other signals that contain the same information.

For example, suppose that, historically, the probability of merger completion drops dras-

¹²For example, Ahern and Sosyura (2013) study explicit news released during merger negotiations. While they focus on news released prior to merger announcement, their analysis suggests that news released after announcement may also strongly affect market expectations.

tically just after event month six. The market observes a new merger approaching month six. The information content of the passage of time tells us that this merger is now unlikely to complete. Consider first the case in which there is no explicit news released after merger announcement. If the price doesn't drop as the merger approaches month six, then we know that markets underreacted to the information content of the passage of time.¹³

Now suppose that, right before month six, the market also observes a news report warning that this deal is unlikely to complete. At this point, the market observes two signals conveying the same information: the passage of time beyond month six and the negative news report. If we again find that the price does not drop, then we know that markets have underreacted to both the information content of the news report and the passage of time.

Given that prices do not drop as the merger approaches month six, could it be that agents underreacted to explicit news but correctly incorporated the information content of the passage of time? No – if markets had incorporated the information content of the passage of time, they would have realized that the merger was unlikely to complete because it was past month six, and the price would have dropped.

In our paper, we show prices do not incorporate information that is available by looking at the passage of time. Therefore, markets underreact to the passage of time. We cannot exclude that prices are also failing to incorporate information contained in explicit news. In fact, if agents receive informative explicit news throughout the life of the merger, they should estimate merger completion probabilities at each point in a merger's event life with less error, and therefore aggregate historical hazard rates should be less predictive of returns.¹⁴

¹³To see why the price should decline as we reach month six, recall that, up to month six, the probability of completion is positive, so the value of the target incorporates the probability that the deal will complete and the target shareholders will gain from the completion. As the completion probability drops, the value of the target drops since now the merger is unlikely to complete.

¹⁴Because the release of explicit news should be a bias against our findings, we do not attempt to measure the exact quantity of explicit news released after merger announcement (doing so is difficult in the context of mergers because much of the news after announcement consists of unobservable insider rumors). Nevertheless, our later results support the idea that explicit news represents a bias against our results. In particular, high market capitalization and trading volume are likely to be associated with more explicit news, including insider rumors. In Section 7, we show that the returns of targets with high market capitalization and trading volume tend to display less underreaction to the passage of time, consistent with the view that the release of explicit news is a bias against us.

5.4 Other Information Content in the Passage of Time

In this paper, we focus on the hazard rates of merger completion because they are easily measured and clearly non-constant over event time. However, variation in hazard rates need not be the *only* reason why the passage of time after merger announcement contains information. The value of the target, acquirer, or combined entity may change systematically with the passage of time for other reasons. For example, the arrival rate of receiving competing bids from other potential acquirers may be non-constant over event time. In Appendix Figure 12, we show that the hazard rate of receiving competing bids is slightly higher in the weeks immediately following merger announcement than in later weeks (although it is relatively flat compared to hazard rates of completion). In addition, the expected value of the target if the deal does not go through may vary over the event lives of mergers.

It is possible that these other real changes to merger value tend to vary systematically with hazard rates. Therefore, we cannot distinguish between the following:

1. Markets underreact to the event time variation in hazard rates of completion
2. Markets have correct beliefs about the event time variation in the hazard rates of completion but underreact to other changes to merger or target value that move in event time with hazard rates.

Importantly, both interpretations are consistent with the behavioral hypothesis in implying that hazard rates (and the real events correlated with hazard rates) predict returns because markets underreact to the information content of the passage of time.

6 Risk and Other Rational Explanations

In this section we study the possibility that risk varies in event time with hazard rates. If so, the pattern in returns documented in Section 4 could reflect compensation for risk within a rational framework. We focus on event time variation in risk because the positive correlation between hazard rates and returns is a phenomenon measured in event time rather than calendar time. Moreover, we observe over 5,000 mergers staggered across calendar time and control for all calendar time variation in risk or risk premia through the use of calendar

year-month fixed effects in all regressions. Since we do not observe event time variation in risk premia, we will focus on event time variation in risk.¹⁵

We explore three types of risk which may vary in event time and generate the observed returns pattern. First, we study systematic risk as captured by the Fama French factors. Second, we consider downside risk, i.e. the possibility of severely negative returns concentrated in bad times. Third, we investigate idiosyncratic risk, which may be important for arbitrageurs because of under-diversification or holding costs.

We measure risk exposures by constructing trading strategies that invest in deals only in specific event time windows. This allows us to capture potential event time variation in risk and to estimate the economic magnitude of the variation in returns not explained by risk. Overall, we find that the event time variation in systematic risk, downside risk, and idiosyncratic risk cannot explain the strong correlation between hazard rates and returns.

Finally, we explore whether event time variation in market frictions or asymmetric information can produce the observed returns pattern within a rational framework. We show that while there is time variation in the volume, turnover, and bid-ask spread of the stock of the target, this variation is concentrated in the short period immediately following merger announcement and cannot explain the year-long event time variation in mean returns. Further, we show that any potential frictions associated with the last day of trading before merger completion cannot generate our returns patterns.

6.1 Constructing Portfolio Strategies

To understand how the risk exposures of deals vary over event time, we construct calendar time returns for a set of portfolio strategies, each of which is exposed only to deals active during specific event windows. Our strategies modify the traditional Buy and Hold merger arbitrage strategy, described in Mitchell and Pulvino (2001), which buys deals after announcement and holds until either completion or withdrawal.

The first step in the construction of these portfolio strategies is to identify three event windows based only on the behavior of the completion hazard rate as estimated from an

¹⁵While we can never observe changes in risk premia over event time, it is not easy to justify why risk premia should change over event time if risk does not also change.

aggregate sample: a first period in which the hazard rate is below its mean (Low Hazard 1 period), a second period in which the hazard rate is above its mean (High Hazard period), and a third period later in a merger's event life when the hazard is again below its mean (Low Hazard 2 period). We estimate these event windows separately for cash and equity deals. The cutoff points are event weeks 11 and 36 for cash deals and 15 and 41 for equity deals. We also adopt a split-sample approach in which we choose event windows using hazard rates from the first half of our sample (pre-1991) and execute the trading strategy in the second half of our sample. Because the shape of the hazard curves remains stable over time, this split-sample method yields very similar cutoff weeks.

Given these cutoff weeks, we construct a series of monthly returns for each of the three strategies. In each calendar month, we invest in all deals that, at the beginning of the month, are active in the relevant event windows for each of the three strategies. To distinguish the three strategies more sharply, we leave 2 weeks around each cutoff point, and we do not invest in deals that are active in those event weeks. All the results that follow are very robust to the exact choice of the cutoffs, as discussed in Section 8.

For example, consider cash mergers. Since the cutoffs are 11 and 36, the Low Hazard 1 strategy only invests in deals that, at the beginning of each calendar month, are active in event weeks 1 through 10. The High Hazard strategy only invests in deals that are active in event weeks 12 to 35. Finally, deals active in event weeks 37 to 45 are selected by our Low Hazard 2 strategy. In the middle of a calendar month, if a deal falls out of the relevant event window (e.g. the deal approaches event week 11 and the relevant event window is weeks 1 through 10), we exit out of the deal and invest the proceeds in the risk free rate for the rest of the month. Similarly, if the deal completes in the middle of a calendar month, we capture the gains from completion and invest the proceeds in the risk free rate.

For each calendar month, we construct an equal-weighted return using all selected deals. If no deals are active in the relevant event window in a given calendar month, the strategy invests in the risk free rate for that month. Following standard merger arbitrage strategy, we go long the target for cash deals. For equity deals, we buy the target and short Δ shares of the acquirer for each share of the target bought. This ensures that the return following deal completion does not depend on the price of the acquirer at the time of completion. Note

that equity deals involve a short position that exposes the trade to potentially large losses. Therefore, when we construct our portfolios at the beginning of each calendar month we exclude deals that involve extreme unbalanced positions for the long and short sides relative to the position implied by the initial terms of the deal. In particular, we exit from deals if the premium falls below 1 (i.e. deals in which the arbitrageur loses money for sure if the deals complete). We also exit from deals if the premium moves above 200% of the initial premium. In these cases the market expects either a competing offer or a major revision of deal terms and deal completion is less likely to be the primary form of uncertainty. Importantly, we filter deals using information available prior to the trade, and we always take into account the gains and losses of exiting a deal.¹⁶

To ensure that our strategy returns do not mistakenly capture price movements due to the initial announcement of the intention to merge, all our strategies start investing on the *second* trading day after announcement or later depending on the event windows. Finally, while all the deals are equally weighted, we will separately explore the returns of strategies that only invest in large or small deals, as measured by the market capitalization of the target.

6.2 Event Time Variation in Systematic Risk

We begin by testing whether event windows covered by the High Hazard strategy still experience higher returns than the periods covered by the Low Hazard 1 and 2 strategies, after controlling for systematic risk. The top panel of Table 3 shows the Fama French alphas of the three strategies for both cash and equity deals, using the full sample. For cash deals, the alphas of the two Low Hazard strategies are -5bp and -7bp per month and statistically insignificant, while that of the High Hazard strategy is 64bp per month (8% per year). Similarly, for equity deals the alpha of the High Hazard strategy is 146bp per month (19% per year), much higher than both Low Hazard strategies, respectively 68bp and -35bp a month. On average, the difference in alphas between the High and Low Hazard strategies across cash and equity mergers is approximately 100bp.¹⁷

¹⁶All results are robust to applying these filters to cash deals as well.

¹⁷A large literature interprets the stock returns of the target and acquirer in a short window after merger announcement as representative of the synergies or value creation from mergers. In this paper, we show that there is significant variation in returns in the event year after merger announcement, and that this returns

Using these estimates, we test the underreaction hypothesis: after controlling for risk, returns and hazard rates are correlated in event time. The corresponding test in terms of the three strategies' alphas can be expressed as:

$$(\alpha_{high} - \alpha_{low_1}) + (\alpha_{high} - \alpha_{low_2}) \leq 0,$$

relative to the alternative $(\alpha_{high} - \alpha_{low_1}) + (\alpha_{high} - \alpha_{low_2}) > 0$.

As shown in the third column of Table 3, the alphas of the High Hazard strategies are significantly higher than the alphas of the Low Hazard strategies, and the p-values of the corresponding tests are less than 0.01 for both equity and cash deals.

The first column of Table 3 also reports the alpha of the traditional Buy and Hold strategy, which invests in deals from announcement until completion or withdrawal. Since the Buy and Hold strategy invests in deals in both the High and Low Hazard event windows, it is unsurprising that the Buy and Hold alpha exceeds the alphas of our Low Hazard strategies but falls short of the alphas of our High Hazard strategies. Because the aim of this paper is to test for behavioral underreaction rather than to maximize portfolio returns, we focus on comparing the High and Low Hazard strategy alphas. Nevertheless, we can also test whether our High Hazard strategy significantly outperforms the traditional Buy and Hold strategy. We find that the High Hazard alpha exceeds the Buy and Hold alpha by an average of 32bp per month across cash and equity deals, with a p-value of 0.006.

Note that our underreaction hypothesis centers on event time variation in average returns, but does not have direct predictions regarding the average *level* of returns over the life of the merger. Consistent with the merger arbitrage literature, we find that the average return of a Buy and Hold strategy exceeds the risk free rate even after controlling for standard risk factors. Within our underreaction model, this is equivalent to saying that the average return around which we expect event time variation is not the risk free rate r , but some higher value $\mu > r$. In this paper, we do not take a strong stand on why the Buy and Hold strategy yields a positive alpha. The literature studying the Buy and Hold return argues that the positive alpha reflects compensation for transaction costs and, to a lesser extent, downside risk (see

variation is consistent with the presence of behavioral biases. This suggests that one should be careful in interpreting returns after merger announcements as evidence of synergies.

Mitchell and Pulvino, 2001 and Baker and Savasoglu, 2002). We will show in later sections that, while downside risk and transaction costs may contribute to the average level of returns, they cannot explain the event time variation in returns.

In Table 3, we use the same sample to estimate the hazard rates (which generate the event window cutoffs for the trading strategies) and to simulate the trading strategies. In the top panel of Table 4, we report the alphas of portfolio strategies that only use information about hazard rates already available at the time of the investment. We choose the event window cutoffs for the High and Low Hazard strategies based upon hazard rates estimated using pre-1991 data, but only invest in deals active during the later 1991-2010 sample. Given that Figures 1 and 2 show that the shape of the hazard rate curves remained stable for the past four decades, it is not surprising that all results remain similar when performing the test using the early hazard rates and later returns.

Finally, note that we adopted a conservative approach to compute the alphas of the various strategies presented in Table 3. Since fewer deals survive into the event window covered by the Low Hazard 2 strategy (many deals have withdrawn or completed before then), it is more likely to find months with no active deals for the Low Hazard 2 strategy than it is for the High Hazard strategy. Since the return of a month with no active deals is set equal to the risk free rate, this may artificially bias the alpha and betas of the Low Hazard 2 strategy towards zero, thus hiding the true risk and return properties of deals during the last event weeks. To avoid this problem, in Table 3 we only include returns from calendar months in which active deals were available for investment. This, while more conservative for tests of event time variation in strategy alphas, does not represent the returns of a more realistic trading strategy that must invest in the risk free rate during calendar months in which no deals are active. For completeness, in the bottom panel of Table 4, we repeat the exercise including all months for all strategies, thus forming a tradeable portfolio strategy. All the previous results hold.

6.2.1 Betas over Event Time

We now directly explore event time variation in risk by looking at the betas of the various strategies. Table 5 reports the strategy betas with respect to the three Fama French factors. Panel A shows that the betas are all quite small, between -0.15 and 0.3. Panel B shows that

the betas for the High Hazard strategy are not significantly larger than the betas for the two Low Hazard strategies.

To capture event time variation in risk exposures in greater detail, we also look at the variation in the betas across each event week (as opposed to dividing the one-year event window into three regions). For each of the 45 event weeks following merger announcement, we construct a calendar time series of returns of a portfolio that only invests in deals that are active in that event week (separately for cash and equity deals). We then construct a panel of calendar time returns for each of the 45 event-week-specific portfolios.

We plot the estimates of the betas in Figure 6. The figure points to two important features. First, the betas with respect to all the Fama French factors are again generally very small (for example, the market beta is usually less than 0.2). The relative magnitudes of the betas cannot account for the difference in the returns that we observe in our High Hazard period (between the two vertical bars) and the Low Hazard periods (the far left and right regions). Second, there does not seem to be significant time variation in any of the betas over event time, although estimation of the betas becomes more noisy as we move toward the right, since fewer deals survive as event time passes.

In Table 6 we formally test whether betas vary positively with hazard rates over event time. We find that the relationship between betas and hazard rates is a well-estimated zero for all three Fama French factors. The point estimates are actually negative and the economic magnitude of the relation is also extremely small: a one standard deviation increase in the hazard rate corresponds to a reduction in each of the betas of around of 0.01. Overall, the results indicate that there is no significant event time variation in systematic risk as captured by the Fama French factors.

6.3 Event Time Variation in Downside Risk

An alternative explanation of the relation between hazard rates and returns is event-time variation in downside risk, i.e. the risk of experiencing particularly bad returns during times when the market return is also very low (see Kraus and Litzenberger, 1976; Shleifer and Vishny, 1997). Exposure to downside risk, similar to exposure to a short position in a put on the market portfolio, has been studied in previous research focusing on the Buy and Hold

strategy. For example, Mitchell and Pulvino (2001) find that their Buy and Hold strategy is indeed exposed to downside risk, although the magnitude of the exposure is small and insufficient to explain the Buy and Hold alpha.

In this section we test whether the higher alpha of the High Hazard strategy relative to the alphas of the Low Hazard strategies can be explained by *differential* exposures to downside risk in event time. We start by calculating the raw performance of each strategy in periods in which the market return is low, defined as all months in which the market portfolio experiences a return below -3 percent (alternative cutoffs of -2 , -4 , and -5 percent yield similar results). Panel A of Table 7 shows that, during market downturns, betas increase slightly for all strategies that invest in cash deals and remain flat or fall for strategies that invest in equity deals (because the strategy maintains a short position in the acquirer). However, the downside betas of the High Hazard strategy do not significantly differ from the downside betas of the two Low Hazard strategies. In addition, the average returns of the three strategies are not particularly low. In months when the market loses more than 3 percent, no strategy loses on average more than 2.6 percent. In the Appendix, we further explore downside risk by plotting the relation between strategy returns and market returns allowing for a piecewise linear functional form (so that the beta in down markets can be different from the beta in normal markets). The figure confirms that the exposure to downside risk is essentially the same across the three event-period strategies.

In Panel B of Table 7, we measure exposure to downside risk by adding the out-of-the-money Put and Call factors constructed by Agarwal and Naik (2004) to the standard set of Fama French factors. We find that the exposure of all strategies to these factors are extremely small and do not vary significantly across high and low hazard periods. In unreported results, we also find that exposures to the in-the-money Put and Call factors are similarly low and do not vary in event time. For completeness, we also estimate exposures to the momentum factor and again find that they are low and do not vary over event time.

We conclude our analysis of downside risk by presenting additional graphical evidence that the High Hazard strategy does not owe its high return to high exposure to downside risk. In Figure 7 we plot the yearly return for the market, the High Hazard strategy and the Buy and Hold strategy. The Figure shows that the returns of both merger strategies are less volatile

than the market return, and that they are not particularly exposed to aggregate downturns. Note also that the High Hazard strategy and the Buy and Hold strategy have similar volatility and are correlated, but the High Hazard strategy almost always has higher returns: this is the graphical counterpart to the higher alpha reported in Table 3.

6.4 Event Time Variation in Idiosyncratic Risk

A final potential risk-based explanation for the correlation between hazard rates and returns is event time variation in idiosyncratic risk. In cases when merger completion comes as a surprise, prices should jump. Therefore, we may expect higher return volatility during event windows when hazard rates of completion are high. Why should idiosyncratic risk be priced at all? It's possible that the arbitrageurs that operate in merger markets are constrained to hold portfolios consisting only of mergers, and require compensation for holding a particularly volatile portfolio. As shown by Pontiff (2006), idiosyncratic risk may matter even for diversified arbitrageurs due to holding costs of arbitrage positions in individual securities.

We find that variation in idiosyncratic risk cannot explain the correlation between hazard rates and returns. Instead of being hump shaped, the volatility of returns from a strategy that invests in all available cash and equity deals increases in event time (the standard deviation of returns is 0.023, 0.040, and 0.077 for the Low Hazard 1, High Hazard, and Low Hazard 2 strategies, respectively).¹⁸

Finally, it is worth noting that we present conservative estimates of the return volatility that merger arbitrageurs are likely to experience. Our High Hazard strategy invests in approximately 20 deals on average in each calendar month, which is sufficient to obtain large diversification benefits that greatly reduce returns volatility. However, our sample of deals is artificially limited because we restrict our analysis to pure cash and equity financed deals which do not have contingency terms. A merger arbitrageur would likely be able to invest in a much larger set of deals, such as mergers that are financed using a mix of cash and equity.

¹⁸We also find that the High Hazard strategy displays large positive skewness of 4.37 relative to the two Low Hazard strategies (which display skewness of -0.56 and 0.15). Thus, the volatility of the High Hazard strategy partly reflects its disproportionate upside potential. To the extent that positive skewness is valued by investors, a rational model would actually predict lower expected returns for the High Hazard strategy, contrary to our findings (e.g. Kraus and Litzenberger, 1976).

6.5 Event Time Variation in Frictions

In this section, we consider three other potential explanations for the returns patterns that are consistent with rational markets. First, it's possible that event time variation in buying and selling pressures leads to predictable returns patterns. In particular, conversations with merger arbitrageurs suggest that large institutional investors, such as mutual funds, tend to sell the target immediately after merger announcement to lock in gains and because the target's risk profile no longer fits with the fund's core strategy (e.g. a small-value investment fund). In fully efficient markets, these sell orders should not affect prices. However, if arbitrage capital moves slowly to take the other side of the trade, the selling pressure can take a while to disappear (Shleifer, 1986). This may generate low returns immediately after announcement, followed by slowly increasing returns in the following days. If selling pressures are responsible for the observed pattern in returns, we expect that measures of liquidity should covary negatively with returns in event time.

Second, it's possible that variation in the degree of asymmetric information generates the returns patterns. Insiders may have greater access to rumors about merger completion than others and this information advantage may be greatest during event periods when hazard rates are high. If asymmetric information is responsible for the observed patterns in returns, we expect that the bid-ask spread should covary positively with returns in event time.

Turning to the data, we find that the event time variation in buying and selling pressure and asymmetric information, as proxied by volume and bid-ask spread, occur on a very different time scale than that of the return predictability we document. Figure 8 compares the evolution over event time of average returns with the evolution of the median volume of target equity (relative to volume in the first week following the announcement) and median bid-ask spread of the target (again relative to the bid-ask spread in the first week following the announcement). The figure shows that volume is very high in the one or two weeks following merger announcement, and then drops to a steady level starting in event week four. A very similar pattern occurs for the bid ask spread, except that the drop towards the steady low level occurs even more immediately following merger announcement. In unreported results, we also look at event time variation in turnover, and find a similar pattern. All the variation

in volume and bid-ask spread is concentrated around announcement, and there seems to be no significant event time variation in the months that follow, where the relevant variation in returns is concentrated. This includes the high average returns starting around event month three as well as the low average returns starting around event month nine.

Finally, we consider whether the hump-shaped returns pattern can be explained by a “last day” effect.¹⁹ In the last day of trading before the merger formally completes and the target delists, deal completion is usually considered certain by all market participants because all parties have publicly agreed to the merger. However, the last recorded target stock price may still trade at a small discount to the “deal consideration,” the final price paid by the acquirer for each share of the target. For example, the target may trade at \$9.99 on the last day given an deal consideration of \$10.00 at deal completion, a difference that corresponds to an additional 10bp return in a single day. Conversations with merger arbitrageurs suggest that this return may not always be realizable by investors due to illiquidity or fees. We show that our returns pattern cannot be explained by the last day effect by simulating a trading strategy that only earns returns based upon traded prices and does not earn any returns based upon the difference between the last traded price and the deal consideration. This simulation purges the strategy returns of any last day effects and is conservative in that it removes some of the positive returns that investors may have actually earned. We find our results qualitatively unchanged, although the alphas of all strategies are reduced. For brevity, we report our results below rather than in table form. For cash deals, the High Hazard alpha is 37bp per month compared to -5bp and -13bp for the Low Hazard 1 and Low Hazard 2, respectively. For equity deals, the High Hazard alpha is 105bp compared to 58bp and -52bp for the Low Hazard 1 and Low Hazard 2 strategies, respectively. We test whether the High Hazard strategies deliver significantly higher alphas than the Low Hazard strategies and find a p-value of 0.004. In other words, the last day effect cannot explain the event time variation in returns.

Overall, we show in this section that the returns pattern cannot be explained by event time variation in systematic risk, downside risk, idiosyncratic risk, buying and selling pressure, asymmetric information, or last day frictions. All of these elements can contribute to the positive Buy and Hold returns. In addition, the presence of frictions can limit arbitrage as

¹⁹We thank Mark Mitchell and Todd Pulvino for bringing this phenomenon to our attention.

shown in the next section. However, they cannot by themselves generate the event time variation in returns.

7 Limits to Arbitrage

To further support the behavioral model of underreaction, we explore why sophisticated arbitrageurs (who are likely to recognize the information content of the passage of time) allow the mispricing to persist. We find evidence suggestive of the existence of both behavioral and sophisticated investors. However, limits to arbitrage prevent sophisticated investors from arbitraging away mispricing in the subset of deals that are likely to have higher transaction costs.

7.1 Sorting on Transaction Costs

We first look at the Fama French alphas for the Low Hazard 1, High Hazard, Low Hazard 2 and Buy and Hold strategies when the strategies are executed on subsamples of mergers according to target characteristics that correlate with the transaction costs faced by arbitrageurs: total dollar volume, average daily turnover, bid-ask spread, and size (market cap) of the target. For each characteristic, we split the set of mergers occurring in each calendar year by the median value of the characteristic, as measured during the second week after announcement. We look at the characteristics *after* announcement to capture the features of the market during the time period when arbitrageurs are likely to operate (for example, turnover following announcement may differ from turnover prior to announcement).

We also report results separately for early (pre-1991) and late (post-1991) calendar periods. This tests the idea that sophisticated arbitrage capital has increased over time, so later calendar periods may display less returns predictability.

Table 8 reports the Fama French alphas of each strategy for the four stock characteristics plus the early and late calendar period division. For each characteristic, the left column corresponds to more difficult arbitrage conditions: small target market cap, low volume and turnover, high bid-ask spread, and the early sample period. For all characteristics, we find significantly higher alphas for the High Hazard strategy corresponding to the sample with

more difficult arbitrage conditions. The only exception is the early and late calendar period split. While alphas are higher in the earlier time period, the difference between the early and late periods is not significant, and the High Hazard strategy still yields a positive and significant alpha in the more recent period.

7.2 Accounting Directly for Transaction Costs

Next, we study the returns to trading strategies that take into account the transaction costs associated with the activity of a realistic merger arbitrage fund. Because it is difficult to precisely estimate trading costs, we present results using two different methods.

The first method closely follows the “RAIM” strategy presented in Mitchell and Pulvino (2001). We simulate four funds that trade in the four main strategies considered in this paper (Low Hazard 1, High Hazard, Low Hazard 2, and Buy and Hold), starting with \$1M of capital each in 1970. Every month, each fund invests equally in all available deals in their respective event windows subject to the following limits to their positions. At most 10 percent of the capital can be invested in any particular deal, and the total trade in any deal cannot produce price pressure of more than 5 percent of the price. We estimate price pressure following the procedure described in Breen et al. (2002).

In addition to limiting the size of the position and the amount of trading that each fund can perform, we compute direct transaction costs the fund incurs (e.g. broker commissions).²⁰ We also compute *indirect* transaction costs, which capture lower returns due to price impact and illiquidity, using the estimates of Breen et al. (2002).

We also present results using a second method to account for trading costs which modifies the procedure described above by proxying for indirect transaction costs using the bid-ask spread. We obtain the bid-ask spread for each trade from CRSP, and when that is not available, we use the bid-ask spread estimated following Corwin and Schultz (2012). For firms for which neither are available, we set the bid-ask spread to the average among firms in our sample by year and size category.

²⁰Following Mitchell and Pulvino (2001), we approximate direct trading costs by assuming a fixed dollar cost per share traded: \$0.1 before 1980, \$0.05 between 1980 and 1990, and \$0.04 between 1990 and 1998. Given the advances in technology after 1998, trading costs have fallen further. For all deals after 1998, we use the conservative estimate of \$0.03 per share.

Table 9 shows that the alphas of all strategies are noticeably reduced once we take into account transaction costs, with Method 2 reducing the alphas by more than Method 1. While transaction costs reduce the alphas of all strategies, our main finding that the alpha of the High Hazard strategy is significantly higher than the alphas of the two Low Hazard strategies still holds under both methods.

Taken together, the results in this section offer an explanation of why the behavioral underreaction is allowed to persist. Not all market participants underreact to the passage of time. A subset of investors, possibly small retail investors, are boundedly rational and generate the mispricing. More sophisticated investors are unable to fully arbitrage away the mispricing in the subset of deals for which transaction costs are particularly high.

8 Robustness

The results in Table 3 correspond to trading strategies that use precise event window cutoffs based upon the estimated hazard rates presented in Figures 1 and 2. In this section we show that these results are very robust to perturbations to the timing of the event window cutoffs.

Figures 9 and 10 report the difference between the alpha of a strategy that only invests in deals active between event weeks t_1 to t_2 , and the alpha of the Buy and Hold strategy. t_1 can be read on the vertical axis, and t_2 on the horizontal axis.

For example, consider cash deals in Figure 9. The Low Hazard 1 strategy invests in deals active between event weeks 1 and 10, so its alpha can be read as $(t_1 = 1, t_2 = 10)$ which corresponds to the circle at the bottom left. The circle in the middle corresponds to the High Hazard strategy and the circle on the top right corresponds to the Low Hazard 2 trading strategy. The bottom-right corner $(t_1 = 1, t_2 = 45)$ corresponds to the Buy and Hold strategy. Since the graph reports the alphas of the strategies relative to the Buy and Hold strategy, it is not surprising to find exactly 0 at $(1, 45)$, negative numbers for the Low Hazard strategies, and a positive number for the High Hazard strategy.

Starting from the circles representing the cutoffs for our three trading strategies, it is straightforward to see that perturbations to the cutoff points in all directions do not dramatically affect the alphas. The Low Hazard strategies lie in an area with low alphas (relative

to the Buy and Hold strategy). Meanwhile, the High Hazard strategy lies in an area with high alphas (relative to the Buy and Hold strategy). This shows that the strategy alphas do not strictly depend on the cutoff points, but more generally align well with the high and low return event windows predicted by the underreaction hypothesis.

9 Conclusion

The absence of news and the passage of time often contain important information. However, no news is likely to be less salient and vivid than traditional news stories. This may lead boundedly rational investors to underreact to the passage of time.

We test how markets react to the passage of time using the empirical context of mergers. Following the initial merger announcement, uncertainty relating to merger completion can take several months to a year to be resolved. We find that hazard rates of merger completion vary strongly over time after the merger announcement, implying that the passage of time can predict merger completion. If markets are rational, prices should correctly incorporate this information and average returns should be constant over event time absent any compensation for risk or frictions. When we examine target return patterns, we find that the aggregate merger completion hazard rates are positively correlated with target returns in event time.

We then investigate two possible explanations for this returns predictability. We first show that the positive correlation between returns and hazard rates can be explained by a behavioral model in which the agents underreact to the passage of time. If agents do not fully appreciate the variation in hazard rates associated with the passage of time, they will behave as if hazard rates are less time-varying (flatter) than in reality. This leads to periods in which agents over- or under-estimate the true hazard rates of completion. When true hazard rates are high, they will be underestimated by the agents and returns will be high due to positive surprises from actual merger completions. When true hazard rates are low, they will be overestimated by the agents, and returns will be low due to negative surprises. This underreaction can explain the observed correlation between hazard rates and returns.

While the positive relationship between returns and hazard rates is consistent with underreaction to no news, it could also be explained by changes in risk or other frictions over

the event lives of mergers. We find that, after controlling for systematic risk as captured by the Fama French factors, the alpha for a strategy that invests in deals during High Hazard event weeks is significantly larger than the alphas for strategies that invest in deals during Low Hazard event weeks. Merger returns have low betas in general, and systematic risk does not vary with hazard rates over the event lives of mergers. We also show that downside risk and idiosyncratic risk do not vary in event time and cannot explain the observed pattern in returns. Finally, we show that event time variation in selling pressures and asymmetric information is unlikely to explain the observed returns patterns. We conclude that aggregate hazard rates of merger completion predict merger returns because markets underreact to the information content of the passage of time.

Using the empirical context of mergers, we demonstrate that underreaction to the passage of time can be costly, resulting in returns variation of up to 100bp per month as time passes after merger announcement. Of course, some investors are likely to be highly sophisticated and rational. We find evidence consistent with the existence of limits to arbitrage. We show that underreaction is concentrated in the subset of deals with lower liquidity and higher transaction costs, suggesting that trading frictions prevent sophisticated investors from arbitraging away the mispricing.

Evidence of underreaction in mergers markets is also suggestive of a more general phenomenon, in which agents underreact to the passage of time because it is often less salient than explicit news stories. Underreaction to no news can be persistent, and can potentially exacerbate asymmetric information problems in many other contexts. We leave to future research to explore the extent to which underreaction to no news pervades other contexts such as the interactions between voters and politicians, managers and employees, or investors and insiders.

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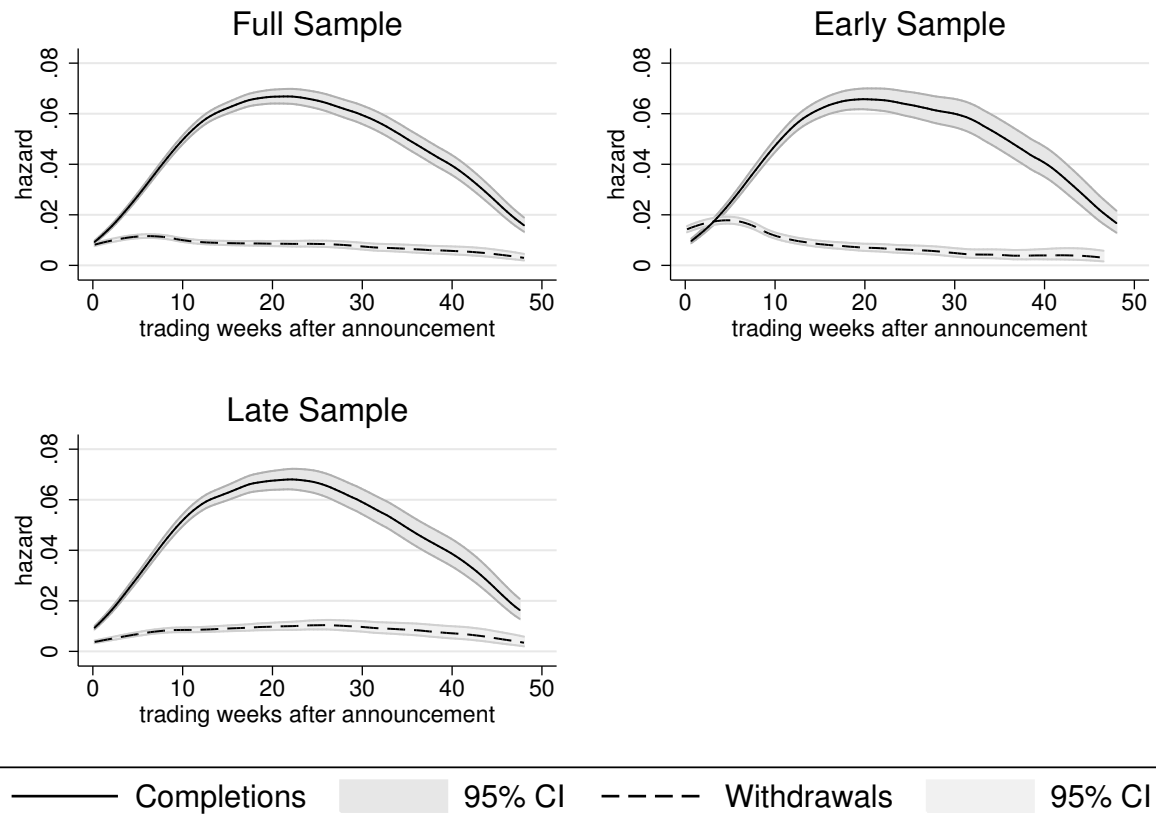


Figure 1: Cash Mergers: Hazard Rates

The Figure reports hazard rates of completion and withdrawal for cash financed mergers over event time estimated using the Kaplan-Meyer estimator of competing hazard rates. The top left panel uses the full sample, 1970-2010, to estimate the hazard rates. The top right panel uses data for the period 1970-1990. The bottom panel uses data for the period 1991-2010.

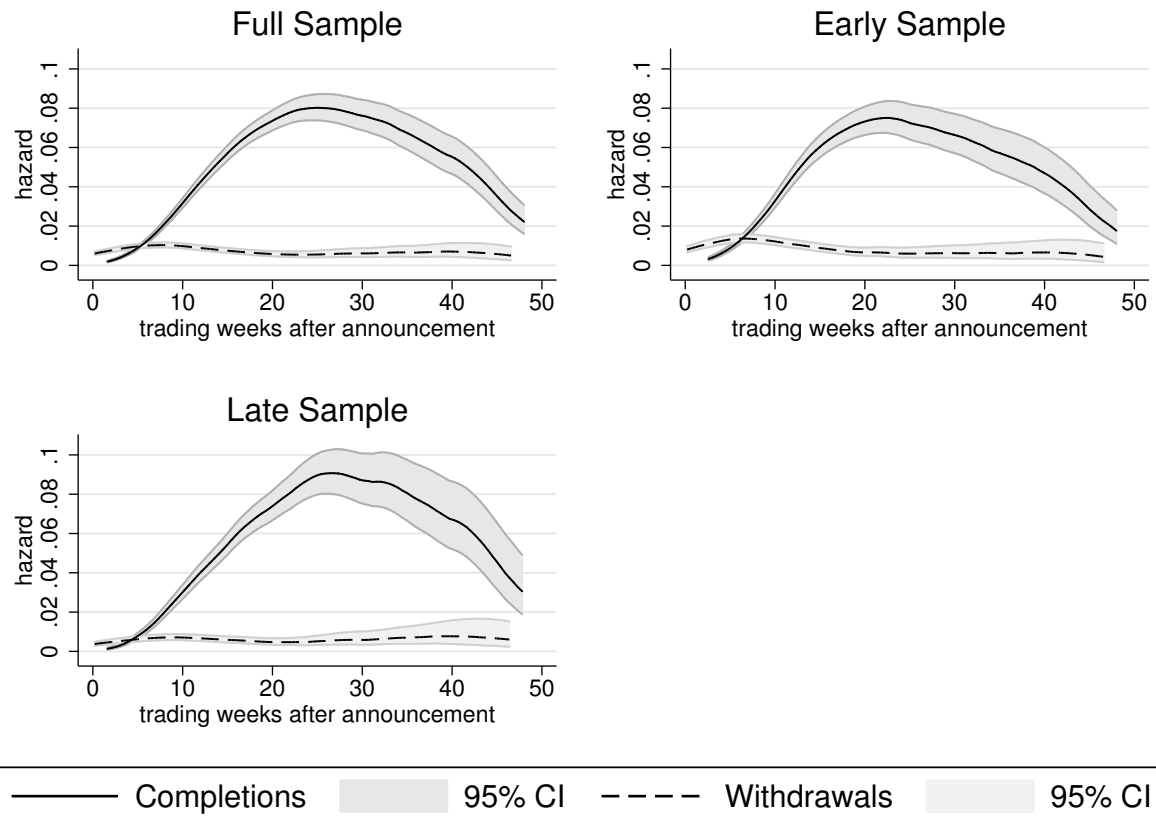


Figure 2: Equity Mergers: Hazard Rates

The Figure reports hazard rates of completion and withdrawal for equity financed mergers over event time estimated using the Kaplan-Meyer estimator of competing hazard rates. The top left panel uses the full sample, 1970-2010, to estimate the hazard rates. The top right panel uses data for the period 1970-1990. The bottom panel uses data for the period 1991-2010.

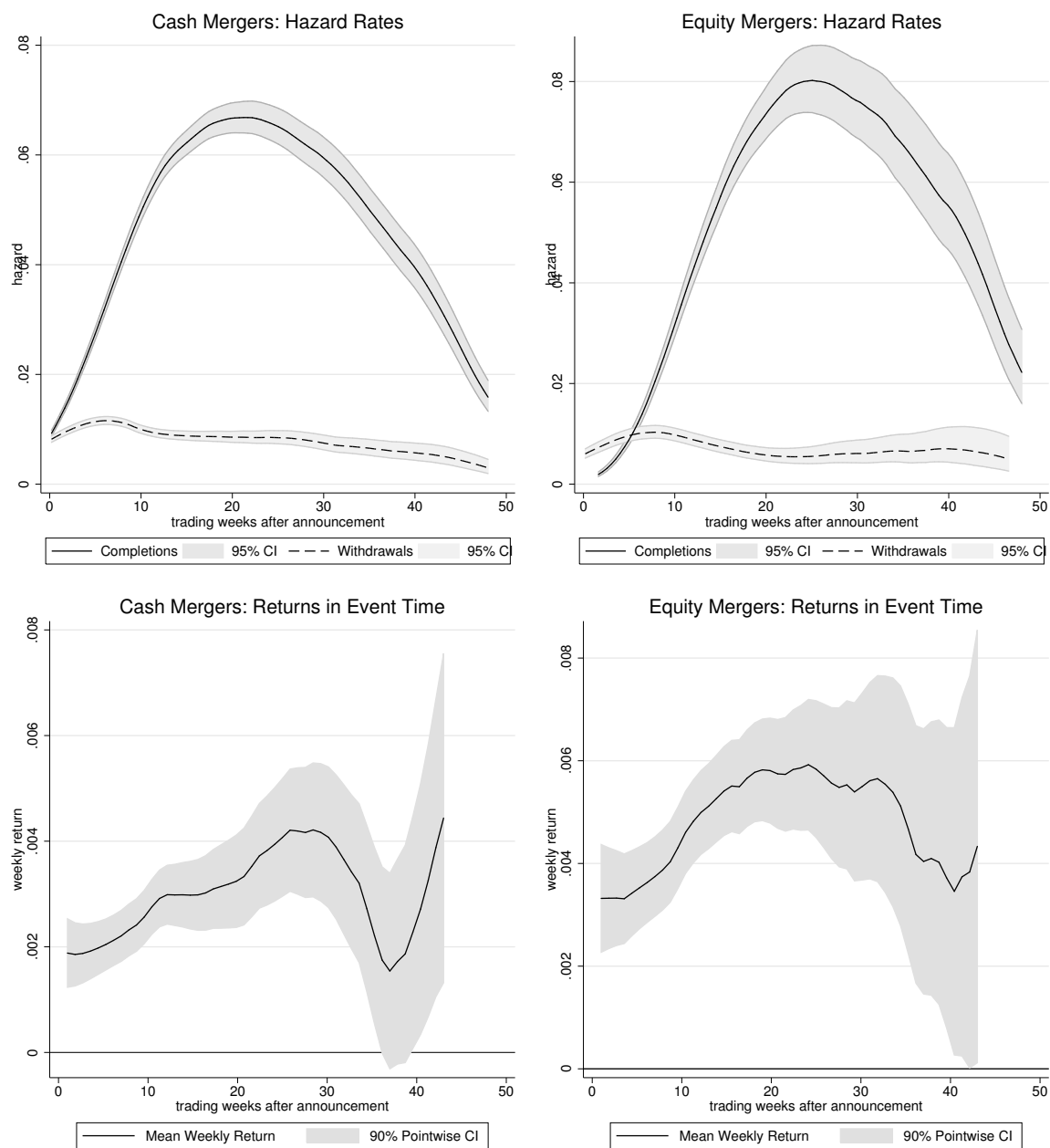


Figure 3: Hazard Rates and Mean Weekly Returns

The top panels report estimated hazard rates for cash (left) and equity (right) mergers over event time, as in Figures 1 and 2. The bottom panel reports the average weekly return across deals over event time, as estimated using a local mean smoother. If a deal completes or withdraws before the end of an event week, the weekly return is calculated as the return from the beginning of the event week to the completion or withdrawal event (in these cases, we do not scale returns to represent full weekly returns).

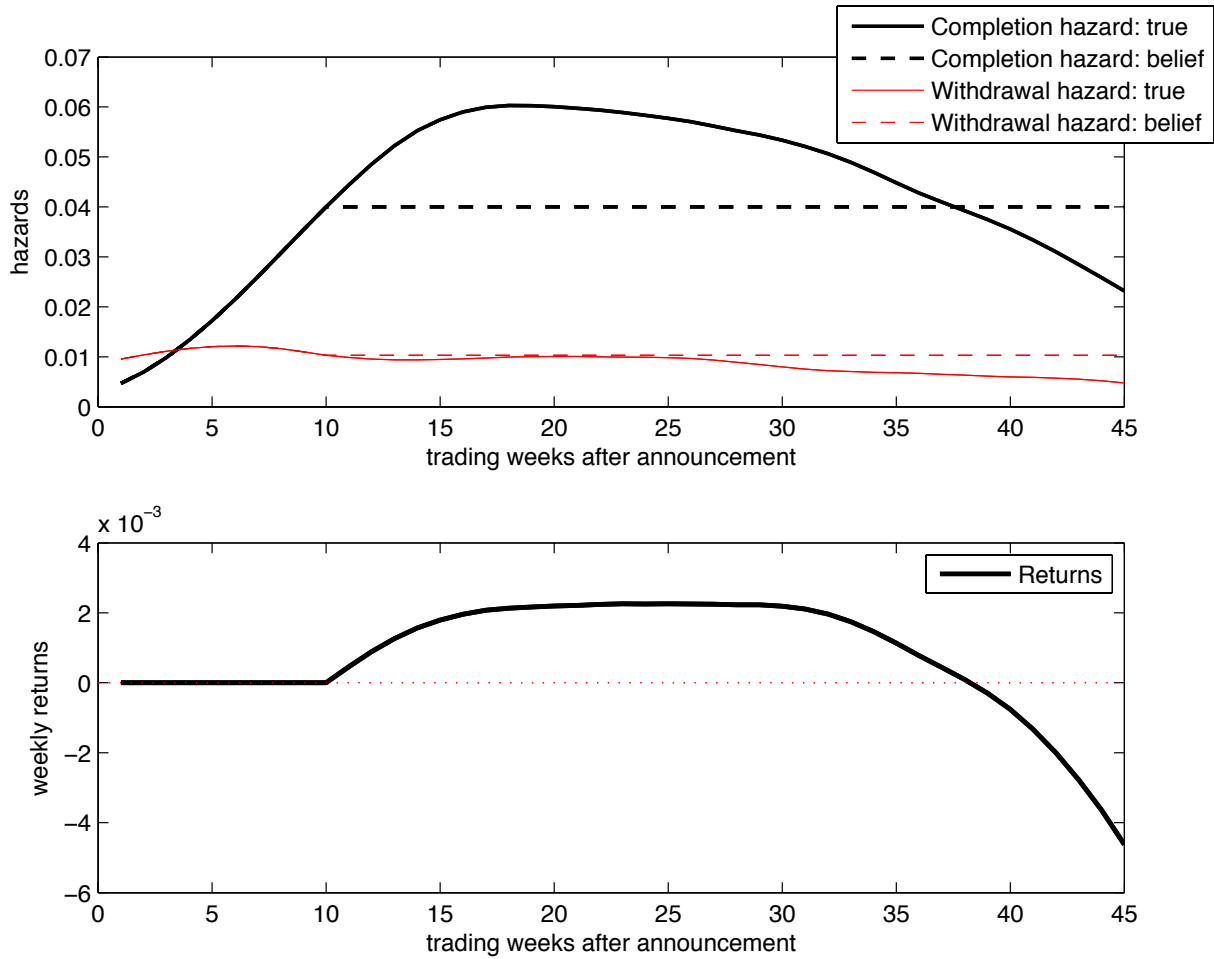


Figure 4: Model Predictions of Returns Given Beliefs

The Figure reports an illustrative example of the returns implied by the model, obtained under a certain set of beliefs. The top panel reports the true hazard rates (solid lines) and an example of beliefs (dotted lines). The bottom panel plots the model-implied weekly excess returns over event time.

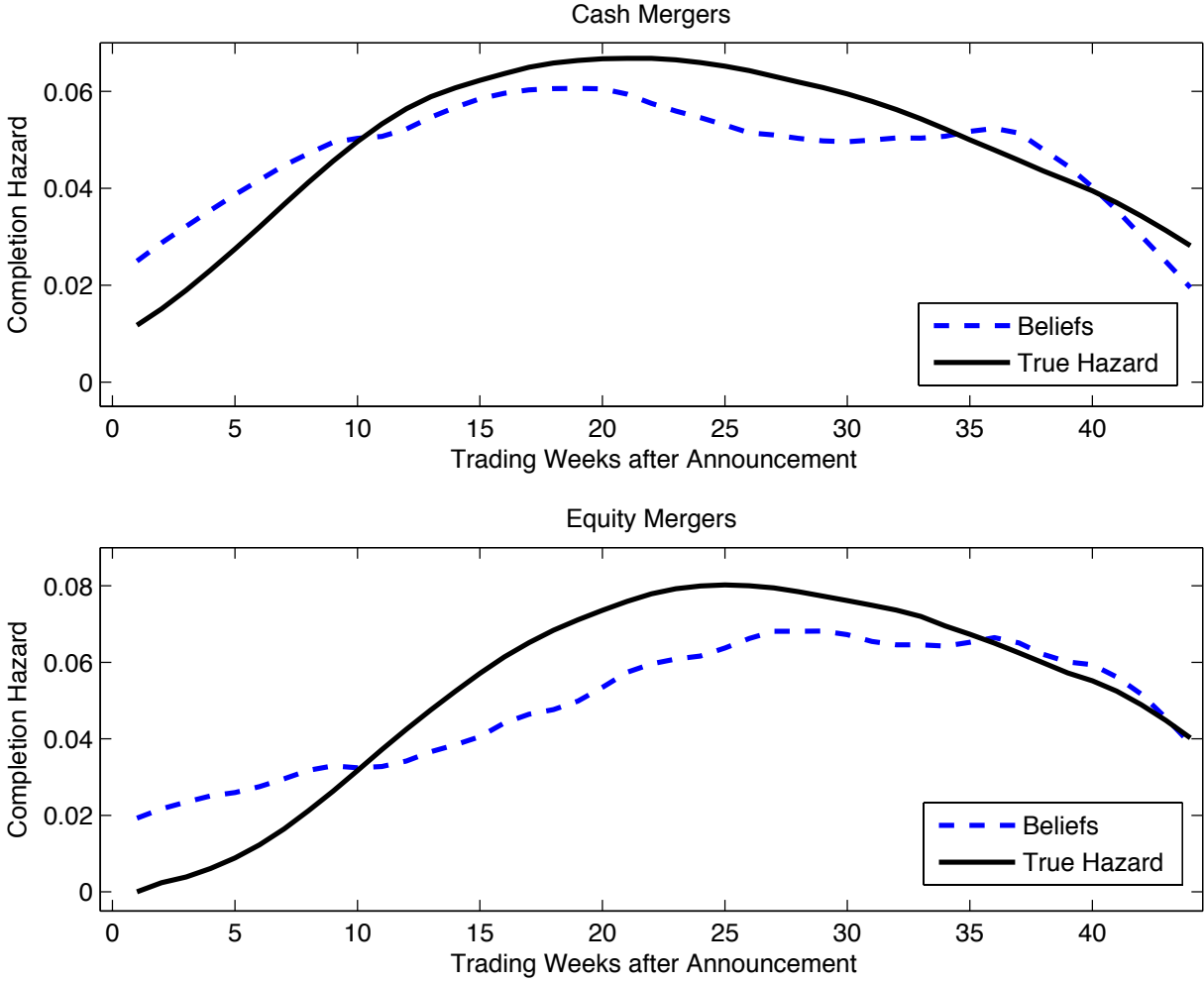


Figure 5: Implied Hazard Rates Beliefs

The Figure plots beliefs about hazard rates of completion over event time estimated from the model described in Section 5. Inputs into the model include estimates of the true hazard rates constructed in Section 3 and observed returns. The top and bottom panels report estimates of beliefs for cash and equity mergers, respectively.

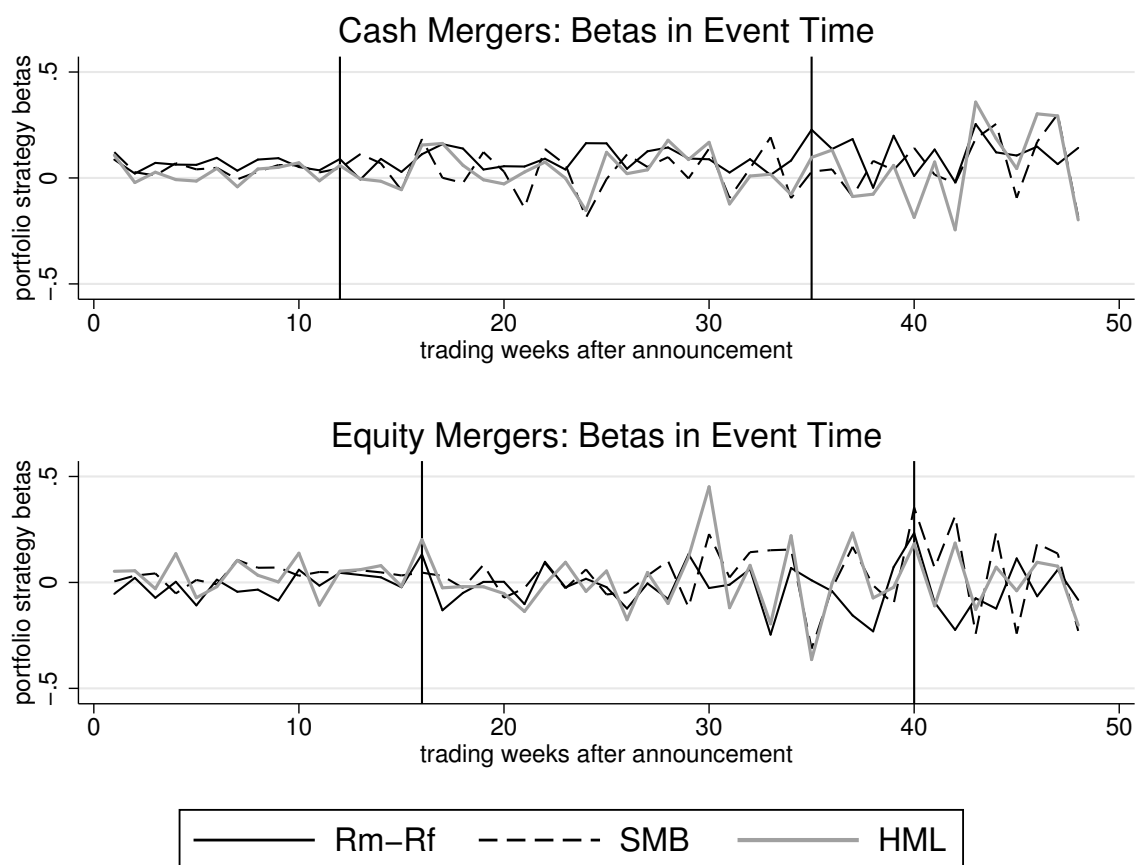


Figure 6: Event Time Variation in Risk

The Figure reports betas with the three Fama French factor separately for each event-week-specific trading strategy. The n^{th} -week trading strategy only invests in deals that are active in the n^{th} week after announcement. Betas are constructed using portfolio returns corresponding to calendar months for which at least one deal is present (this prevents betas corresponding to later event windows, in which fewer deals exist, from being biased toward zero). The vertical bars mark the three event windows for the Low Hazard 1, High Hazard, and Low Hazard 2 trading strategies described in Section 6.

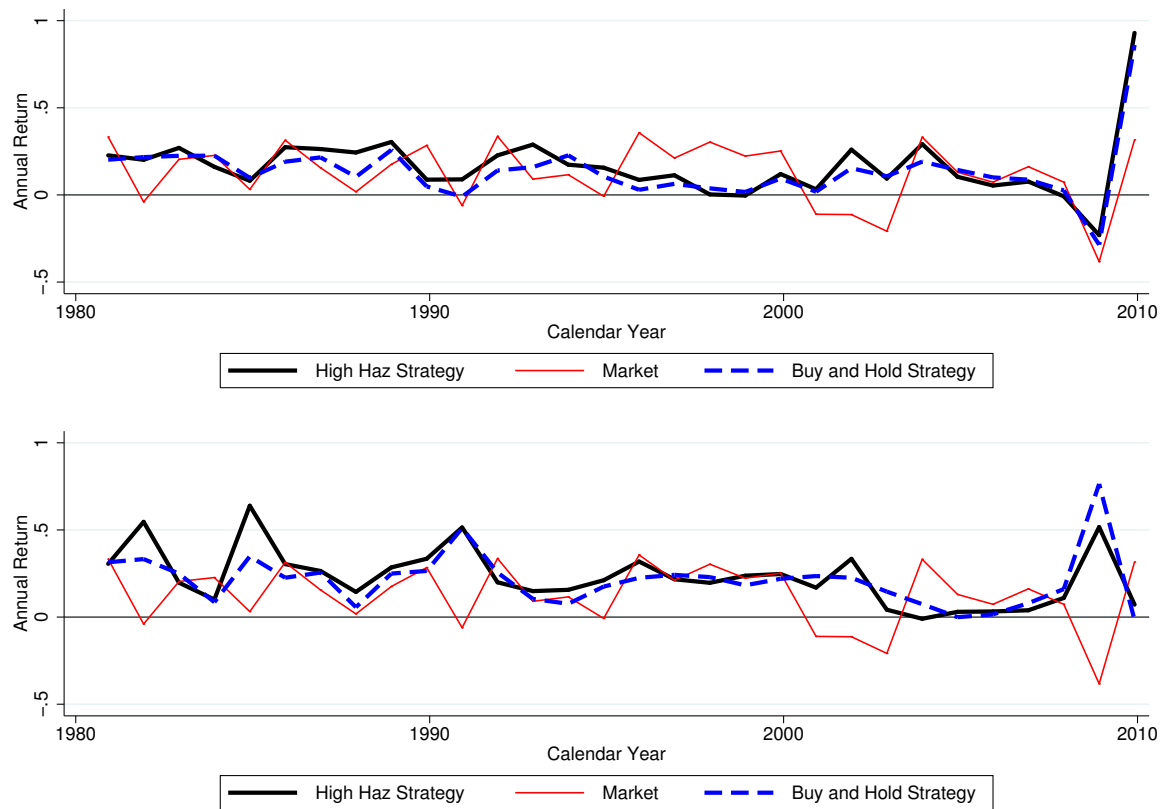


Figure 7: Portfolio Returns Comparisons

The Figure plots the realized yearly returns of the High Hazard and Buy and Hold strategies as well as the market return. The top panel reports the strategies that invest in cash financed mergers, while the bottom panel reports the returns of strategies that invest in equity financed mergers.

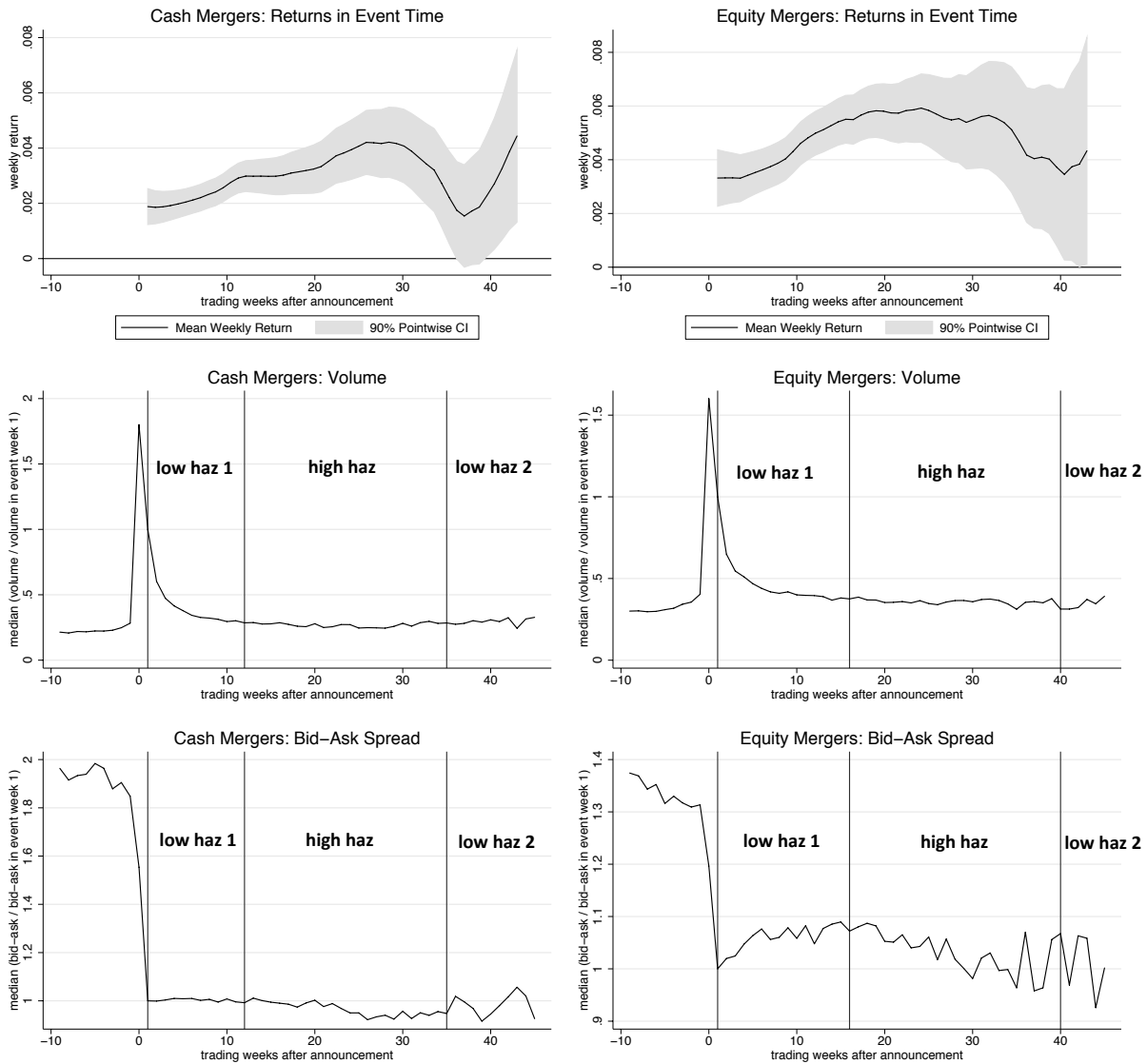


Figure 8: Event Time Variation in Volume and Bid-Ask Spread

The Figure plots average returns for cash and equity financed mergers (top row) together with median volume (middle row) and median bid-ask spread (bottom row), over event time. Median volume is the median of the target's average daily volume in each event week relative to the average daily volume in the week following the merger announcement. Median bid-ask spread is the median of the target's average daily bid-ask spread in each event week relative to the average daily bid-ask spread in the week following the merger announcement.

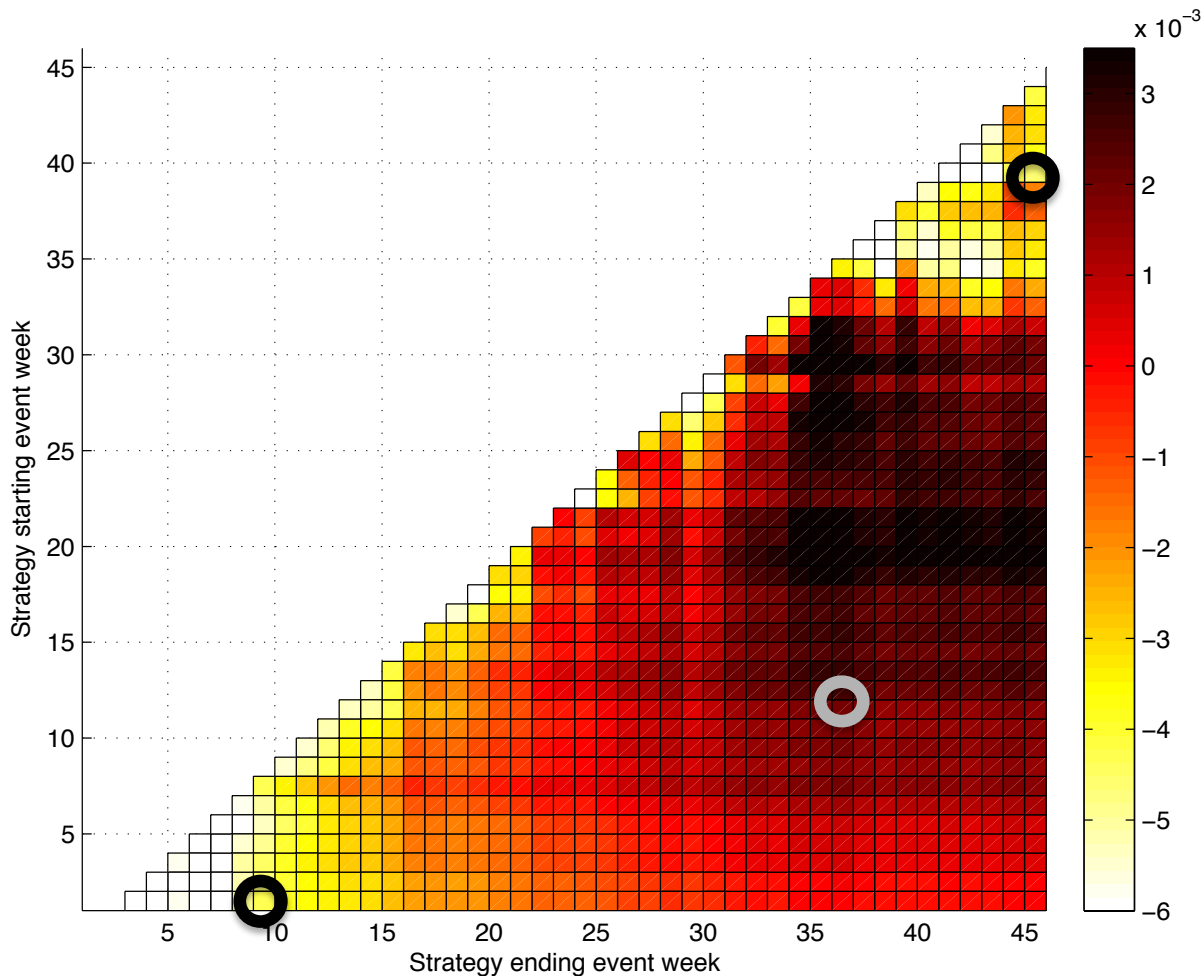


Figure 9: Cash Mergers: Strategy Alphas

The Figure reports the Fama French alphas of all possible event window trading strategies in excess of the alpha of the Buy and Hold strategy for cash financed mergers. On the y axis, we report the first week of the strategy's event window. On the x axis, we report the last week of the strategy's event window. The color at point (x, y) indicates the relative alpha for a strategy that invests in all deals active between event weeks y to x . The three circles correspond to the Low Hazard 1, High Hazard, Low Hazard 2 strategies.

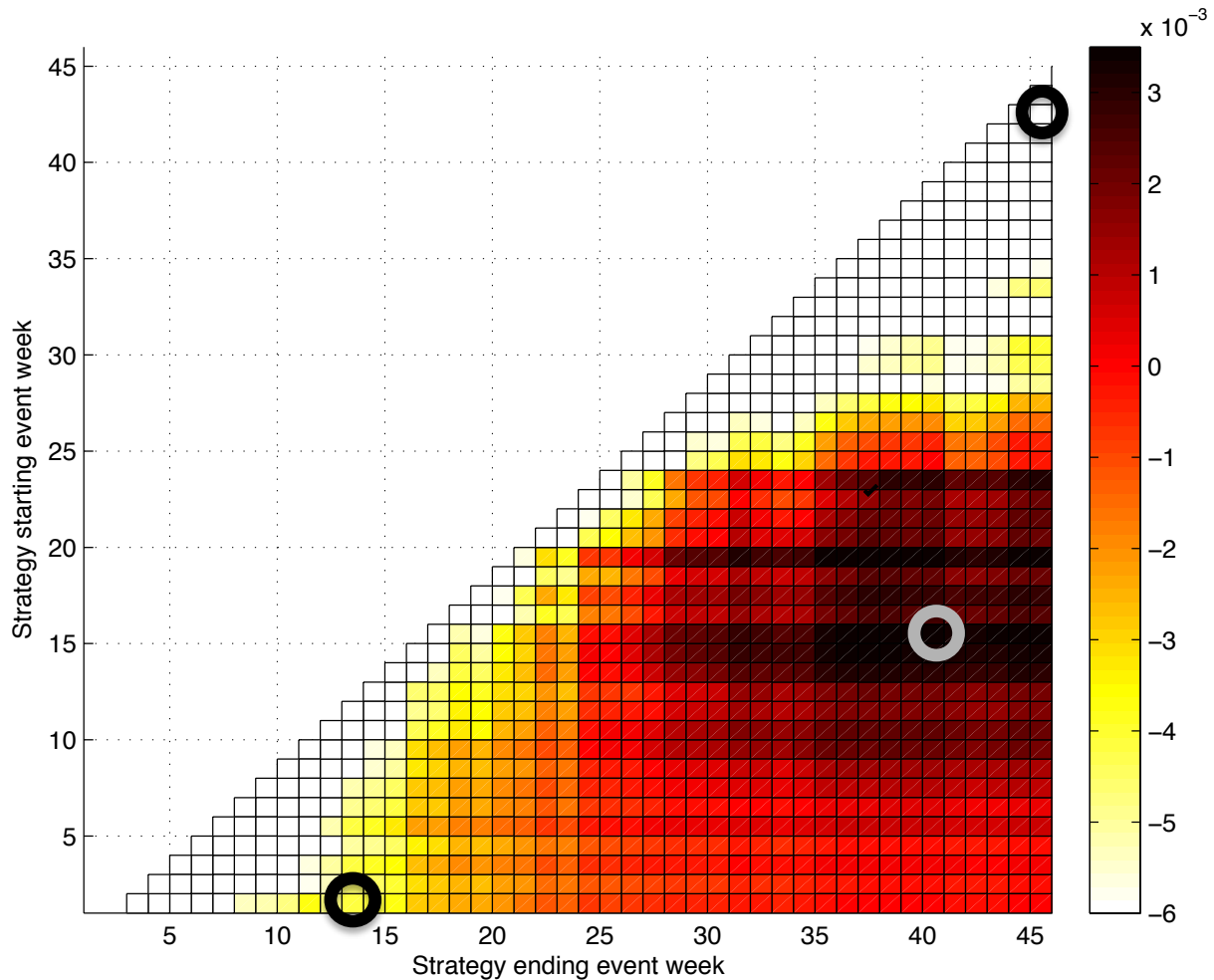


Figure 10: Equity Mergers: Strategy Alphas

The Figure reports the Fama French alphas for of all possible event window trading strategies in excess of the alpha of the Buy and Hold strategy for equity financed mergers. On the y axis, we report the first week of the strategy's event window. On the x axis, we report the last week of the strategy's event window. The color at point (x, y) indicates the relative alpha for a strategy that invests in all deals active between event weeks y to x . The three circles correspond to the Low Hazard 1, High Hazard, Low Hazard 2 strategies.

	Cash Mergers			Equity Mergers		
	Mean	Median	Stdev	Mean	Median	Stdev
Number of deals	3414			1963		
Time to completion (trading days)	99.2	83.0	60.8	110.2	97.0	57.8
Time to withdrawal (trading days)	65.9	40.0	85.7	66.2	44.0	94.0
% Completed within one year	70.5			76.8		
% Withdrawn within one year	22.2			18.9		
% Pending within one year	7.3			4.3		
Premium	1.32	1.24	0.90	1.33	1.23	1.22
Size 1960-1979 (\$mil)	54.6	19.3	96.0	67.8	27.5	146.3
Size 1980s (\$mil)	228.1	50.6	762.3	241.2	51.4	742.3
Size 1990s (\$mil)	269.5	69.7	673.3	686.4	142.9	2884.0
Size 2000s (\$mil)	1014.4	191.8	3150.5	1147.1	166.0	4344.5

Table 1: Summary Statistics

The Table reports summary statistics separately for cash financed and equity financed mergers.

Dep Var: Weekly Return	(1)		(2)		(3)	
	Cash	Equity	Cash	Equity	Cash	Equity
Weekly hazard	0.0327 *** (0.011)	0.0357 *** (0.009)	0.0368 *** (0.011)	0.0390 *** (0.011)	0.0283 ** (0.013)	0.0346 ** (0.017)
Calendar year x month FE	N	N	Y	Y	Y	Y
Stderr clustered by deal & (calendar year x month)	Y	Y	Y	Y	Y	Y
Split sample (early hazards, late returns)	N	N	N	N	Y	Y
Obs	62587	27457	62587	27457	38813	12824
R2	0.0001	0.0003	0.0178	0.0161	0.0158	0.0141

Table 2: Hazard Rates vs. Returns

The Table reports the results of regressions of weekly returns on hazard rates. The following specification is estimated: $r_{iwt} = b_0 + b_1 h_w + \gamma_t + \epsilon_{iwt}$ where i indexes mergers, t is calendar time (year-month), and w is event week following merger announcement. γ_t represents a set of calendar time year-month fixed effects. h_t is the hazard rate, as estimated using the full aggregate sample in Figures 1 and 2. Column (1) reports the estimates without calendar time fixed effects while Column (2) includes them. Column (3) employs a split sample approach in which returns following the year 1991 are regressed on hazard rates measured using the pre-1991 sample. All standard errors are allowed to be double clustered by calendar year-month and by merger.

		Individual Strategies		Tests: P-values
		Alpha	Stderr	High > Low
Cash	Low hazard 1	-0.0005	0.0015	
	High hazard	0.0064 ***	0.0016	0.0084
	Low hazard 2	-0.0007	0.0046	
	Buy and hold	0.0038 ***	0.0013	
Equity	Low hazard 1	0.0068 ***	0.0015	
	High hazard	0.0146 ***	0.0023	0.0002
	Low hazard 2	-0.0035	0.0055	
	Buy and hold	0.0109 ***	0.0012	
Obs		3190		Joint test
R2		0.0779		0.0000

Table 3: Strategy Alphas

The Table reports Fama-French alphas for the three portfolio strategies Low Hazard 1, High Hazard, Low Hazard 2, as well as for the Buy and Hold strategy. The “High > Low” column reports p-values for the null hypothesis that $(\alpha_{high} - \alpha_{low_1}) + (\alpha_{high} - \alpha_{low_2}) \leq 0$. The joint test combines the previous tests for cash and equity financed mergers. We compute alphas using only calendar months in which a strategy invests in at least one active merger. We exclude months without active deals (rather than assuming the strategy obtains the risk free rate) to avoid biasing the alpha of the Low Hazard 2 strategy toward zero (Low Hazard 2 invests in deals toward the end of event life and therefore has fewer deals to invest in relative to the other two strategies).

		Individual Strategies		Tests: P-values
		Alpha	Stderr	High > Low
Panel A: Late Sample, Early Hazards				
Cash	Low hazard 1	-0.0003	0.0022	0.2077
	High hazard	0.0043 *	0.0024	
	Low hazard 2	0.0019	0.0066	
	Buy and hold	0.0034 *	0.0019	
Equity	Low hazard 1	0.0083 ***	0.0024	0.0129
	High hazard	0.0139 ***	0.0029	
	Low hazard 2	0.0033	0.0036	
	Buy and hold	0.0107 ***	0.0019	
Obs		1521		Joint test
R2		0.0847		0.0271
Panel B: Tradable Strategy				
Cash	Low hazard 1	-0.0005	0.0015	0.0018
	High hazard	0.0063 ***	0.0016	
	Low hazard 2	-0.0008	0.0033	
	Buy and hold	0.0038 ***	0.0013	
Equity	Low hazard 1	0.0067 ***	0.0014	0.0000
	High hazard	0.0130 ***	0.0020	
	Low hazard 2	-0.0003	0.0006	
	Buy and hold	0.0109 ***	0.0012	
Obs		3888		Joint test
R2		0.0759		0.0000

Table 4: Strategy Alphas - Robustness

The Table reports Fama French alphas for the Low Hazard 1, High Hazard, Low Hazard 2 and Buy and Hold strategies using more feasible investment strategies. In Panel A, we use hazard rates of completion estimated in the early period (prior to 1991) to determine the event window cutoffs for each of our three strategies (separately for cash and equity mergers). Then, we compute alphas using returns only during the later period (starting in 1991). In Panel B, we compute the alphas and betas by using all calendar month returns and assume that each strategy earns the risk free rate in months in which there are no active deals to invest in. The tests reported are as defined in Table 3.

		Alpha	Rm-Rf	SMB	HML	Obs	R2
Panel A: Betas							
Cash	Low hazard 1	-0.0005 (0.0015)	0.2088 *** (0.0507)	0.1495 *** (0.0409)	0.0847 (0.0824)		
	High hazard	0.0064 *** (0.0016)	0.2975 *** (0.0668)	0.1920 *** (0.0571)	0.1695 * (0.0888)		
	Low hazard 2	-0.0007 (0.0046)	0.2762 ** (0.1126)	0.2393 (0.1721)	0.0116 (0.1758)		
Equity	Low hazard 1	0.0068 *** (0.0015)	-0.1043 *** (0.0340)	0.0947 ** (0.0427)	0.0142 (0.0513)	2220	0.065
	High hazard	0.0146 *** (0.0023)	-0.1124 * (0.0597)	0.0628 (0.0623)	-0.0207 (0.0810)		
	Low hazard 2	-0.0035 (0.0055)	-0.1235 (0.1310)	0.2363 (0.1701)	0.0719 (0.1591)		
Panel B: Tests on Betas (P-values)			Rm-Rf	SMB	HML		
Cash	High hazard > Low hazard 1		0.1186	0.2438	0.1846		
	High hazard > Low hazard 2		0.4383	0.6128	0.2141		
Equity	High hazard > Low hazard 1		0.5471	0.6687	0.6466		
	High hazard > Low hazard 2		0.4690	0.8227	0.6960		

Table 5: Strategy Betas

The top panel of the Table reports the betas with respect to the Fama French factors for the different trading strategies. The bottom panel of the table tests the null hypothesis that $(\beta_{high} - \beta_{low_1}) \leq 0$ and $(\beta_{high} - \beta_{low_2}) \leq 0$, separately for cash and equity deals and for each of the three factors.

Dep Var: Betas	Rm - Rf	SMB	HML
Weekly hazard x Cash	-0.063 (0.691)	-0.833 (1.003)	-0.556 (1.101)
Weekly hazard x Equity	0.139 (0.472)	0.152 (0.685)	-0.267 (0.753)
Merger type dummies	Y	Y	Y
Obs	96	96	96
R2	0.33	0.01	0.01

Table 6: Time-Varying Betas

The Table reports the results of a regression of the Fama French betas of each event-week-specific strategy described in Section 6 on the estimated hazard rate of the corresponding event week. Betas and hazard rates are measured at the merger type (cash or equity) by event week level.

Panel A:		Average	Alpha	Rm-Rf	SMB	HML	Obs	R2
Rm < -3%		return						
Cash	Low 1	-0.0173 (0.0051)	0.0230 ** (0.0099)	0.4518 *** (0.0941)	0.1528 (0.0977)	-0.1181 (0.2195)		
	High	-0.0128 (0.0050)	0.0213 ** (0.0107)	0.4635 *** (0.1459)	0.1626 (0.1200)	0.0373 (0.1953)		
	Low 2	-0.0259 (0.0116)	0.0217 (0.0278)	0.6503 * (0.3340)	-0.2086 (0.3564)	-0.1990 (0.3327)		
Equity	Low 1	0.0161 (0.0034)	0.0150 * (0.0077)	-0.0126 (0.1230)	0.2815 *** (0.0994)	0.2060 ** (0.1009)	338	0.2396
	High	0.0208 (0.0052)	0.0135 (0.0098)	-0.1662 (0.1643)	0.1990 (0.1579)	-0.0643 (0.1695)		
	Low 2	-0.0139 (0.0173)	-0.1984 ** (0.0974)	-2.8060 ** (1.3083)	0.7859 (0.4937)	0.5982 (0.5760)		
Panel B:			Alpha	UMD	OTM call	OTM put	Min	Max
Other Risk							return	return
Cash	Low 1		-0.0014 (0.0018)	-0.0325 (0.0334)	-0.0073 *** (0.0022)	-0.0034 (0.0030)	-0.125	0.15
	High		0.0067 *** (0.0021)	-0.1338 ** (0.0618)	-0.0051 (0.0034)	0.0022 (0.0042)	-0.111	0.40
	Low 2		0.0002 (0.0062)	-0.2951 (0.2190)	-0.0043 (0.0114)	-0.0044 (0.0086)	-0.311	0.60
Equity	Low 1		0.0086 *** (0.0020)	-0.0067 (0.0492)	-0.0007 (0.0025)	-0.0001 (0.0037)	-0.13	0.35
	High		0.0158 *** (0.0028)	0.0443 (0.0498)	0.0029 (0.0061)	-0.0010 (0.0048)	-0.211	0.41
	Low 2		-0.0046 (0.0064)	0.0508 (0.1107)	0.0016 (0.0087)	-0.0066 (0.0056)	-0.164	0.10
Market							-0.225	0.166

Table 7: Other Risks

The top panel of the Table reports the average return, alphas, and betas of the portfolio strategies conditional on restricting the sample to calendar months in which the market return is less than or equal to -3%. The bottom panel reports alphas and betas of a six-factor model that includes the three Fama French factors (betas not reported in the table), the momentum factor UMD, and two option-based factors from Agarwal and Naik (2004). Note that the alphas and sample sizes are slightly different from our baseline case because these option factors are only available from 1983 to 2011.

	Size			Volume			Turnover			Bid-ask spread			Time period		
	Small	Large		Low	High		Low	High		High	Low		Early	Late	
Low haz 1	0.0001 (0.0021)	-0.0020 (0.0016)		-0.0002 (0.0022)	-0.0010 (0.0016)		-0.0020 (0.0023)	0.0008 (0.0017)		-0.0027 (0.0027)	0.0013 (0.0013)		-0.0010 (0.0018)	-0.0003 (0.0022)	
High haz	0.0113 *** (0.0024)	0.0020 (0.0021)		0.0103 *** (0.0022)	0.0019 (0.0021)		0.0084 *** (0.0022)	0.0037 (0.0024)		0.0080 *** (0.0028)	0.0005 (0.0017)		0.0083 *** (0.0021)	0.0048 ** (0.0024)	
Low haz 2	-0.0039 (0.0072)	0.0024 (0.0047)		-0.0020 (0.0085)	-0.0005 (0.0042)		-0.0004 (0.0077)	-0.0012 (0.0049)		-0.0064 (0.0077)	0.0018 (0.0041)		-0.0026 (0.0041)	0.0009 (0.0073)	
Buy & hold	0.0069 *** (0.0018)	0.0000 (0.0014)		0.0056 *** (0.0018)	0.0009 (0.0014)		0.0041 ** (0.0019)	0.0030 ** (0.0014)		0.0031 (0.0022)	0.0016 (0.0013)		0.0043 *** (0.0014)	0.0034 * (0.0019)	
Low haz 1	0.0062 *** (0.0023)	0.0060 *** (0.0020)		0.0055 ** (0.0023)	0.0050 ** (0.0023)		0.0058 ** (0.0023)	0.0075 ** (0.0030)		0.0067 * (0.0036)	0.0076 ** (0.0031)		0.0055 *** (0.0018)	0.0087 *** (0.0024)	
High haz	0.0181 *** (0.0037)	0.0103 *** (0.0021)		0.0174 *** (0.0035)	0.0083 *** (0.0026)		0.0155 *** (0.0033)	0.0084 *** (0.0029)		0.0162 *** (0.0054)	0.0077 *** (0.0021)		0.0151 *** (0.0032)	0.0137 *** (0.0030)	
Low haz 2	0.0002 (0.0144)	-0.0075 (0.0062)		-0.0172 (0.0109)	-0.0041 (0.0064)		-0.0134 * (0.0075)	-0.0082 (0.0107)		0.0107 (0.0082)	0.0000 (0.0040)		-0.0099 (0.0086)	0.0036 (0.0054)	
Buy & hold	0.0124 *** (0.0021)	0.0084 *** (0.0014)		0.0111 *** (0.0021)	0.0073 *** (0.0019)		0.0111 *** (0.0021)	0.0086 *** (0.0020)		0.0124 *** (0.0029)	0.0082 *** (0.0021)		0.0111 *** (0.0016)	0.0108 *** (0.0019)	
High:															
Illiquid > Liquid	0.0005			0.0001	0.0043		0.0052			0.1884					
High > Low	0.0019	0.0073		0.0000	0.0302		0.0000	0.0445		0.0142	0.2521		0.0000	0.0359	
Obs	5929			5836	5806		3784			3190					
R2	0.0601			0.0599	0.0534		0.0636			0.0841					

Table 8: Limits to Arbitrage

The Table reports alphas for trading strategies after dividing the sample in half by target characteristics (columns 1-8) or by calendar time (columns 9-10). The sample splits by target characteristics are executed separately within each calendar year using the median target characteristic in that year as measured two days following merger announcement. At the bottom of the table we report p-values for the test “High > Low”, corresponding to the similar test in Table 3. We also report a test “High: Illiquid > Liquid” which tests the null hypothesis that the alphas in the environment in which arbitrage is more difficult (left column of each subdivision) is less than or equal to the corresponding alpha in the environment in which arbitrage is more favorable (right column of each subdivision).

Pooled Strategy (Cash and Equity Mergers)	No Trading Costs Alpha	Trading Costs Alpha (Method 1)	Trading Costs Alpha (Method 2)
Low hazard 1	0.0025 ** (0.0012)	-0.0034 *** (0.0010)	-0.0076 *** (0.0009)
High hazard	0.0091 *** (0.0018)	0.0035 *** (0.0012)	-0.0011 (0.0012)
Low hazard 2	0.0018 (0.0029)	-0.0008 (0.0009)	-0.0015 ** (0.0008)
Buy and hold	0.0071 *** (0.0011)	0.0025 ** (0.0010)	-0.0011 (0.0009)
P-value: High > Low	0.0015	0.0000	0.0025
Obs	1916	1916	1916
R2	0.0542	0.1175	0.1322

Table 9: Accounting for Transaction Costs

The left column of the Table reports the returns of strategies that invest equally in all available deals from 1970 to the present, ignoring transaction costs and limits to portfolio weights. If no deals are active during the relevant event window for each strategy, the return is equal to the risk free rate. In the right columns, we follow Mitchell and Pulvino (2001) and Breen et al. (2002) in estimating the alphas for feasible trading strategies after accounting for transaction costs. Each strategy starts with \$1M of funds in 1970. Every month, each fund invests equally in all available deals in their respective event windows subject to the limitation that at most 10 percent of the capital can be invested in any particular deal. For each trade, we account for direct transaction costs of \$0.10 per share prior to 1980, \$0.05 per share from 1980 to 1989, \$0.04 per share from 1990 to 1998, and \$0.03 from 1999 onwards. In addition, we account for indirect transaction costs using two methods. Method 1 computes indirect transaction costs using the estimates of price pressure from Breen et al. (2002). In addition, we impose the additional restriction that the total trading in any deal cannot produce price pressure of more than 5 percent of the price. Method 2 computes indirect transaction costs using the bid-ask spread. If data on bid-ask spread is unavailable from CRSP, we supplement with the estimated bid-ask spread from Corwin and Schultz (2012).

Appendix

Proof of Proposition 1

Suppose that the true hazard rate of completion for firm i is $h_i(t) = \alpha_i h(t)$, where $h(t)$ is the common component and α_i is a firm-specific unobservable parameter distributed in the cross-section according to the distribution function $G(\alpha)$ with mean 1. Suppose also that $h(0) = h(T) = 0$. Then, we have

$$E_\alpha[\alpha h(t)] = h(t) \geq h_\theta(t),$$

where $h_\theta(t)$ is the measured hazard rates ignoring the unobserved heterogeneity. Since $h(0) = h(T) = 0$, $h(t)$ has to be more time-varying than $h_\theta(t)$.

Proof: Hazard rates are defined such that

$$h_\theta(t) = \frac{\int_0^\infty -\alpha S(t)^{\alpha-1} S'(t) g(\alpha) d\alpha}{\int_0^\infty S(t)^\alpha g(\alpha) d\alpha},$$

and

$$h(t) = E_\alpha(\alpha h(t)) = \int_0^\infty -\alpha S(t)^{-1} S'(t) g(\alpha) d\alpha.$$

Rearranging terms yields

$$E_\alpha(\alpha h(t)) = \int_0^\infty -\alpha S(t)^{-1} S'(t) g(\alpha) d\alpha = \int_0^\infty \frac{-\alpha S(t)^{\alpha-1} S'(t)}{S(t)^\alpha} g(\alpha) d\alpha.$$

For ease of notation call

$$\begin{aligned} X &= -\alpha S(t)^{\alpha-1} S'(t), \\ Y &= S(t)^\alpha, \end{aligned}$$

with $E[Y] \geq 0$ since $S(t) \geq 0$ and $\alpha \geq 0$. We have:

$$E_\alpha(\alpha h(t)) = E\left[\frac{X}{Y}\right],$$

$$h_\theta(t) = \frac{E[X]}{E[Y]}.$$

Now define $Cov(\frac{X}{Y}, Y) = E[X] - E[\frac{X}{Y}]E[Y]$. It follows that

$$Cov(\frac{X}{Y}, Y) = Cov(-\alpha S(t)^{-1} S'(t), S(t)^\alpha) \leq 0,$$

since $S(t)^{-1} \geq 0$, $S'(t) \leq 0$ and $Cov(\alpha, S(t)^\alpha) \leq 0$ ($S(t)^\alpha$ is decreasing in α since $S(t) < 1$).

This implies

$$E\left[\frac{X}{Y}\right]E[Y] \geq E[X],$$

and since $E[Y] > 0$ we can write:

$$E\left[\frac{X}{Y}\right] \geq \frac{E[X]}{E[Y]},$$

or:

$$E_\alpha(\alpha h(t)) \geq h_\theta(t).$$

Downside Beta

In this section we replicate the estimation of downside beta proposed in Mitchell and Pulvino (2001). In particular, we estimate the coefficients of the regression:

$$R_{strat} - R_f = (1 - \delta)[\alpha_{mktlow} + \beta_{mktlow}(R_M - R_f)] + \delta[\alpha_{mkthigh} + \beta_{mkthigh}(R_M - R_f)] + \epsilon,$$

where δ is an indicator that the monthly market return is below a threshold (which we take to be -4% as in Mitchell and Pulvino, 2001), R_{strat} is the return of the strategy (we perform the exercise for our Low Hazard 1, Low Hazard 2 and High Hazard strategies separately), and R_M is the market return. To ensure continuity of the relation between expected strategy returns and expected market returns, we constrain the coefficients to satisfy:

$$\alpha_{mktlow} + \beta_{mktlow}(-4\%) = \alpha_{mkthigh} + \beta_{mkthigh}(-4\%).$$

Figure 13 plots the estimated piecewise linear functions for the three strategies for cash mergers. The figure shows that the three strategies have extremely similar exposures to downside risk. We also estimate piecewise linear functions for the three strategies for equity mergers (omitted for brevity). Due to the short position that acts as a hedge, the downside betas are negative and cannot explain the returns variation.

Appendix Figures

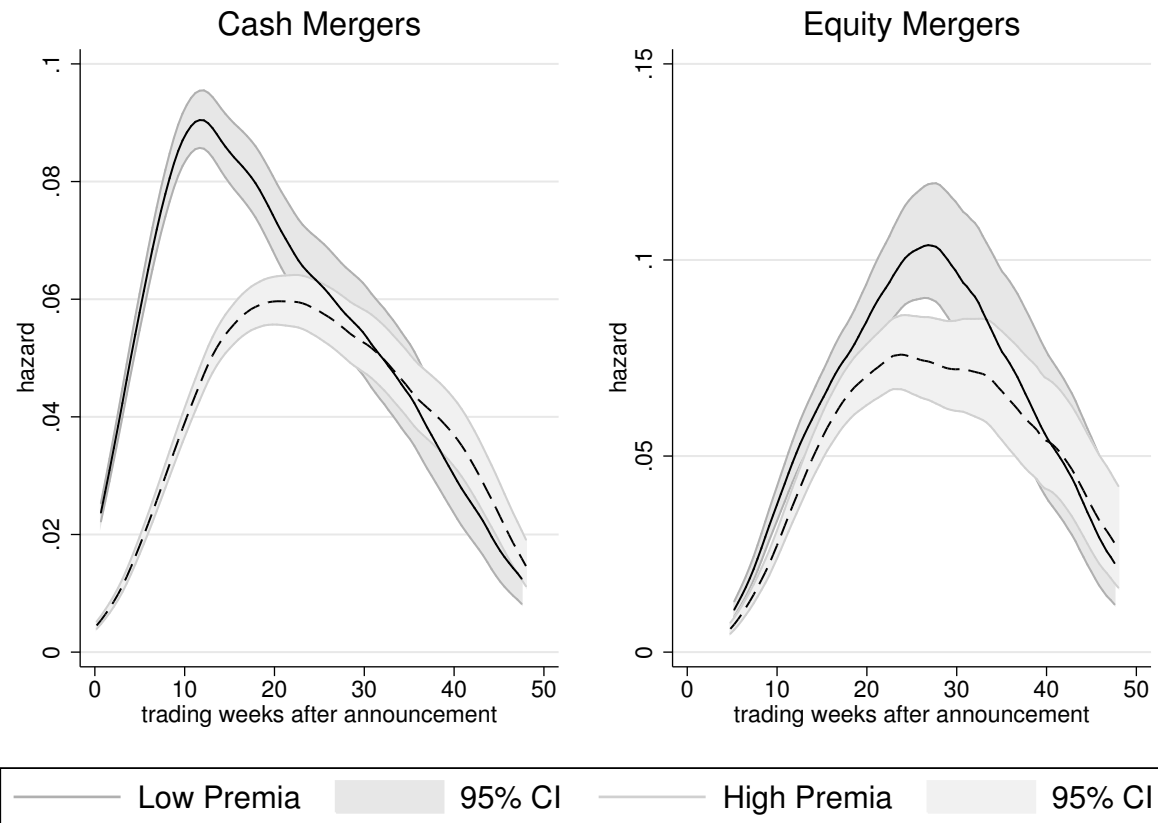


Figure 11: Hazard Rates by Premia (2 Days After Announcement)

The Figure reports the estimated hazard rates of completion for cash and equity mergers after splitting the sample in half in terms of the premium as measured two days after announcement. The premium is a proxy for the market's assessment of the probability that the merger will eventually complete. The premium for cash mergers is the ratio of the initial offer price at deal announcement to the price of the target two days after deal announcement. For equity mergers, the premium is defined as $\Delta * P_{t=2}^A / P_{t=2}^T$, where Δ is the exchange ratio, defined as the number of acquirer shares offered for each share of the target, and P^A and P^T are the acquirer's and target's share prices, respectively.

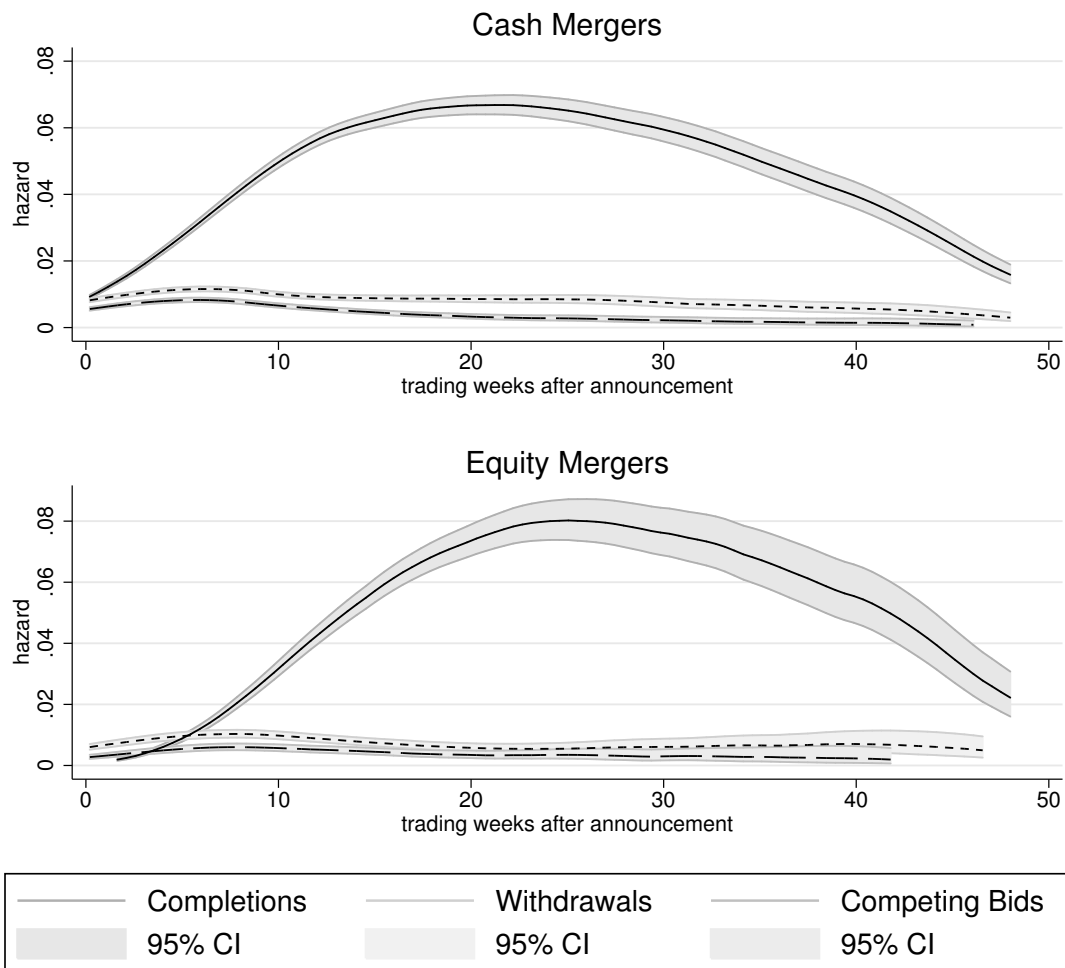


Figure 12: Hazard Rates of Completion, Withdrawal, and Competing Bids

The Figure reports the estimated hazard rates of completion, withdrawal, and of receiving a competing bid from another acquirer. The hazard rate of receiving a competing bid represents the probability of receiving at least one competing bid in event week t conditional on no completion or withdrawal prior to week t . The hazard rates of completion and withdrawal are as defined in Section 3.

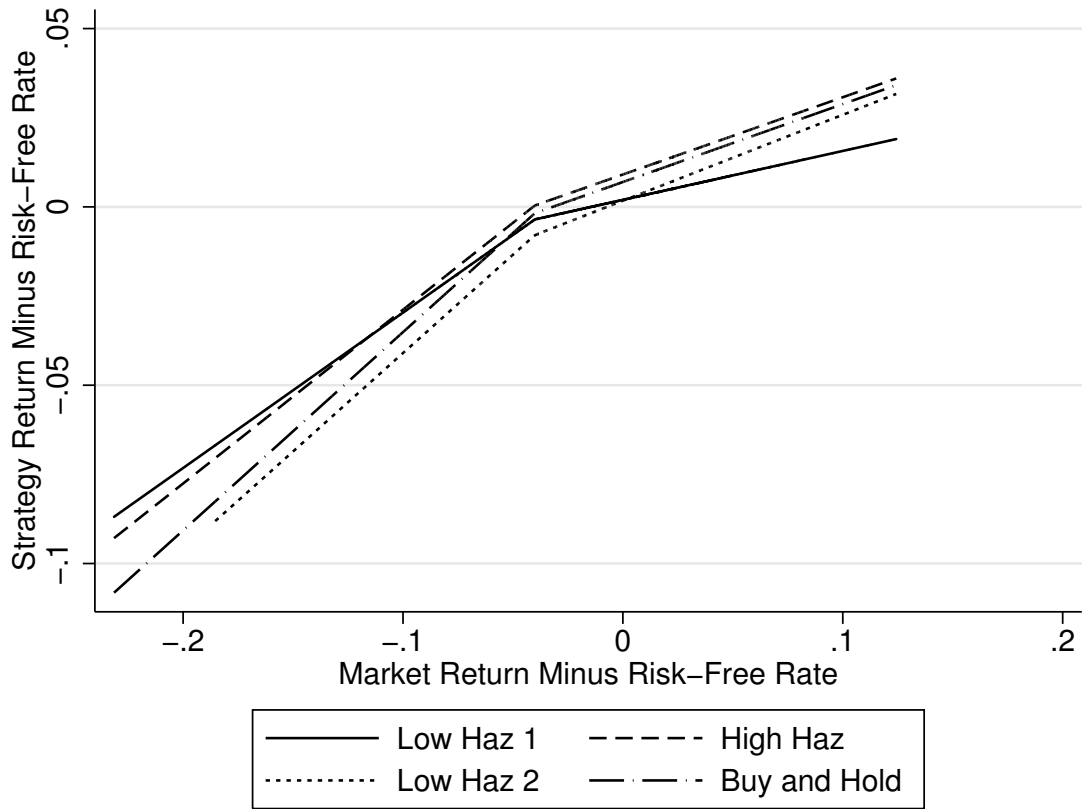


Figure 13: Downside Beta

The Figure explores event time variation in downside beta. We estimate piecewise linear functions of the expected returns of the four trading strategies (Low Hazard 1, Low Hazard 2 and High Hazard, and Buy and Hold) against the market return. The specification is described in the Appendix.