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Merger Arbitrage in the American Stock Market

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Abstract

This thesis investigates risk-adjusted returns for the merger arbitrage strategy in the time period running from 1998 to 2017 using a sample which contains 4,462 mergers. This thesis finds a nonlinear relationship when investigating weekly return estimates, which suggests that the strategy has similar characteristics to a portfolio constructed of a short market index put option, long market index call option, and a long position in a risk-free asset. In particular when pricing the replicating portfolio using the "Black Scholes Merton" model the merger arbitrage strategy produces excess returns between 4 and 8 percent annually. Similar levels of excess returns are found when applying linear risk-adjustment models which demonstrates that the nonlinear model fails to properly explain the excess returns produced by merger arbitrage.

Moreover, this thesis finds that 84.2% of all deals are completed successfully with significant evidence that the probability of success increases when the acquiring and target firm operates within the same industry and has its headquarters in the same country.

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1 Introduction

Merger arbitrage is an event-driven hedge fund investment strategy. It has gained an increased number of followers in recent years with more and more investors channeling capital into hedge funds which are dedicated to exploiting this apparent mispricing in the marketplace (Bloomberg 2018 [1]). Given the increase in the amount of capital applied to take advantage of this trading strategy, this thesis seeks to explore whether the so-called arbitrage strategy is still able to generate positive economic profits to its adherents. Despite common financial theory stating that markets are efficient and that no trading strategy should be able to consistently produce abnormal profits, the continued existence of dedicated merger arbitrage hedge funds would suggest otherwise.

Previous studies have been conducted with the aim of determining to what extent the merger arbitrage strategy is able to generate excess returns against the market. In particular, Mitchell and Pulvino 2001 [2] is to this date the most thorough study of the historical performance of merger arbitrage conducted with a sample of 4,750 firms during the period 1963 to 1998. This thesis aims to determine whether it is still possible to generate positive economic profits in modern times from merger arbitrage and likewise examine different causes for why these profits are found.

These above reasons, along with the authors interest in capital markets, motivated the particular choice of topic in this thesis.

1.1 Thesis Problem Statement

The research question for this paper is defined as follows

To what extent has merger arbitrage been able to generate significant risk-adjusted returns in the US stock market in the period from 1998 to 2017?

To answer this research question, the paper first constructs a historical sample of mergers from 1998 to 2017. From this sample, several portfolio construction approaches will be applied to backtest the historical performance of merger arbitrage to examine the returns it has produced. To obtain insight into the characteristics of the merger events, an analysis of which factors are significant for predicting the outcome of a deal is conducted. Since there is more than one approach to determine if a strategy produces risk-adjusted returns, the paper will consider a multitude of tests to discuss under what circumstances the merger arbitrage strategy produces risk-adjusted returns. Furthermore, tests are conducted on different deal types to examine how the characteristics differ for cash and stock offers. The paper will relate the findings to those of previous researchers where it is relevant, while also providing economic intuition for the findings.

1.1.1 Thesis Outline

In order to answer the research question in the most thorough way possible, the remainder of this thesis is structured in the following way

2. Merger Arbitrage; This chapter takes the reader through the rationale behind the merger arbitrage strategy.

3. Literature review; This chapter presents the main findings from previous key studies on the topic of merger arbitrage. Furthermore, it will distinguish between US and outside US research.

4. Methodology; This section gives the reader full insight into the quantitative framework which has been applied in order to analyze the data sample which has been selected for this thesis.

5. Data Description; This chapter provides an overview on the data which was used for the study. Furthermore, it describes the collection process and exclusion criteria which has been applied in order to arrive at the final sample.

6. Results; This chapter will present the findings as well as discussing and relating the findings to previous studies.

   (i) Analysis I; The main goal of the first analysis is to estimate the probability that a merger deal is successful, given different estimation parameters.

   (ii) Analysis II; The second analysis presents the historical performance of the strategy between 1998 and 2017. Moreover, the section present findings regarding the return distribution of the strategy, as well as presenting the key risk measurements related to the investment strategy.

   (iii) Analysis III; The final analysis has been conducted with the main goal of risk-adjusting the strategy returns. The section will both introduce linear and nonlinear regression modeling. Moreover, the section will construct a replicating portfolio which mimics the payoff of the merger arbitrage strategy and price it using contingent claim pricing.

7. Conclusion; At last, this chapter will answer the research question presented in section 1.1.

1.2 Thesis Delimitation

Previous researchers disagree about the extent to which transaction costs carry a significant impact on the returns which are earned by a merger arbitrageur. Researchers, such as Mitchell and Pulvino 2001 [2], find that transaction costs have a significant impact on the returns, while researchers such as Baker and Savasoglu [3] find that they do not. This thesis will, for practical purposes, ignore transaction costs when calculating the historical returns produced by merger arbitrage, although it is important to bear in mind that a real-life implementation of a trading strategy inevitably involves transaction costs for the investor which will decrease any returns which are reported in this paper.

In terms of geography this paper will limit itself to only consider the universe of publicly traded US equities. Although considering mergers from multiple countries is an interesting proposition, various regulations both in terms of how mergers and stock markets operate in different countries, mean that this thesis will limit itself to only evaluate US mergers.

The sample applied in this thesis builds on the entire universe of public US mergers in the defined time period. Consistent with previous research, this paper considers only a subset of these mergers. To define exactly which mergers will be considered for the research in this paper, various exclusion criteria will be further defined and applied in chapter 5, which will also contain justifications for the exact choices which are made.

2 Merger Arbitrage

2.1 Definition of Merger Arbitrage

Merger arbitrage, also commonly referred to as risk arbitrage in the academic literature, is an event-driven investment strategy, mainly applied by hedge funds to obtain excess returns. The idea behind the investment strategy is to exploit a market inefficiency which is hypothesized to occur during a corporate takeover event.

The process by example: Firm A wants to acquire firm B, which is publicly traded. Firm A places a takeover bid on the stock of firm B. Suppose that firm B's stock currently trades for a price of \$35, and firm A places a bid on firm B's stock at \$50. Immediately, firm B's share price will increase and the stock price will make a jump. However, since the deal is not 100% guaranteed to be successful, the share price will usually jump to a level which is below the bid price. The difference between the bid price and the stock price following the announcement is defined as the arbitrage spread.

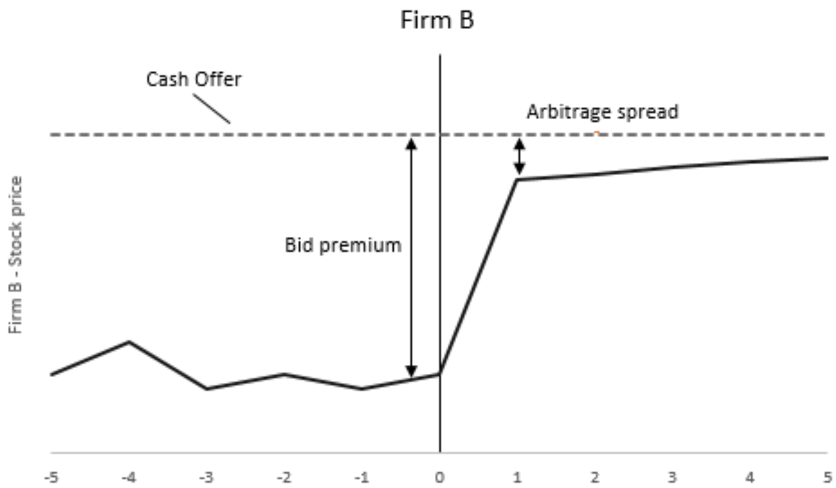


Figure 2.1: The development of Firm B's share price before and after an announcement, based on a pure cash offer.

2.2 M&A Deal Types

A firm which wishes to acquire another has multiple options when compensating the target firm's shareholders for their stake in the target firm. The most common methods of payment are defined and explained below.

- **Cash offer** is the most straightforward deal type. The acquiring company pays for the target firm's shares by the use of cash, which may either be raised internally or by issuing new equity or debt. The arbitrage spread in this situation amounts to the difference between the post-announcement price and the takeover price. The investor will exploit the mispricing by taking a long position in the share if the investor believes the probability of success is higher than the probability implied by the market price. Conversely, the investor may short the target share if the probability of success is lower than indicated by the market. If the offer is successful, the investor will receive the takeover bid and earn a return which is equal to the arbitrage spread. If, on the other hand, the deal is terminated, the target stock price will most likely decrease significantly, yielding a negative return for the investor.
- **Stock offer** is a method of payment in which the shareholders of the target firm receives a fixed or floating conversion ratio of the acquiring firm's shares. In a stock offer, the bid price is therefore constantly fluctuating. This means that in order to construct a hedged portfolio, the investor must short a fraction of the acquiring firm's shares, which is equal to the initial conversion ratio. The investor must then take a long position in the target company. If the arbitrage spread narrows, the investor will then earn a positive return. If the deal is successful, the investor will receive shares in the acquiring firm in exchange for the investor's shares in the target firm and close the position with a profit equal to the original arbitrage spread.

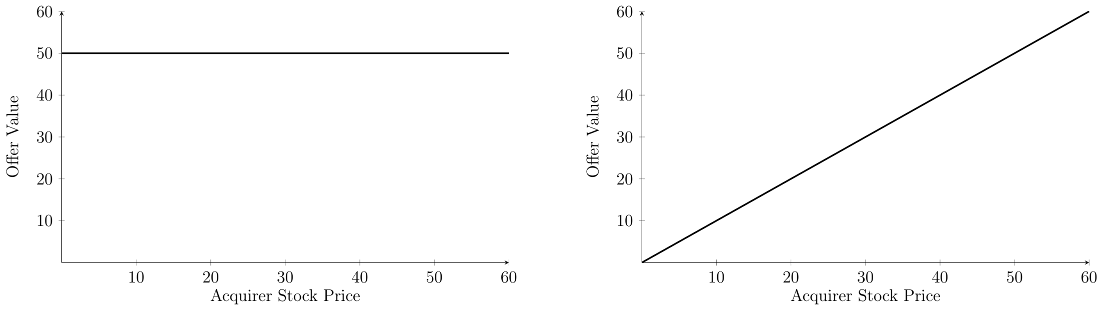


Figure 2.2: Offer value dependent on the share price of the acquirer, for pure cash (left) and stock (right) deals.

- **Hybrid offer** denotes any other offer than pure cash or stock offers. The hybrid payments can incorporate both cash and stock, and may also incorporate stock options and other financial derivatives. Due to their more complex nature, these types of deal transactions are harder to analyze. When performing an empirical study on merger arbitrage containing hybrid deal transactions, each deal would have to be treated individually, which is beyond the scope of this thesis. Furthermore, while hedging a stock offer is relatively non-trivial as it can be done by merely shorting the acquirers stock, hedging a hybrid offer can be incredibly complicated, as it might involve forming a portfolio of several different types of securities, many of which are unlikely to be available in the market.

2.3 Returns

An investment based on merger arbitrage will earn a return which in simple terms can be thought of as either a positive return conditional on a successful outcome of the merger process or a negative return in the case of failure. The overall expected return of the strategy is, therefore, dependent on 1) the average arbitrage spread 2) the loss in the case of deal termination 3) the probability for each of those outcomes.

Empirical evidence, as presented in Mitchell and Pulvino 2001 [2], suggests that the price of shares undergoing a merger is dependent on the market's assessment of the deal risk. I.e., the arbitrage spread is larger when a merger is less likely to succeed, and the possible larger returns given a successful merger are therefore offset by the decreased probability of success.

The reason why the target share price at any time after the announcement is different from the target bid price is due to the fact that the probability of acceptance implied by the market is incorporated in the share price. In other words, the difference is the arbitrage spread, and its size depends on the probability of success. As time passes, and the probability that the outcome of the M&A process is successful increases, the size of the arbitrage spread will decrease accordingly. By taking a long position in the target share, the market participants believe the market is incorporating too low a probability of success and is, therefore, taking advantage of the mispricing.

2.4 Risks in Merger Arbitrage

Within financial theory, arbitrage is a specific concept upon which financial markets are built. Financial products are priced based on the notion of "absence of arbitrage." More specifically, arbitrage arises when a market participant takes advantage of price differences on the same product in different markets, or different products within the same market, to gain a risk-free profit without the use of one's own cash. As an example: if a product X is priced at \$5 in market A, but \$4 in market B, then it is assumed that an arbitrageur would exploit this price difference by buying the product in market B and selling it in market A to make a profit of \$1.

The reason why financial products and markets are structured on the notion of "absence of arbitrage" is due to the fact that if price differences are observed between markets, all rational investors would buy the product in the "cheap" market and sell it in the "expensive" market, thus driving the prices of the "cheap" market up and driving the prices of the "expensive" market down, until they reach an equilibrium. Therefore, arbitrage in financial markets should not exist, and if it does, it should only be for a brief period until the market powers have driven the price differences to an equilibrium.

Using the term arbitrage within merger arbitrage is misleading, as the returns to an investor applying the strategy are in fact not risk-free. If an investor has taken a long position in the target share, and the deal turns out to be unsuccessful, the share price may drop back to its old level (or even further), causing the investor to suffer a net loss. In other words, the risk arises from the possibility that the deal will be resolved unsuccessfully. The risk related to the strategy can thus be divided into two components. Firstly, the idiosyncratic risk which describes risks which are specific to the individual deal itself. Secondly, the systematic risk which concerns risks which can cause multiple deals to fail simultaneously.

2.4.1 Idiosyncratic Risk

When a merger is proposed, or even agreed upon, it could still fail due to a number of legal and financial reasons. In a merger process, the accompanying merger agreement will usually state multiple conditions which must be fulfilled for the merger to be completed. Some of the most important ones are as follows.

- **Acceptance of target shareholders**

  For large public corporations, ownership is usually divided between a large number of individual shareholders. Since the purpose of a merger is to get ownership of the target firm, the acquirer will often require the acceptance of a minimum number of shareholders, for example, 90%. At this level, the acquirer can then proceed to gain full ownership of the target firm.

- **Antitrust approval**

  In the US, there are multiple parties which may intervene while a merger is underway, most importantly, the Federal Trade Commission (FTC). For example, in cases where the merger of two large entities can result in the formation of a monopoly, the FTC may restrict the merger from ever happening, causing a negative return for an investor.

- **Financing**

  It is sometimes the case that the acquirer is unable to obtain the necessary capital to accomplish the merger. For example, an acquirer, who has made a large cash offer, may find that banks are less enthusiastic about the merger than the acquirer is. If this happens, the deal will naturally fail.

- **No material adverse effects**

  Even after a merger is proposed, it is common that the offer is made conditional upon the due diligence process being completed satisfactory, and that no findings during the merger process cause a material change to the fundamentals of the target company.

2.4.2 Systematic Risk

The individual target specific risks defined above can be diversified away in a portfolio containing a large number of target firms. However, the risks which can not be diversified away are the so-called systematic risks. Most notably, empirical findings, presented in chapter 3, show how adverse economic conditions, such as financial crises, tend to result in multiple deals failing at the same time. Cash deals are especially vulnerable to such conditions, as a cash offer which seemed attractive for the acquirer during boom times, may no longer seem as attractive after asset prices have deteriorated. Stock deals, on the other hand, may not be as sensitive, since the value of the offer consisting of acquirer stocks will usually also have dropped during a market downturn.

2.5 Investors

There are different investors with different approaches on how to perform the merger arbitrage strategy. Some investors are actively engaged in the merger process and select a number of mergers which they then try to influence. Active investors engage in the target company in order to influence the deal process; the reason is due to several factors. First, they are able to actively work on increasing the size of the bid. Second, they can actively engage in forcing the target firm's acceptance, and possibly overturn the decision of a hostile board. Both of these reasons could potentially lead to a higher excess return.

Passive investors can be divided into two subgroups. The first group's objective is to invest indiscriminately in all target firms subject to a bid without any concern for deal size, industry or the probability of success. The second subgroup of passive investors is more selective than the first group in terms of which M&A activity they invest in. These investors do not actively engage in influencing the merger process, but do actively allocate their capital to the deals which they believe are most likely to succeed.

2.6 Efficient Markets and Merger Arbitrage

Fama 1969 [4] established the original Efficient Market Hypothesis (EMH) and defines the efficient market as follows

"A market in which prices always "fully reflect" all available information is called efficient"

Fama defines three different levels of efficiency which reflects this available information to varying degrees. The weak form assumes that all historical knowledge is included in the price formation for the asset which further implies that historical prices have no impact on future price movements. The semi-strong form includes the same information as the weak form but, in addition, it incorporates all the information which is publicly available. The strong form contains the same information as the two previous forms but also all of the information which only a limited number of market actors have access to. This implies that even though only a few people hold some critical information about the asset, this knowledge is still fully reflected in the price.

If the shares of merger targets were priced efficiently, one should not be able to profit systematically from purchasing them after a merger announcement. In the case that those assets are underpriced, it is a clear violation of the efficient market hypothesis, as investors should not be able to profit from this information which is already known by the market. Given that merger arbitrage has been found to generate excess returns over several decades, it is likely that the efficient market hypothesis does not hold, but rather that there is some other factor which causes the abnormal profits to persist. Previous researchers, such as Baker and Savasoglu [3] hypothesize that the abnormal returns generated by merger arbitrage may be caused by the fact that existing shareholders look to divest from merger targets following an announcement. This is due to the asymmetric distribution of returns investors face, earning either a small return at completion or suffering a substantial loss upon termination.

3 Literature Review

3.1 Previous Research - US

3.1.1 Mitchell and Pulvino 2001 - *"Characteristics of Risk and Return in Risk Arbitrage"*

In their 2001 paper "Characteristics of Risk and Return in Merger Arbitrage"[2], Mitchell and Pulvino investigate merger arbitrage in the United States. They analyze 4,750 mergers which take place from 1963 to 1998 to provide analysis about the risks and returns of merger arbitrage. It is the largest study included in this thesis, and the paper has become widely cited within the field of merger arbitrage. Mitchell and Pulvino argue that the excess returns produced by merger arbitrage which are found in previous studies suggest that the financial markets are *"systematic inefficient"*, since a strategy should not be able to keep producing abnormal returns if markets are efficient. However, they recognize that there might be in particular two other possible explanations for the excess returns, which led them to develop two hypotheses.

The first hypothesis which Mitchell and Pulvino examine is whether the excess returns produced by the merger arbitrage strategy, which they develop, might be explained by transaction costs. The second hypothesis is related to the fact that investors might attain a risk premium to compensate them for the negative returns they suffer if the deal is terminated.

In their paper, Mitchell and Pulvino construct two different portfolios denoted "Value Weighted Average Return Series" (VWRA) and "Risk Arbitrage Index Manager Returns" (RAIM). The VWRA portfolio weights each individual asset based on its relative market cap, which leads to large companies having a more significant influence on the portfolio returns. The methodology which Mitchell and Pulvino apply to construct the RAIM portfolio is more complicated and aims to better represent the possibilities and constraints faced by a real fund which wishes to implement a merger arbitrage strategy. The portfolio simulates a fund which begins with $1 million, which it then invests over time subject to various constraints. First, no investment may make up more than 10 percent of the invested capital. Second, the price impact of a trade may not cause the target or acquirer's share to deviate more than 5% from its pre-trade level. The third constraint concerns indirect trading costs, where a formula is defined in which transaction costs associated with conducting each trade rises exponentially as the total value of shares traded increases. The final constraint which is imposed is a direct trading cost for each share traded, which is decreasing through the time period 1963 to 1998.

Mitchell and Pulvino find that the RAIM portfolio significantly underperforms the VWRA portfolio, due to the constraints which are imposed on it. In numerical terms, Mitchell and Pulvino find that the RAIM portfolio produces a compound annual rate of return of 10.64% (Sharpe Ratio = 0.57), while the VWRA provides a compound annual return of 16.05% (Sharpe Ratio = 1.06). According to Mitchell and Pulvino, ignoring the frictions imposed on trading more illiquid securities, therefore, results in returns which are biased significantly upwards. It is also worth noting that the RAIM portfolio in Mitchell and Pulvino's methodology earns a compound annual rate of return which is 1.6% lower than the market. However, the RAIM still has a higher Sharpe ratio of 0.57 as opposed to the market's 0.40 over the same period.

Following their examination of the impact of transaction costs, Mitchell and Pulvino proceed to investigate whether merger arbitrage returns are truly the result of a market inefficiency, or if it is a compensation for carrying a risk unique to the merger event.

The second approach in Mitchell and Pulvino's paper is to investigate the alpha produced by merger arbitrage through linear and nonlinear regression models. The authors consider the possibility that the exposure to market risk found in linear regression models does not serve as a reliable indicator of the real risks faced in an event-driven investment strategy such as merger arbitrage. The authors, therefore, establish a piecewise linear regression model, with the purpose of estimating how the slope of the regression model differs during varying market conditions.

Having established the linear and piecewise regression models, Mitchell and Pulvino proceed to examine the returns of the RAIM portfolio. They find that the market coefficient is not significantly different from zero when the market return is positive; it is, however, significantly positive when the market is declining. The correlation between the strategy and the market, therefore, changes depending on the market state. Mitchell and Pulvino decide to apply a threshold of -4% in the piecewise linear model to separate appreciating from decreasing markets. The authors conclude that the shape of the piecewise linear regression model resembles the payoff diagram of a put option, with a steep downwards slope for market returns below a threshold of -4%, and a flat slope for market returns higher than -4%. The difference between the two slope estimates, from the piecewise linear model and from the linear regression model, suggests that the simple linear regression model may not be able to account for how the correlation between the market returns and the returns from a merger strategy increases dramatically during an economic crisis.

Given the asymmetric payoffs earned by an investor applying a merger arbitrage strategy, which is similar in form to that of writing a put option, Mitchell and Pulvino proceed with a test involving contingent claim pricing. Mitchell and Pulvino compare two alternative investments. The first alternative is an investment of $100 in the merger arbitrage strategy beginning each month. The second alternative is a replicating portfolio, which is composed of a long position in the risk-free asset, and a short position in a put option written on the value of the market index. The strike price of this put option is equal to $\$100(1+\text{Threshold}+r_f)$, where the threshold is defined as above and r_f as the risk-free rate. The fraction invested in the put option is equal to the merger arbitrage portfolio's market beta in a down market. Both the merger arbitrage portfolio and the replicating portfolio thus has a small positive payoff when the market is flat or booming, and a large negative payoff when the market suffers a major decline. Conducting this analysis, Mitchell and Pulvino find that the replicating portfolio, constructed with index put options, has a price which is 0.33% higher than the merger arbitrage investment with the same notional investment of $100, thus concluding that the merger arbitrage index provides a monthly excess return of 0.33% based on this approach.

Finally, Mitchell and Pulvino consider the different variables which may impact the probability that a deal is successfully concluded. First, they find evidence that deals are more likely to fail during a decreasing market. Second, the authors conclude that when the acquirer is a private firm, the probability of failure increases. Third, the probability of success is increasing in the market value of the target firm's equity. Finally, Mitchell and Pulvino find evidence that the attitude of the target firm's management has an impact on the probability. More specifically, the probability of termination increases when the offer is hostile.

3.1.2 Baker and Savasoglu 2002 - *"Limited arbitrage in Mergers and Acquisitions"*

Baker and Savasoglu 2002 [3] examine the returns related to merger arbitrage during the period from 1981 to 1996. As Mitchell and Pulvino, they perform their analysis on pure cash and stock deals in the US market. More specifically, they analyze 1,901 M&A transactions. They acknowledge the abnormal returns found in previous papers and try to explain why these abnormal returns are not arbitraged away. In contrast to Mitchell and Pulvino, Baker and Savasoglu expand their analysis by the use of both an equally weighted portfolio, as well as a value weighted portfolio, which is based on the stock's relative size to the size of the overall portfolio. Baker and Savasoglu find abnormal returns which are higher that what Mitchell and Pulvino found. More specifically, depending on the weighting technique, they reported monthly excess returns in between 60 to 80 basis points, corresponding to an annual return of 7% to 10%.

Baker and Savasoglu developed a simple model of limited arbitrage, and they found three possible drivers of why excess returns exist. Namely, excess returns increase in termination risk, selling pressure and decreasing merger arbitrage capital.

Firstly, Baker and Savasoglu find that excess returns are increasing in termination risk, to compensate investors for holding a more risky asset. In order to quantify the probability of a deal completion, they use predictions from regressing merger outcomes on the acquirer attitude. To quantify the difference in payoffs, they use the takeover premium scaled by the value of the target firm the day after the announcement. Baker and Savasoglu examine the 5 variables Hostile/Friendly, Target market cap, Acquirer market cap, Takeover premium and Cash/Stock deals to identify which of those variables most accurately explain merger outcomes. The results of the regression show that the attitude of the target board, measured as friendly or hostile, is the most important single determinant of a successful merger process. Given the relationship between probabilities and prices, it should, therefore, be expected that target firms with a hostile board should be priced lower than firms with a friendly board.

Secondly, Baker and Savasoglu use the fact that excess returns are increasing in target size the day after the announcement, as a proxy to quantify selling pressure by target shareholders. The main idea behind selling pressure is that it might lead to overestimating the probability of termination. As an example, illiquidity could potentially force shareholders to sell off blocks of equity, pushing the price down which will show up as an increase in the probability of termination, and thus higher excess returns for the arbitrageur. In their paper, Baker and Savasoglu find that there is significant selling pressure following a merger announcement, causing a decline in the probability that the merger will be successful and thus provide a higher expected return for an arbitrageur.

Finally, Baker and Savasoglu measure the total equity holdings of arbitrageurs, in order to investigate the influence of the general supply of merger arbitrage capital. The main idea is that if there exists more available arbitrage capital for merger arbitrageurs, the trading volume on target shares will increase, forcing the share prices upwards. This will result in the probability for success being exaggerated and result in a decrease of the excess returns of arbitrageurs. When regressing merger arbitrage returns against changes in arbitrage capital, they find, consistent with their hypothesis, that a decrease in arbitrage capital corresponds to higher returns.

3.1.3 Branch and Yang 2006 - *"A test of Risk Arbitrage Profitability"*

In their 2006 paper, Branch and Yang [5] investigate the profitability of merger arbitrage during the period from 1990 to 2000 in the US market. Their final sample consists of 1,309 mergers and acquisitions, out of which 1,176 were successful, while 133 were terminated. They perform their analysis consistent with Mitchell and Pulvino's earlier approach, in an attempt to find evidence of what drives the profitability of merger arbitrage.

Branch and Yang establish three propositions to structure the research in their paper. Firstly, they examine if a successful stock offer generates a higher return for the arbitrageur, compared to successful cash and collar offers. Secondly, the authors investigate whether an investment in a target with a cash offer has a higher beta than other offers. The final proposition is set up to examine whether the return from investing in a cash offer has a more nonlinear relation to the market return than an investment in targets with other payment types.

They find a significant monthly alpha for the pure cash, stock and collar portfolio of 150, 140 and 200 basis points respectively. When combining the three different deal types into an aggregate portfolio, they find a significant monthly alpha of 170 basis points (approximately 22% annualized). By examining the returns generated from investing in successful stock offers compared to those generated by successful stock and collar offers, Branch and Yang find that successful stock offers provide significantly higher returns than cash offers. Branch and Yang work with the hypothesis that information asymmetry is the differentiating factor between the returns which an arbitrageur can achieve by investing in cash and stock offers. When launching a takeover bid, the managers of the acquiring firm are more likely to have a better understanding of the true value of the acquiring firm's equity than the market does. Therefore, when the managers of the acquiring firm decide to launch a takeover bid of the target firm, Branch and Yang hypothesize that it is more likely that the bid offer will include stock, in those cases where management believes the stock to be overvalued. Conversely, when management launches a cash offer, it may be evidence that management believes the equity of their firm is undervalued.

To test their second proposition, that cash offers have a higher beta than stock offers, Branch and Yang examine regressions of the historical returns from portfolios of each deal type on the market index. Branch and Yang find clear evidence that the changing market betas differ significantly depending on the deal type. Betas for cash offers are found to be slightly positive, while betas for stock offers are in general negative. More specifically, the betas for the different deal types are 0.121, -0.221 and -0.568 for cash, stock and collar offers respectively. The negative beta associated with an investment in a stock deal is the result of the hedged long position in the target and the short position in the acquirer.

Consistent with Mitchel and Pulvino, Branch and Yang also identify a nonlinear relationship for the returns generated by merger arbitrage. Furthermore, they note that the different deal types behave differently during down markets. Based on their findings, they argue that betas reveal a nonlinear relationship between market returns and the returns from merger arbitrage. Branch and Yang do not find any evidence which supports their proposition, namely that stock offers reduces the nonlinearity compared to cash offers.

3.2 Previous Research - Outside US

3.2.1 Maheswaran and Yeoh 2005 - *"The Profitability of Merger Arbitrage: Australian Evidence"*

Maheswaran and Yeoh 2005 [6] investigated the Australian merger markets by using a sample constructed from 193 cash mergers and acquisitions during the period 1991 to 2000. The reason for not including stock offers within their sample is due to the fact that there are merely 16 stock deals reported during the entire time period. They constructed both an equally weighted and a value weighted portfolio, consistent with

Baker and Savasoglu 2002 [3].

Maheswaran and Yeoh regressed their returns against the two linear models, CAPM and the Fama-French 3 factor model. They found that merger arbitrage as a strategy yields significant monthly risk-adjusted excess returns of approximately 0.84% to 1.20%, before accounting for transaction costs. However, after accounting for transaction costs, they could not conclude that the risk-adjusted excess returns were significant. Maheswaran and Yeoh also contradict previous studies on US markets, such as Mitchell and Pulvino 2001 [2], by concluding that merger arbitrage in the Australian equity markets is a market-neutral investment, and that the returns have a linear distribution.

3.2.2 Nguyen and Sudarsanam 2009 - *"UK Evidence on the Profitability and the Risk-Return Characteristics of Merger Arbitrage"*

Nguyen and Sudarsanam 2009 [7] examine the merger arbitrage strategy on the British stock market. Their sample contains a total of 1,105 mergers which took place between 1987 and 2007. The researchers find that applying a merger arbitrage strategy in the UK has produced large annual returns between 13.23% and 18%, with risk-adjusted returns between 5.52% and 11.35% when applying similar factor models and portfolio construction approaches as previous researchers. Like Mitchell and Pulvino 2001 [2], Nguyen and Sudarsanam examine if a nonlinear relationship exists between merger arbitrage and the market return in the UK market. The researchers find that such a relationship does exist, but only during the most severest of market declines. They decide upon a threshold of -11.9% for distinguishing between up and down markets. By using this threshold, they find that the down market beta significantly exceeds that of the up market beta for their portfolio constructions. There is, however, only a single monthly observation falling below this threshold, caused by the market crash in October 1987. The authors suggest that the reason why the nonlinear relationship exists for only the largest down markets is due to the fact that legislation in the UK severely restricts an acquirer who wishes to abandon a merger due to a negative market return. Merger processes are therefore more robust against severe market declines than in the US, where an acquirer may cite adverse market conditions as a condition for abandoning a merger.

3.3 Summary

Literature Overview					
Paper	**Market**	**Sample period**	**Sample size**	**Deal type**	**AGG**
Mitchell and Pulvino, 2001	US	1963-1998	4,750	Cash and Stock	7.4%
Baker and Savasoglu, 2002	US	1981-1996	1,901	Cash and Stock	7-10%
Branch and Yang, 2006	US	1994-2003	1,309	Cash, Stock and Collar	22%
Maheswaran and Yeoh, 2005	AUS	1991-2000	193	Cash	10-14%
Nguyen and Sudarsanam, 2009	UK	1987-2007	1,105	Cash and Stock	6-11%

Table 3.1: Summary of the data and the historical returns found in the papers which were discussed previously. The column labeled AGG presents the annualized excess returns found by each paper in an aggregate portfolio of all stocks in their respective sample.

Probability of Outcomes

Both the papers Baker and Savasoglu 2002 [3] and Mitchell and Pulvino 2001 [2] contain an analysis of exactly which factors predict the outcome of a merger process. From an investor's perspective, mergers can be classified as either a success or failure. Mitchell and Pulvino examine how well various variables serve as predictors for the outcome of a takeover bid. They find significant evidence showing that mergers are more likely to fail during decreasing market returns. This finding is intuitive, as mergers inevitably look less attractive in a market which is declining in value.

Baker and Savasoglu 2002 [3] find evidence that the probability of success for a merger depends on the target firm's market value of equity. They find that the probability of success is decreasing in target size, which is in contrast to Mitchell and Pulvino who find that targets with a larger market cap are more likely to be acquired successfully. Both papers find that their results are significant at the 1% level.

Both papers also find significant evidence that when management is hostile towards a takeover bid, the probability of success decreases significantly. In terms of payment type, Mitchell and Pulvino find that cash offers are significantly more likely to succeed. Baker and Savasoglu also find an increased probability of success for cash offers. However, they do not find their results to be significant. Notably, Baker and Savasoglu do not find that acquirers who operate within the same industry as the firms they target are more likely to complete their mergers successfully.

Market Neutral Investment

Mitchell and Pulvino 2001 [2] along with Baker and Savasoglu 2002 [3] acknowledge that the returns from a merger arbitrage strategy have a linear relationship to market returns in flat and increasing markets. However, Mitchell and Pulvino find evidence of a nonlinear relationship when the market is decreasing beyond a certain threshold. In contrast, Maheswaran and Yeoh 2005 [6] find no evidence of nonlinearity in decreasing markets when investigating the Australian market. In fact, they find evidence that the nature of the merger arbitrage strategy is market neutral and independent of different market movements.

There are several critical reasons why differences exist among the various authors. First, there are fundamental differences between the markets which are investigated. This could potentially mean that the Australian and UK markets are not perfectly comparable to the US market. Second, Maheswaran and Yeoh exclude pure stock offers from their sample and are thus only left with cash offers. The differences in the deal types which are used, and the proportion of each deal type over the examination period, mean that the papers do not have approaches which are identical to one another. Third, the sample size used in the different research papers vary in magnitude. More specifically, Baker and Savasoglu use a sample of 1,901 transactions over a 15 year period, yielding on average 125 transactions a year, while Maheswaran and Yeoh only investigate an average of 21 transactions a year. This could potentially leave Maheswaran and Yeoh's portfolio empty at times, which could interfere with the results when analyzing the relationship to the market during a market decline.

Risk-adjusted Returns

All of the previously mentioned papers conclude unequivocally that merger arbitrage has produced significant positive risk-adjusted returns. The papers do however differ in their explanations of why these large returns are observed. For instance, Mitchell and Pulvino 2001 [2] conclude that transaction costs have a significant negative impact on the real-life returns which an arbitrageur can obtain, a conclusion which Baker and Savasoglu 2002 [3] rejects explicitly. Baker and Savasoglu, on the other hand, hypothesize that shareholders in target firms are likely to sell their shares upon the announcement of a takeover bid. The shareholders do this to avoid what Baker and Savasoglu describe as the gamble of earning either a small gain following a completion or a substantial loss after a termination. Since merger arbitrageurs only have access to a limited amount of capital, they require a premium to take the risk of a substantial loss, which thus explains the systematic underpricing of target shares.

All of the previous papers examine risk-adjusted returns with the use of the exact same risk factors, namely the market, HML and SMB (further explained in section 4.3.1.2). The models which are used are thus the CAPM and the Fama-French 3 factor model. By applying these models, the papers find that merger arbitrage has produced significant positive risk-adjusted returns. The reason why their risk-adjusted return estimates differ can be due to several reasons. As explained previously, the time period and sample size which is used vary considerably between the various papers. The different results can thus both be the result of noise or fundamental differences across time and markets.

4 Methodology

This chapter focuses on the methodology which forms the foundation for the research conducted in this thesis. The chapter first provides an overview of how the individual return series are derived and calculated for cash and stock deals. Second, how those individual returns are aggregated into various portfolios which can be used for further analysis. Finally, the chapter presents various models which are used in order to risk-adjust the returns. Combined, these methods are the foundation for the analysis conducted, which jointly allows the paper to answer the research question.

4.1 Individual Returns

An arbitrageur's involvement in a merger process begins with the launch of a takeover bid on a target firm and ends with the resolution of the ensuing bid process for that firm. As mentioned in section 2.1, a large jump in the stock price is usually observed on the announcement day of a takeover bid. To ensure that the initial price increase does not bias the return series upwards, this paper, consistent with Baker and Savasoglu 2002 [3], assumes that the investor enters the position at the closing of the trading day, two days following the initial announcement. Supposing that the deal process ends in failure, it is common to observe a large decrease in the share price of the target firm. To ensure that the significant decrease in the share price is properly captured, a position is assumed to be held until the market closes two days after the merger is terminated.

When multiple bids are initiated on the same target, this paper assumes that the merger arbitrageur takes a position in the target share on the day of the first bid and holds the position until all bids are resolved. An investor can thus earn a significant positive return on his position in the case that a rival bid is launched during the merger process at a higher bid price. In several instances, the target share can be seen to trade at a negative arbitrage spread, implying that the market expects a higher bid to be launched.

4.1.1 Cash Offers

When the offer is a pure cash offer, the takeover price is specified by the acquirer on the date of the takeover announcement, as explained in section 2.1. The original offer price may then be subjected to an amendment at a later date, which can either result in the bid price being raised or lowered. When a takeover bid is launched, and cash is offered, the strategy which a merger arbitrageur applies will consist of taking a long position in the target share on the announcement day. If the merger is resolved successfully, the shares are then exchanged for cash on the completion date. If the merger fails, the position is closed following the termination of the takeover process.

Previous studies, such as Mitchell-Pulvino 2001 [2] and Baker and Savasoglu 2002 [3], state that the returns which an investor earns from a long position in a target stock are derived from two sources. The first source is the change in price on target stock i over the holding period. The second source is the payment of any dividends which the holder of the asset receives over the holding period.

The formula, which captures the above-mentioned, looks as follows

$$r_t^i = \frac{P_t^i + D_t^i}{P_{t-1}^i} - 1 \tag{4.1}$$

where D_t^i refers to the dividend paid by the target stock. P_t^i corresponds to the closing price on day t. P_{t-1}^i refers to the closing price on stock i on trading day *t-1*.

Equation 4.1 calculates the discrete return over a given holding period. The equation captures both sources of returns defined above. However, it fails to capture the effect of for example stock splits, which will influence the price but not the actual returns to an investor. In order to capture these effects, this paper deviates from the papers reviewed in section 3, and attempts to improve equation 4.1 by applying adjusted prices.

The adjusted prices which are used in this thesis are based on the actual closing price as recorded by CRSP (CRSP code: prc) and a cumulative factor to adjust prices (CRSP code: cfacpr). The adjusted prices are derived by dividing the actual price (prc) with the cumulative adjustment factor (cfacpr). Daily returns are then calculated for each position by utilizing these adjusted prices. Following this method, P_t^{Ai} denotes the adjusted price of share i at time t. Finally, the formula for calculating the return becomes

$$r_t^i = \frac{P_t^{Ai}}{P_{t-1}^{Ai}} - 1 \tag{4.2}$$

The adjusted price takes into account both dividends and other factors which affect the return to the holder of the share. However, the final distribution to target shareholders on the day of completion of the merger is not recorded in the CRSP closing prices. CRSP provides separate data for the final distribution (CRSP Code: dlret) which is utilized to calculate the last part of the investor's holding period return.

4.1.2 Stock Offers

When a stock offer is announced, the process for creating a position is more complex from a merger arbitrageur's point of view than with a cash offer. The position which is formed is a hedged position consisting of a long position in the target firm and a short position in the acquiring firm. The number of the acquiring firm's shares which is shorted for each target share bought is given by Δ (the hedge ratio). The hedge ratio corresponds to the conversion ratio which is offered by the acquiring firm. For instance, if a firm offers 2 of its own shares for each of the target firm's shares, then $\Delta = 2$, and the position consists of being long one target share and short two acquirer shares.

The returns derived from this position come firstly from the price changes on the individual shares which are held in the position, and secondly from the dividends which are either received on the long position or paid on the short position. Finally, besides earning the return on the shares involved in the transaction, an investor is also assumed to earn the risk-free rate on his short positions.

Consistent with Mitchell and Pulvino 2001 [2], the formula which captures the elements mentioned above is stated as

$$r_t^{ia} = \frac{(P_t^i + D_t^i - P_{t-1}^i) - \Delta(P_t^a + D_t^a - P_{t-1}^a - r_f P_{t-1}^a)}{PositionValue_{t-1}} \tag{4.3}$$

where r_t^{ia} is the overall portfolio return for shorting acquiring stock a and longing the target stock i at time t. The first term in the numerator is equivalent to the description in section 4.1.1. Δ is the hedge ratio which is equal to the initial exchange ratio between the shares of the target and acquiring firms. P_t^i, P_{t-1}^i and D_t^i refer to the prices and dividend of the target firm at time t and *t-1*. Similarly, P_t^a, P_{t-1}^a and D_t^a refer to the price and dividend of the acquiring firm at time t and *t-1*. The denominator, *PositionValue*, refers to the combined investment in both the target and the acquirer which is equal to the price of one target share and Δ acquirer shares.

In financial theory, one of the implications of perfect capital markets is that the arbitrageur is able to short the acquirer's stock and invest the proceeds in the target share without any constraints. However, in reality, this assumption does not hold. Short positions must be covered by the use of a closed margin account. More specifically, the proceeds received from the short position are placed into a closed account, earning an interest rate below the risk-free rate. The reason for why the interest rate which is offered is lower than the risk-free rate is to provide the current holder of the share with an incentive to lend out the shares. Consistent with Baker and Savasoglu 2002 [3], this paper will assume that the arbitrageur does not have access to the short proceeds, and the paper thus approximates the interest rate which is earned to zero percent, which results in

$$r_t^{ia} = \frac{(P_t^{iA} - P_{t-1}^{iA}) - \Delta(P_t^{aA} - P_{t-1}^{aA})}{PositionValue_{t-1}} \tag{4.4}$$

The methodology presented in Mitchell and Pulvino 2001 [2] only captures the impact of price changes and dividends. To calculate the actual returns an investor earns when holding the long and short positions, this paper applies adjusted prices. This paper, therefore, adopts the method from Baker and Savasoglu 2002 [3], which is based on returns rather than prices. By utilizing adjusted prices and assuming that investors do not earn any interest on their short proceeds, the return during time t on position i thus becomes

$$r_t^i = r_T \ - r_A \ \frac{P_{t-1}^{iA}}{P_{t-1}^{iT}} \ \Delta \tag{4.5}$$

Where r_t^i denotes the return of stock i in time t. r_T is the return for the target share. The r_A is the return on the acquiring firm's share. Δ is the hedge ratio between the target and acquirer's shares. P_{t-1}^{iA} and P_{t-1}^{iT} is the price for the acquirer and target share in time *t-1* respectively.

4.2 Portfolio Returns

In order to assess the viability of merger arbitrage as an investment strategy, the returns from each individual position are aggregated into portfolio returns. These portfolio returns can then be used to gain additional insight into the historical performance of a merger arbitrage strategy which is broadly invested in many different shares. This thesis considers both an equally weighted and a value weighted portfolio. For both portfolios, the assumption is made that investors operate in perfect capital markets, implying that they do not face any transaction costs or any other obstacles when it comes to purchasing or selling shares.

4.2.1 Equally Weighted Returns

The first approach for aggregating returns into a portfolio is to weight all the assets equally by taking the arithmetic average of all returns during each period. Applying this method, asset i is added to the portfolio after a takeover bid is launched. During each day, the portfolio is then rebalanced whenever a new takeover bid is launched, or an existing bid is resolved. The portfolio weight of each asset is, therefore, $\frac{1}{N}$, and the portfolio return is given as

$$r_P = \frac{1}{N} \sum_{i=1}^{N} r_i \tag{4.6}$$

where N denotes the total number of assets in the portfolio, and r_i is the return on asset i. The return for the portfolio in a given period is, therefore, the arithmetic average return of all assets in the portfolio.

4.2.2 Value Weighted Returns

A more complex approach involves taking the market weighted average of each individual return. By doing this, each asset is weighted according to its relative market capitalization. In this case, the target firm's equity value is denoted V_i, and the weighted return is given as

$$r_P = \frac{\sum_{i=1}^{N} V_i r_i}{\sum_{i=1}^{N} V_i} \tag{4.7}$$

This portfolio is analogous to the common method for calculating stock market index values, where each asset is weighted based on its market capitalization. A portfolio based on market weights, therefore, results in a portfolio return where illiquid assets have a smaller impact on the overall return.

To ensure that the results which are found are not exclusively valid for the equally weighted and value weighted approaches, a final portfolio construction with a 10% cap is also applied. In this portfolio, all assets are value weighted but with a constraint that no asset may make up more than 10% of the total weight. When an asset takes up more than 10% of the total weight in the value weighted portfolio, it is therefore automatically set at 10%, and an iterative process is conducted, where the remaining asset weights are adjusted so that the sum of the weights is always 100%. These iterations continue, until no single asset holds a weight of more than 10%.

4.3 Factor Models

In order to investigate how the portfolio returns of the merger arbitrage strategy relates to the market and other factors, it is necessary to introduce different regression models. This section will present how the paper deals with regressing the portfolio returns against numerous factors. The objective of applying these regression models is to determine if a linear relationship exists between the returns generated by merger arbitrage and various risk factors proxied by, for instance, the market return. Later, the paper evaluates if the returns have a nonlinear relationship to the market. More specifically, the paper will apply single and multiple linear regression models (CAPM and Fama-French 3 factor model), along with a nonlinear model (piecewise linear model).

4.3.1 Linear Regression Modelling

In order to predict the value of a dependent variable, regression models are frequently used. Denoting the dependent variable y and the predictors x_i where $i = 1, ..., N$. Independent of whether $i = 1$ or $i = N$, the relationship between the dependent variable y and the predictors x_i are of linear nature, which means that every additional unit of input has a proportional impact on the output.

The linear regression model is quantified as

$$y_i = \alpha + \beta x_i + \epsilon_i \tag{4.8}$$

The linear regression can be considered as a set of two blocks. Namely, the structural part: $\alpha + \beta_i x_i$, where $i = 1, ..., N$ and the error part: ϵ_i. The structural part contains information about the structure of the model since it includes the predictors, while the error part contains information regarding the response variable which cannot be explained by the model.

In order to obtain the most accurate predictors for the regression model, the least squares method is applied. More specifically, the parameters are estimated by minimizing the sum of squared errors (SSE) for the sample regression

$$min \sum_{i=1}^{N} \epsilon_i^2 \tag{4.9}$$

4.3.1.1 Capital Asset Pricing Model (CAPM)

The CAPM is widely applied in research and practice. It was originally developed in the early 1960s by William Sharpe [8], amongst others. The model is based on the rather simple assumption that many of the risks associated with holding a single asset can be diversified away by holding a diversified portfolio of assets. More specifically, the risks which affect an asset can be divided into systematic (market risk) and idiosyncratic (firm specific) components. Within the CAPM framework, the only risk which must be accounted for is the systematic risk, since the idiosyncratic risks are assumed to be diversified away by investors. In other words, in a world where the CAPM holds, there is only a single source of systematic non-diversifiable risk. One of the assumptions implied by the model is that market participants are best served by holding a diversified portfolio of all possible assets, with each asset weighted by their respective market value.

By holding a combination of this market portfolio and the risk-free asset, investors can do strictly better than by holding any other possible portfolio.

The CAPM is a linear function and looks as follows

$$r_i = r_f + \beta_i(r_m - r_f) \tag{4.10}$$

when regressing the excess returns of the asset against the market, the regression model is given as

$$(r_i - r_f) = \alpha_i + \beta_{iMKT}(r_m - r_f) + \epsilon_i \tag{4.11}$$

where β_{iMKT} measures the exposure to systematic risk. α_i denotes the abnormal return of asset i over the return which the CAPM, given by equation 4.10, would predict. Furthermore, r_f denotes the risk-free rate which is the rate an investor can earn on a risk-free investment, which is further elaborated upon in the section below, while r_m denotes the return on the market portfolio. The market return is calculated and applied as explained in section 5. Since the beta coefficient tracks the movement of an asset with respect to the market, the β_{iMKT} related to the individual asset has a value equal to one if the asset has the same movements as the market.

Risk-free Rate

The risk-free asset is defined as an asset not bearing any risk and having a fixed payoff no matter the market conditions. Therefore, the risk-free asset has a market beta of zero by definition. Since this paper is investigating the performance of a strategy based on US data, the most appropriate choice is to use the US risk-free rate denominated in US dollars. A security which tends to be considered risk-free is the US government bond. As defined by Pietro Veronesi

"The US Government, as with most governments, needs to borrow money from investors to finance its expense,....,. The US Treasury is extremely unlikely to default on its obligations" – Pietro Veronesi, Fixed Income Securities, 2010, p.29 [9]"

More specifically, the US government has the capability to create money, if ever in financial distress. Combined with the ability to raise and collect taxes, it is therefore reasonable to assume that the bonds issued by the US government are risk-free. For the purposes of this paper, the risk-free rate is, therefore, defined as the rate offered by US government bonds.

Market Return

In the CAPM setting, the market portfolio is defined as a value weighted portfolio of all possible assets which an investor can hold within that specific market. Furthermore, all assets are assumed to be infinitely divisible and perfectly available without any transaction costs nor liquidity constraints. For instance, an investor with $100 available would be able to invest in all assets in the market proportional to their relative weights and thus hold the market portfolio.

In real life, however, it is not possible for any market participant to hold such a portfolio. A common convention is, therefore, to use a proxy for the market portfolio. Consistent with previous research papers presented in section 3, this paper use a large cap stock index as a proxy. Further elaborations regarding the proxy will be further discussed in chapter 5.

4.3.1.2 Fama-French 3 Factor Model

Following the original development of the CAPM model, researchers, such as Fama and French, found the model inadequate for properly explaining the empirical returns observed in the market. This shortcoming of the CAPM inspired Fama and French to develop their widely cited multi-factor model. In their paper from 1993 [10], Fama and French claim that their 3-factor model provides a more accurate estimate of asset returns. The Fama-French model is a multiple linear regression model which includes two factors in addition to the factor of the market return. Namely, small-minus-big (SMB) and high-minus-low (HML).

The Fama-French multiple regression model is stated as follows

$$(r_i - r_f) = \alpha_i + \beta_{iMKT}(r_m - r_f) + \beta_{iSMB}SMB + \beta_{iHML}HML + \epsilon_i \tag{4.12}$$

Where α_i denotes the abnormal return of asset i when taking into account its exposure to the three risk factors. The three individual betas measure asset i's exposure to each of the three risk factors. If the α_i is significantly different from zero, it indicates that the three factors alone are not sufficient for explaining the returns of the asset.

Small-Minus-Big (SMB)

The SMB factor, also commonly referred to as the size factor, measures an asset's exposure to a portfolio constructed from a long position in small cap stocks and a short position in large cap stocks. Historically, Fama and French find that small firms have had higher returns. The researchers argue that the higher returns produced by small firms are a result of those firms having more volatile earnings than larger firms. Due to this finding, Fama and French motivate the inclusion of the SMB factor in the regression model and argue that investors demand a risk premium for being exposed to this risk.

High-Minus-Low (HML)

The HML factor measures exposure to a portfolio which is composed of a long position in high book-to-market (value) stocks and a short position in low book-to-market (growth) stocks. The HML factor is therefore also commonly referred to as Value-Minus-Growth.

Historically, value stocks have outperformed growth stocks, and assets with a larger exposure to the HML factor should, therefore, have higher expected returns.

Other factors

Following Fama and French's original paper which introduced two additional factors to the linear CAPM, other risk factors have been introduced by a number of different researchers. For instance, Harvey et al. 2004 [11] examined a number of top journals within financial economics in their paper. They identified 316 different risk factors which have been used to explain excess returns when applying linear regression models.

Carhart 1997 [12] applies the original Fama-French 3 factor model and expands it with the inclusion of a UMD factor. The UMD factor (Up-Minus-Down) can be seen as a momentum factor. The UMD is constructed as a portfolio composed of a long position in those stocks which have had the highest returns for the past 12 months, and a short position in those stocks which have had the lowest return for the past 12 months.

Furthermore, Fama and French have extended their own 3-factor model with two factors, resulting in the Fama-French 5 factor model. The two added factors are: RMW(robust minus weak) and CMA(conservative minus aggressive).

Given the large number of factors which have been identified in previous research, one could potentially include a large number of factors in the regression analysis. This paper limits itself to only consider the market return and the SMB and HML factors, consistent with the choice of earlier researchers within the field.

4.3.2 Nonlinear Regression Modeling

Whenever the distribution is of nonlinear nature, linear regression modeling (section 4.3.1) will not be sufficient to explain the dependent variable. There are various models that are of nonlinear nature. This thesis will introduce and apply logistic regression modeling as well as piecewise linear modeling.

4.3.2.1 Logistic Regression Model

Whenever the response variable is of categorical nature, linear regression modeling will not be able to predict values accurately. If the dependent variable only takes two possible values (1 or 0), the dependent variable is labeled a binary response variable. As explained in section 4.3.1, the linear models are estimated through the least squares method. When applying the logistic regression model the maximum likelihood estimation (MLE) is used, i.e., the coefficients are estimated with the values that provide the sample with the maximum probability of occurring.

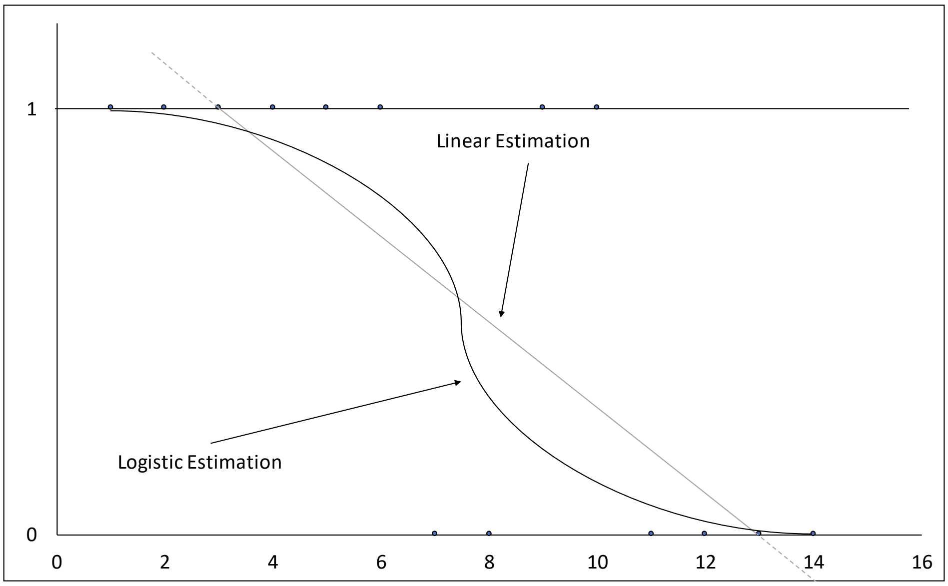


Figure 4.1: Displays the advantage the logistic regression model has over the linear regression model. The figure displays the output variable on the y-axis (ranging from 0 to 1) and the input variable on the x-axis. If the input variable is below 3 or higher than 13 the output variable will take a value which is higher than 1 or lower than 0 respectively. The linear regression model breaks down due to this.

The logistic regression model is defined by the logistic form

$$\pi = P(y_i = 1) = \frac{e^{\beta_0+\beta_1 x_1+\ldots+\beta_p x_p}}{1 + e^{\beta_0+\beta_1 x_1+\ldots+\beta_p x_p}} \tag{4.13}$$

which is the equivalent of the logit form

$$\log\left[\frac{\pi}{1-\pi}\right] = \log\left[\frac{P(y_i = 1)}{1 - P(y_i = 1)}\right] = \beta_0 + \beta_1 x_1 + ... + \beta_p x_p \tag{4.14}$$

which means that the logarithm of the ratio between the probability that the event will occur and that the event does not occur is modeled as a linear function of the p coefficients. The ratio $\left[\frac{\pi}{1-\pi}\right]$ is the ratio between the occurrence probability π to the non-occurrence probability $(1-\pi)$.

4.3.2.2 Piecewise Linear Model

The piecewise linear model can be seen as two linear regression models, which are combined with two different straight lines, with different slopes changing at a threshold x^*. More specifically, if the relationship of the dependent variable y_i and covariate x_i is of linear nature, but is changing depending on a threshold x^*, then the relationship can be explained by

$$y_i = \alpha_1(1-\delta) + \beta_1 x_i(1-\delta) + \alpha_2\delta + \beta_2\delta x_i + \epsilon_i \tag{4.15}$$

Where the δ_i is a dummy variable, taking the value of 1 whenever $x_i > x^*$ and 0 if $x_i < x^*$. The regression model is estimated following the least squares method. However, the model requires x^* to be known. In order to determine the level of x^*. x^* takes on the value which minimizes the SSE.

Previous research papers, such as Mitchell and Pulvino 2001 [2], have speculated that the abnormal positive returns associated with event-driven investment strategies such as merger arbitrage can be the result of the nonlinear distribution of the strategy's returns. Furthermore, if the correlation between the returns of the market and the merger arbitrage strategy differ depending on the state of the market, the relationship between the two is nonlinear. Mitchell and Pulvino find evidence that the investment strategy has a return distribution which closely mimics that of a portfolio consisting of a short put option combined with a long position in a risk-free asset. In order to test for the nonlinearity of this portfolio, they apply the piecewise linear model.

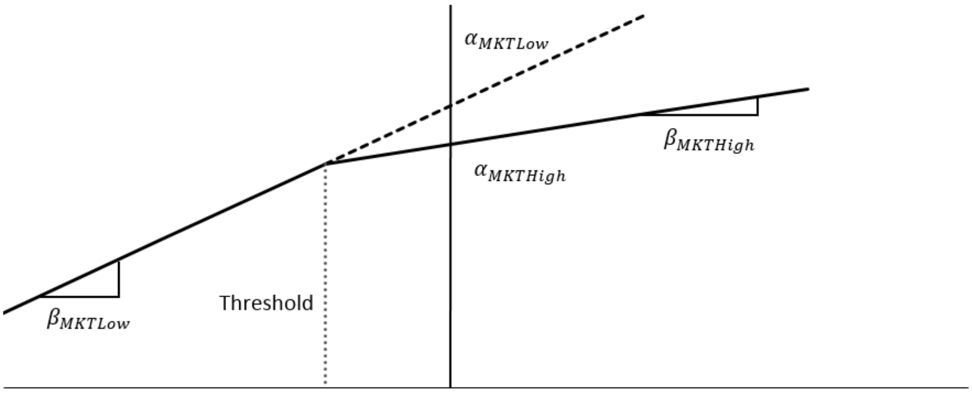


Figure 4.2: Displays the return distribution of the merger arbitrage portfolio and the market which is similar to the payoff on a portfolio with a long position in the risk-free asset, and a short position in a put option using the proxy for the market as the underlying asset. The strike price of the put option is defined as a threshold estimated by applying the piecewise linear model and minimizing the sum of squared errors.

The piecewise linear model is quantified as

$$(r_P - r_f) = (1-\delta)\Big[\alpha_{MktLow} + \beta_{MKTLow}(r_m - r_f)\Big] + \delta\Big[\alpha_{MKTHigh} + \beta_{MKTHigh}(r_m - r_f)\Big] \tag{4.16}$$

where δ is a dummy variable which is equal to 1 when the excess return of the market is higher than the defined threshold level and 0 otherwise. This means that the model contains two different alphas and betas as well as the threshold level. All the parameters may be estimated by minimizing the sum of squared residuals for the entire model.

The threshold is calculated by imposing the following condition to ensure that the model is continuous

$$\alpha_{MktLow} + \beta_{MktLow}(Threshold) = \alpha_{MktHigh} + \beta_{MktHigh}(Threshold) \tag{4.17}$$

If a linear relationship exists between the portfolio returns and the market returns, the alpha and the beta estimated in a low and a high market (equation 4.16) should be equivalent. If the return characteristics of the merger arbitrage portfolio differ depending on the return of the market, the alpha and beta should vary depending on the market return. As a consequence, the beta should be higher when the market return is below the threshold defined in equation 4.17, if the correlation between the returns of the portfolio and the market increases in a declining market.

4.3.2.3 Contingent Claim Model

Glosten and Jagannathan 1994 [13] argue in their paper that investment strategies which are of a nonlinear nature are best served by being evaluated with a contingent claim approach. More specifically, the idea is to establish a replicating portfolio which has the same payoff characteristics as the merger arbitrage strategy and then calculate the present value of the replicating portfolio. Financial theory states that whenever two assets yield the same payoffs, their present values must also be the same; otherwise an arbitrage opportunity exists.

As mentioned in section 2.1, previous research has found that the merger arbitrage strategy has a similar payoff profile as a portfolio consisting of a short put position, with the market index as the underlying asset, combined with a long position in a risk-free asset. The put option has a strike price equal to $\$100(1 + r_f + Threshold)$. The number of put options that must be shorted is equal to the market beta in a depreciating market (β_{MktLow}). The face value of the risk-free asset is equal to $\$100(1 + r_f + \alpha_{MktHigh} + \beta_{MKThigh} \cdot Threshold)$.

The relationship between the two strategies is

$$V_0^{MA} = V_0^{RP}$$

Where V_0^{MA} is the value of the merger arbitrage strategy at $t = 0$, and V_0^{RP} corresponds to the value of the replicating portfolio at $t = 0$. Whenever $V_0^{MA} < V_0^{RP}$ the merger arbitrage strategy generates excess returns.

The payoff of the replicating portfolio at time t is quantified as

$$\begin{aligned} V_T^{RP} &= B_T - [(K - S_T), 0]^+ \\ &= B_T - [K - S_T]\mathbf{I}_{\{K \geqslant S_T\}} \end{aligned} \tag{4.18}$$

Where B_T is the face value of the risk-free asset. $[K - S_T, 0]^+$ refers to the payoff of the put option with strike price K and underlying price level S_T, taking the highest positive value of $[K - S_T]$ and 0. $\mathbf{I}_{\{K \geqslant S_T\}}$ is an indicator function which is equal to 1 whenever the condition $K \geqslant S_T$ is fulfilled.

In order to evaluate V_t^{RP}, a probability distribution function is required, i.e., to determine the probability that the price of the underlying asset becomes larger or smaller than the strike price K at maturity. Black, Scholes and Merton derived and developed a partial differential equation, which when solved with the assumption that volatility is constant, yields the famous Black-Scholes-Merton model. This paper will not derive the rationale behind the equation, but just briefly state the findings which are relevant for the analysis in chapter 6.

The probability of the state of the underlying given various assumptions is given by

$$\begin{aligned} \mathbf{E}[S_T\mathbf{I}_{\{K \geqslant S_T\}}] &= S_T\Phi(-d_1) \text{ relative payoff} \\ K\mathbf{E}[\mathbf{I}_{\{K \geqslant S_T\}}] &= K\Phi(-d_2) \text{ absolute payoff} \end{aligned}$$

where

$$d_{1,2} = \frac{ln\left(\dfrac{S_0}{K}\right) + \left(r_f \pm \dfrac{\sigma^2}{2}\right)(T - t)}{\sigma\sqrt{T - t}} \tag{4.19}$$

$\Phi(x)$ is the cumulative distribution function with distribution $N(0,1)$. S_0 is the underlying price at $t=0$, K is the strike price. r_f is the risk-free rate, σ^2 is the variance of the underlying and $T-t$ is the time to maturity of the option contract. When applying this, the present value of the replicating portfolio is quantified as

$$V_0^{RP} = e^{-r_f(T-t)}B_T - e^{-r_f(T-t)}K\Phi(-d_2) + S_0\Phi(-d_1) \tag{4.20}$$

The Black-Scholes-Merton option pricing model relies on numerous assumptions regarding the market in general and the underlying security. First, Black, Scholes, and Merton assume that the underlying asset evolves dynamically according to a continuous time stochastic process, and thus the underlying asset returns follow a log-normal distribution. Second, they assume that the notion of perfect capital markets holds. More specifically, the market is driven by a single source of randomness, such that the uncertainty is perfectly correlated with the underlying asset, and thus a replicating portfolio can be constructed by combining the underlying asset with a fraction of a plain vanilla call option, such that the portfolio becomes risk-free. Third, they assume that the market has no liquidity constraints and that no trading will have any impact on the price of the underlying asset. Finally, they assume that no investment constraints exist, such that any amount and fraction of the underlying asset can be traded (Tebaldi, 2018, [14]). One major setback of the BSM model is that it is derived from the BSM partial differential equation (PDE) with the assumption that the underlying volatility measure is a constant. However, when relaxing the assumption that volatility is constant, and instead assuming that it is a stochastic process, the BSM PDE must be solved differently, and thus the BSM model fails to price the option securities fairly.

A model which expands on the BSM model is the Heston model (Tebaldi, 2018, [14]) which replaces the constant volatility with a stochastic process that drives the evolution of the volatility throughout the option's life. I.e., there are two interpolated processes, the underlying price level and the underlying volatility. When relaxing the assumption that the market is complete (i.e., the underlying volatility is not perfectly correlated with the underlying price), there are two independent sources of risk, which means that in order to create a perfect replication argument, an additional traded asset is necessary.

Even though there are major drawbacks of the BSM model, it is widely used due to its convenience and simplicity. This paper, along with Mitchell and Pulvino 2001 [2], therefore applies this formula when evaluating the risk-adjusted returns in a nonlinear setting.

4.3.3 Performance and Risk Measures

This section presents various measurements which are required for estimating the historical performance of a trading strategy. By using these measures, it is possible to compare the performance of the strategy with both the performance of the market and the findings of previous researchers.

The first measurement is used to evaluate the historical excess return level. The average return can be calculated as the arithmetic mean as follows

$$E[r_p - r_f] = \frac{1}{T}\sum_{i=1}^{T}(r_{pi} - r_f) \tag{4.21}$$

To calculate the return which is earned over the entire investment horizon, the holding period return (HPR) is presented in the analysis. HPR for asset i is calculated as

$$HPR_i = \frac{P_{iT} - P_{it}}{P_{it}} \tag{4.22}$$

where P_{it} denotes the asset value at beginning of the investment period for asset i, and P_{iT} is the final asset value.

Next, the standard deviation is calculated in equation 4.24 as the square root of the variance calculated in equation 4.23 to provide insight into the riskiness of the strategy

$$Var[r_p - r_f] = \sum_{i=1}^{T}(r_{pi} - r_f - E[r_p - r_f])^2 \tag{4.23}$$

$$\sigma[r_p - r_f] = \sqrt{Var[r_p - r_f]} \tag{4.24}$$

In order to calculate the maximum losses suffered by an investor over the investment horizon, the drawdown (DD) is calculated as

$$DD_t = \frac{P_t^{Max} - P_t}{P_t^{Max}} \tag{4.25}$$

where P_t^{Max} denotes the maximum historical asset value at time t, while P_t is the current asset value.

Sharpe Ratio

The Sharpe ratio is named after William Sharpe who established it in 1966 [15]. Where the expected return only measures the potential rewards an investor can earn, the Sharpe ratio also takes into account the riskiness of those rewards. The Sharpe ratio is given as

$$SR = \frac{E[r_p - r_f]}{\sigma[r_p - r_f]} \tag{4.26}$$

In all of the papers which were reviewed in section 3, the Sharpe ratio is calculated and used to evaluate the performance of a merger arbitrage strategy. The Sharpe ratio will, therefore, be used to evaluate the performance of the strategy and the market in this paper. It will also be used to relate the performance of the strategy in this paper to the findings in other papers.

The Sharpe ratio analyses the risk-adjusted returns, and quantifies how much value can be created when taking on additional risk. However, the Sharpe ratio is derived from the Markowitz mean-variance portfolio theory, and it only measures one dimension of risk, the variance. It is therefore designed to be applied on strategies that carry a normal distribution of expected returns. As observed by Mitchell and Pulvino 2001 [2], the distribution profile of the merger arbitrage strategy has the characteristics of an asymmetric distribution, which violates the assumptions necessary for the Sharpe ratio to be applied properly. Another set back of the Sharpe ratio is related to the time period of the returns evaluated. The reason is due to the fact that longer time periods tend to result in lower portfolio volatility, and therefore will bias the measurement. However, this paper motivates the inclusion of the Sharpe ratio in order to compare merger arbitrage returns to previous studies.

5 Data

This section is divided into four parts. Firstly, the paper will lead the reader through how the sample of firms, which are included in the analysis, has been created. Secondly, the paper presents how the asset return data, along with the market data, has been collected. Thirdly, this section will display and discuss limitations and the quality of the data which has been used. Finally, the paper presents an overview of the data and a description of how it has developed over time.

5.1 Sample Collection and Construction

The first step when constructing the sample is to consider the entire universe of M&A deals registered in the Bloomberg database within the United States. By applying various exclusion criteria, which are to be defined later in this section, the paper arrives at the finalized sample.

5.1.1 Population

Bloomberg's M&A (MA-screener) database was utilized to construct the sample of deals which will be the basis for the analysis in chapter 6. The first step when gathering the data is to consider the entire universe of available transactions in the US. The objective of this paper is to analyze with respect to the US market. Without applying any other filters, the entire universe of US merger transactions provides this paper the starting point. The population is displayed in table 5.1.

Population	
Bloomberg MA-screener	**Number of Transactions**
Cash	71,214
Stock	12,683
Others	83,147
Total	**167,044**

Table 5.1: Displays the total population of both public and private mergers prior to applying any exclusion criteria. Breaking down the population between different deal types.

5.1.2 Exclusion Criteria

In order to decide upon which merger activities should or should not be included in the finalized sample for the analysis, exclusion criteria are defined in this section. Five different criteria are established and further explained and elaborated on below.

1 Non-publicly traded

Bloomberg's M&A database is not designed specifically to track only public mergers and takeover bids which can be used in a merger arbitrage strategy. The vast majority of deals which are available from Bloomberg consists of transactions where the target firm is a private company. For the transactions, the target share is required to be publicly traded, due to several reasons. First, the arbitrageur needs the assets to be liquid, in order to have the possibility to take a long position and sell (in the state of termination), without facing any liquidity constraints. Second, the size of the target firms needs to have a certain magnitude, such that block-trades would not be affecting the returns themselves. Third, investors must be aware of the takeover event. In particular, a bid on a listed firm must be disclosed to the general public, while a bid on a private company can be negotiated and finalized in discretion. The implication of this is that a merger may be completed before an arbitrageur gains knowledge regarding the takeover attempt. Moreover, the lack of information regarding privately held firms would make backtesting the strategy somewhat cumbersome. Therefore, the first step is to exclude all of those transactions where the target firm is not a publicly listed company. Furthermore, in pure stock deals, due to the required short position in the acquiring firm, an additional assumption that the acquiring firm must be publicly traded is also applied.

2 Time horizon

When deciding upon the time interval, the first intuitive idea is to apply the notion of "the bigger the better". However, the sample should only consist of data related to a time horizon which adds value to the analysis. Upon inspecting the available sample from Bloomberg, it is clear that the data available after 1998 contains more observations compared to the data which is available prior to 1998. The total number of available data points before 1998 consists of 115 deals, while the number of deals in 1998 alone consists of 693, more than 6 times as much. The natural conclusion is therefore to exclude all merger activity which took place prior to 1998. Furthermore, the available CRSP database subscription means that the data is only updated on an annual basis, making all observation after 2017 impossible to extract. Therefore, the natural instinct is to set the end of 2017 as the end point of the sample.

3 Deal type

The payment which is offered to shareholders in target firms (as mentioned in section 2.1) may consist of either cash, stock in the acquiring firm or different combinations of cash, stock, debt and other components, so called hybrid deals. Due to their more complex and irregular nature, these hybrid deals are excluded from the sample. As a result, the only deals which are considered within the sample are of either pure cash or pure stock characteristics. Applying this criterion is in consistency with previous research methodologies brought up in section 3. To be more specific, Baker and Savasoglu 2002 [3], Mitchell and Pulvino 2001 [2], amongst others. All deals which are not of these two transaction characteristics are treated as hybrid deals and are, therefore, excluded from the sample.

4 Announcement interference with completion

In Bloomberg, several transactions are marked as being completed on the same day as they are announced. Since this implies that no return can be earned by a merger arbitrageur during the merger process, these deals are excluded from the sample.

5 Restricted data availability

In order to calculate the returns which an investor can earn, the price data must be available for the target firm for the period in which the deal process takes place. Since the position for a stock deal also requires that the investor takes a short position in the acquiring firm, it is likewise necessary that the price data is available for the acquiring firm in a stock deal. In those cases where the price data is not available in the CRSP database, the observations are excluded. The observations are extracted from the Bloomberg database, but prices are collected through CRSP. Therefore, those two databases need to be synchronized with each other. For each company in the sample, a delisting date is extracted from CRSP (CRSP code: dlstdte) which is compared to the reported completion date in Bloomberg, to ensure that the correct price data is extracted. In those cases where the two dates are not the same, the deals are deleted from the sample.

Exclusion Criterion	**Number of Transactions**
Population	167,044
1. Non-publicly traded	-156,043
2. Time Horizon	-343
3. Payment type	-3,049
4. Announcement interference with completion	-820
5. Restricted data availability	-2,327
Final Sample	**4,462**

Table 5.2: Displays the exact amount of deals which are removed from the population by applying each exclusion criterion defined below in order to arrive at the final sample.

5.1.3 Final Sample

By applying the exclusion criteria from section 5.1.2, this paper is left with a final sample which consists of N_{cash} = 3,407 for cash deals and N_{stock} = 1,055 for stock deals, yielding a total of N_{total} = 4,462 mergers which took place between January 1st 1998 and December 31st 2017. The sample contains 4,422 transactions which are announced and resolved, along with 40 which are still active as of December 31st 2017. A total breakdown is displayed further in table 5.3.

	Final Sample				
Year	Cash	Stock	Cash %	Stock %	**Total**
1998	182	186	41%	59%	368
1999	224	143	50%	50%	367
2000	262	143	53%	47%	405
2001	196	97	67%	33%	293
2002	142	44	76%	24%	186
2003	161	49	77%	23%	210
2004	135	47	74%	26%	182
2005	186	30	86%	14%	216
2006	237	36	87%	13%	273
2007	262	24	92%	8%	286
2008	158	24	87%	13%	182
2009	101	29	78%	22%	130
2010	180	25	88%	12%	205
2011	145	20	88%	12%	165
2012	155	14	92%	8%	169
2013	141	21	87%	13%	162
2014	111	35	76%	24%	146
2015	138	26	84%	16%	164
2016	161	28	85%	15%	189
2017	130	34	79%	21%	164
Total	**3,407**	**1,055**	**76%**	**24%**	**4,462**

Table 5.3: Displays a summary of the finalized sample for each individual year in the time period running from 1998-2017. The table also displays the relative weights with respect to the different deal types.

Data Extraction

First, as part of the information extracted from Bloomberg's MA database a CUSIP code is collected for each target and acquiring firm. This CUSIP code is then used in order to extract information from the CRSP database. For each individual stock, the following data points are extracted from CRSP: price (CRSP code: prc), adjusted prices (CRSP code: cfacpr), shares outstanding (CRSP code: shrout), the delisting date (CRSP code: dlpdt) and the delisting return (CRSP code: dlret). This data is extracted for all stocks from the day after announcement until two days after resolution. The data is collected for all target firms as well as for those acquiring firms which are engaged in a stock offer. Furthermore, in order to apply the value weighted approach, which requires a measure of each firm's market value of equity, the total number of shares outstanding is multiplied with the target firm's price on the day of announcement. The weight of each firm in the portfolio is therefore given by this market capitalization. Moreover, in order to calculate the return series for stocks deals, a conversion ratio is required. Therefore, the conversion ratio is extracted from the Bloomberg database.

5.2 Market Data

Risk-free Asset

To derive the excess returns of a trading strategy, it is first necessary to determine the risk-free rate. This paper examines return series over various estimation periods. Different tests are conducted on both weekly and monthly return series, and as such it is a requirement that different risk-free rates are applied depending on the time frame over which the return series are calculated. e.g., to determine an excess monthly return series, monthly risk-free rates are applied, and likewise for weekly data. The risk-free rates are derived from Kenneth R. French's publicly available database [16] for all relevant time periods. The risk-free rates are calculated based on US treasury bills.

Market Return

Although it can be argued that the proper market index should represent the entire possible investment universe for the relevant investor, a proxy is commonly used for for practical purposes. In this thesis, the CRSP value weighted market index is used as a proxy for the market return. This choice is also consistent with previous researchers, such as Baker and Savasoglu 2002 [3] and Mitchell and Pulvino 2001 [2]. The index therefore also serves to increase the comparability between this paper and the ones reviewed in chapter 3.1. The returns of the market index are extracted both for weekly and monthly returns for the purpose of conducting the research presented in the next chapter.

Fama-French Factors

To conduct a regression on the 3 Fama-French factors, it is necessary to extract return series for the HML and SMB factors which are described in section 4. These factors are collected through Kenneth R. French's publicly available database, which is likewise widely used within academic research, including the aforementioned papers. The factor returns are conveniently available for both weekly and monthly return periods. All of these are extracted in order to conduct the research in this thesis. French constructs the return series for the SMB factor as a portfolio composed of a long position in 3 different portfolios composed of small capitalization stocks and a short position in 3 portfolios of large capitalization stocks. The HML portfolio contains a long position in 2 different portfolios of value stocks and a short position in 2 portfolios of growth stocks [17].

5.3 Quality of Data

The validity of the research which is conducted in this thesis undoubtedly relies heavily on the quality of the databases which are utilized to conduct the analysis. Therefore, it is relevant to consider the accuracy of particularly two sources. Firstly, Bloomberg, from which information about all relevant mergers are obtained. Secondly, the CRSP database from which price data is extracted.

According to the Financial Times March 21st 2018 [18], Bloomberg was the world's largest financial data provider in 2017 with a market share of 33%. However, it should be noted that no study is found which validates or discredits the Bloomberg merger database on its own merits. However, Bloomberg's large market position and the depth with which it reports information on each individual merger event would indicate that the database is well constructed and reliable. Although no exact count is conducted, a large number of the merger events listed in the Bloomberg database contain a rich variety of documents from various news sources as well as original SEC merger documents. This thesis therefore assumes that the data is of adequate quality to conduct the analysis.

This paper uses return data from CRSP which is widely employed within academic research. For instance, CRSP is both used in all of the US based papers which are reviewed in section 3, as well as in Fama and French's original paper introducing the 3 Fama-French factor. According to a widely cited paper by Ince and Porter 2006 [19], CRSP is the most commonly used source for US equity data within academia. Another advantage of CRSP is that it provides delisting returns for companies as they are removed from public trading on the market. These delisting returns are naturally highly relevant for estimating the returns for merger arbitrage, as every completed deal is delisted. Using return data from an alternative source which does not consider this final equity return would therefore not provide an accurate reflection of the returns which a merger arbitrageur can potentially earn.

When conducting historical research, a key concern is always to what extent the chosen time period is sufficient to provide clear conclusions. The time horizon in this paper contains 20 years of data spanning 1998 to 2017. There are two natural concerns when selecting the time horizon. First, to what extent is the amount of data sufficient to draw conclusions from. The 20 years which are used in this paper represents a longer time period than most of the comparable papers reviewed in section 3, and the sample of more than 4,000 firms is larger than those used in previous research, except for the sample used by Mitchell and Pulvino 2001 [2]. The second concern is to consider to what degree the earliest data is still relevant for drawing conclusions. The capital markets and the behavior of market participants change as time passes. A potential bias in the research of the paper is, therefore, to what extent the conclusions building on data which is up 20 years old is still relevant today.

5.4 Sample Description

5.4.1 Merger Activity

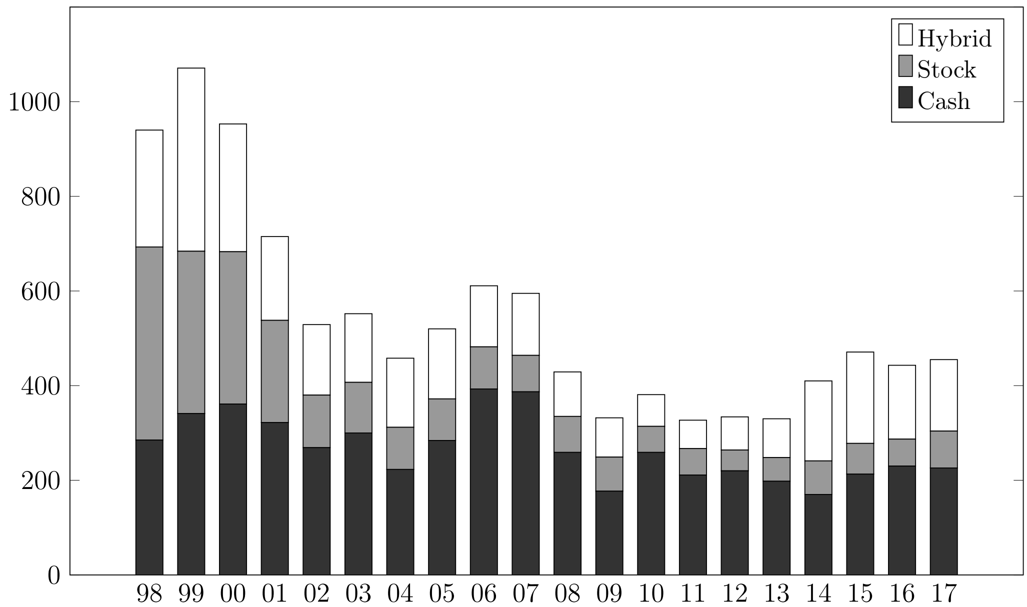


Figure 5.1: Displays the total number of public deals per year before applying exclusion criteria between 1998 and 2017, dividing into the different deal types.

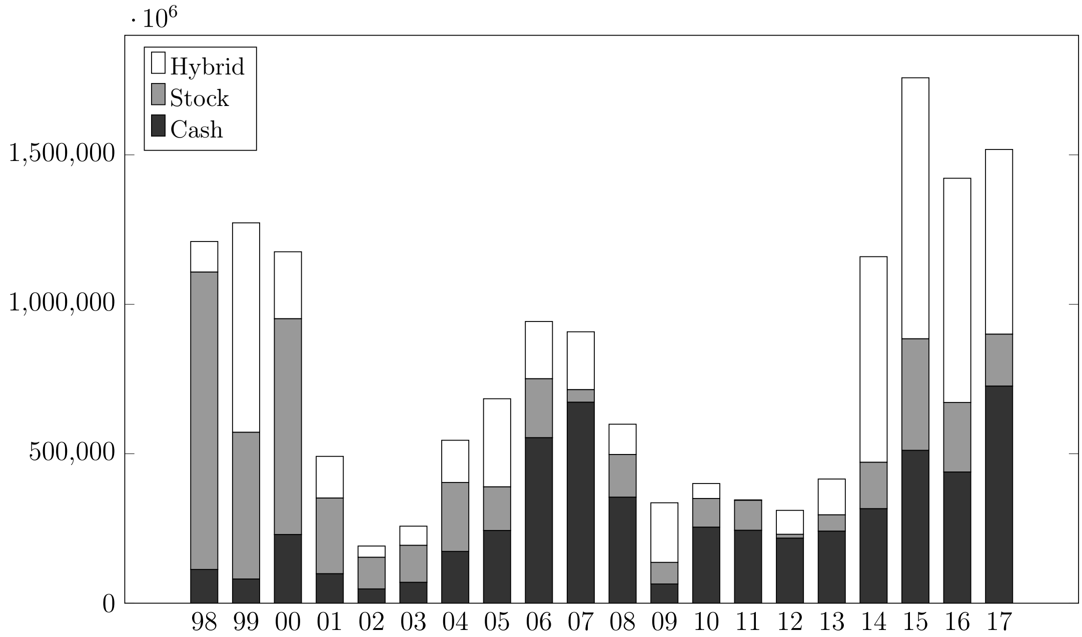


Figure 5.2: Displays the total market capitalization of mergers per year between 1998 and 2017. Forming an almost wave-looking image with high activity in increasing markets, such as the dotcom bubble between 98-00, and low activity in decreasing markets such as the financial crisis 08/09.

It is clear from figure 5.1 that the level of merger activity has been far from constant over the past two decades. Previous research regarding changes in merger activity over time has identified a similar effect. For instance, Harford 2005 [20] identifies how historical merger waves are largely a function of the amount of liquidity which is available. Harford argues that when asset prices are increasing, management teams face fewer obstacles when raising capital to initiate mergers and acquisitions. This result implies that the number of mergers which an investor or fund applying merger arbitrage can invest in are likely to be considerably higher in an increasing market than it is in a falling market.

A merger arbitrageur requires active merger processes to keep the capital invested. The larger the number of available deals is, the more positions the investor is able to take, which are both contributing to the overall return and reducing idiosyncratic risks. Besides experiencing negative returns in a financial crisis, the investor is therefore also faced with a reduced number of deals in which to invest. This reduced number of deals result in a less diversified portfolio, which in turn makes it harder for the investor to reduce the deal-specific idiosyncratic risks which the portfolio faces.

As can be seen when analyzing figure 5.1, as well as figure 5.2, the large number of deals, as well as the large amount of capital, found during the period 98/99/00 is consistent with the theory of Harford, and can be related to the dotcom bubble, vastly rising markets and the ease of accessing capital. Furthermore, the total amount of merger activity is decreasing around the financial crisis in 08/09. When analyzing figure 5.2, the amount of capital in the market is dramatically decreasing after the financial crisis in 08/09. This implies that liquidity is a constraint following with decreasing markets.

Another interesting observation which stands out in figure 5.2 is the fact that the market capitalization of hybrid deals is increasing over time, when analyzing with respect to the total market capitalizations of merger targets. This can be a result of financial optimization techniques which develop as the financial markets become more sophisticated, but also the fact that it could potentially be more difficult to receive full funding in contemporary times. However, as mentioned in section 2.1, this paper will only analyze portfolios consisting of either pure cash or pure stock deals, and thus exclude hybrid deals from the sample.

5.4.2 Duration

Stock deals in particular tend to have a higher average duration compared to cash deals. This can be due to the fact that stock deal transactions usually are bigger and the process is of broader nature. Another driver of why this might be can also be related to the credibility cash offers actually impact on the target firms and the market.

From figure 5.3, it can be seen that on average the stock deals tend to have a higher duration compared to cash deals. The development of the stock deals is quite constant with a slight increase, ranging from 106 to 116 days for the time period analyzed, with a peak in 2012 at 146 days and with the lowest recorded point in 2001 at 88 days. However, for cash deals, it can be seen that there is a slight decrease in the average

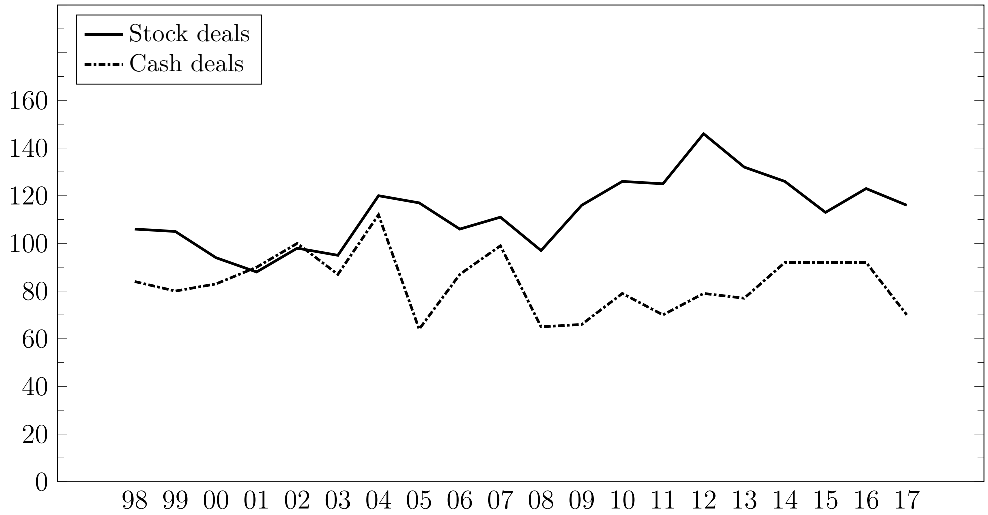


Figure 5.3: Displays the average duration in trading days throughout the time period analyzed. Development of the median duration for the entire sample period running from 1998 to 2017, for both cash and stock offers.

duration ranging from 63 to 112 days, with the lowest recorded average duration in 2005, recorded at 63 days. However, in consistency with Mitchell and Pulvino2001 [2], who find no apparent pattern in the duration, no apparent trends can be found when analyzing the development of the duration over time in this paper.

5.4.3 Arbitrage Spread

As argued in section 4, there are two sources which contribute to the profit of the merger strategy containing only cash deals. Namely, the spread between the post-announcement price and the cash offer price and the dividend paid by the target company. Furthermore, there are three sources of returns in a merger strategy portfolio containing pure stock deals. Namely, the price difference between the proceeds of the short position of the acquirer and the long position in the target firm, the dividend paid by the target firm (which is offset by the dividend required to be paid by the short position), and the interest paid on the proceeds from the short position.

The return which arbitrageurs gain is due to the arbitrage spread, which was discussed and introduced in section 2.1. The arbitrage spread indicates how the market is assess-

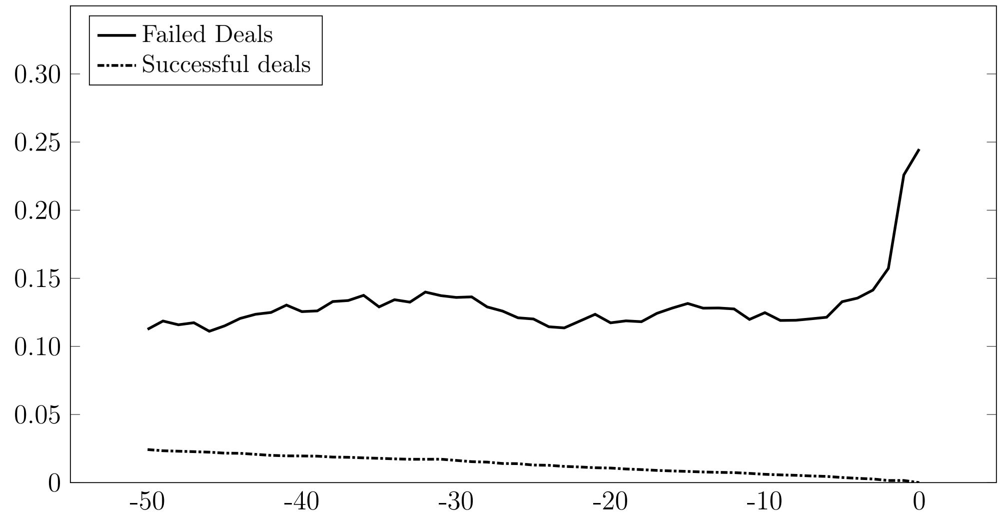


Figure 5.4: Displays the development in the median arbitrage spread running from 50 days prior to deal resolution.

ing the probability of the different outcomes of the merger process.

Figure 5.4 shows the median arbitrage spread plotted against time until deal resolution. The figure demonstrates how the market evaluates the probabilities of the outcomes on each day before resolution. More specifically, for successful deals 50 days prior to resolution the median arbitrage yields approximately 3 percent. Furthermore, as time progresses, the median arbitrage spread for successful deals is decreasing with an almost linear slope, until it reaches completion and the spread turns to zero. However, when analyzing the development of the arbitrage spread of deals which were terminated it shows inconsistencies with the development of completed deals. More specifically, the arbitrage spread related to deals which were terminated has a higher volatility, as there exists some movement as time progresses. As can also be noted from figure 5.4, the median spread 50 days prior to resolution is approximately 22%. An interesting point is that the spread is rather constant over time for terminated deals, until it jumps on the day of termination, implying that the failure comes as a surprise to the market. This finding is consistent with Mitchell and Pulvino 2001 [2]. For successful deals, a consistent decrease over time is observed, implying that the market believes completion is more likely each day prior to the resolution.

6 Results and Analysis

In this section, results will be presented from the sample period 1998 to 2017. This paper will perform three different analyses, which focuses on various aspects related to the merger arbitrage strategy. In the first analysis, the paper investigates the sample of individual merger events to examine which factors are more likely to explain whether a merger is completed successfully or not, by performing logistic regression modeling. The second analysis is split into two components. First, the paper displays summary statistics for the characteristics of individual mergers. Second, the paper demonstrates the historical results of the merger arbitrage strategy which is examined. In the third analysis, the paper considers the risk-adjusted returns which a merger arbitrageur has earned historically and to what extent the strategy correlates with the market. Moreover, the paper considers to what extent a nonlinear relationship exists between the market and the merger arbitrage portfolio, before evaluating the historical performance of merger arbitrage by applying a contingent claim pricing method.

This chapter will present the findings of the paper by using a mixture of graphical illustrations and tabular presentations and relate the findings of this paper to previous studies which are presented in section 3. Lastly, this chapter presents a final summary and discussion where critical points are raised.

6.1 Analysis I: Predicting the Deal Outcome

The target firms in the sample have very different characteristics. In this section, a number of logistic regressions, introduced in section 4.3.2.1, are conducted to obtain a more thorough understanding of which individual firm characteristics make a takeover bid more likely to be resolved successfully. In order to perform these regressions, a dummy variable denoted "SUCCESS" is established for each individual deal. This variable is equal to 1 when the merger is completed successfully and equal to 0 when the takeover bid is terminated. The sample used for conducting these regressions is the sample of cash deals used when calculating the merger arbitrage portfolio. However, those deals which are still pending as of December 31^{st} 2017 are excluded from these tests. All deals where at least one of the characteristics are missing are likewise excluded from the sample. In all of the regressions, the "SUCCESS" variable is a bivariate response variable. Each of the first six regressions presented in table 6.1 contains a single independent variable regressed against the "SUCCESS" variable. The seventh and final regression is a multivariate regression in which all of the previous 6 independent variables are included. When adjusting equation 4.13 presented in section 4.3.2.1 the regression will be quantified as follows

$$\log\left[\frac{SUCCESS}{1-SUCCESS}\right] = \alpha + \beta_1 MVE + \beta_2 Industry + \beta_3 Domestic$$
$$+\beta_4 PE + \beta_5 Premium + \beta_6 MKT_t$$

The numbered columns in table 6.1 display the seven regressions which are conducted with the dependent variable as a dummy variable. "MVE" is the logarithm of the target firm's market value of equity. "Industry" is a dummy variable equal to 1 if the acquiring and target firm operate in the same industry. "Domestic" is a dummy variable equal to 1 if the acquirer has its headquarters in the US. "PE" is a dummy variable equal to 1 if the acquirer is a private equity firm (according to Bloomberg). "Premium" is the logarithm of the takeover premium. MKT_t is the market's return in the month of deal resolution. The 7^{th} regression is a multivariate regression incorporating all 6 covariates.

Coefficients	1	2	3	4	5	6	7
MVE	0.017						0.012
Industry		0.058					0.085
Domestic			-0.058				-0.086
PE				0.028			0.065
Premium					0.041		0.072
MKT_t						-0.091	-0.100
Significance Single	***	***	***	-	*	-	
Significance Multiple	*	***	***	**	**	-	
N	3048	3048	3048	3048	3048	3048	3048

Table 6.1: Displays the seven different single and multiple logistic regressions, which are conducted in order to predict the merger outcomes. The coefficient values have been converted in order to simplify the interpretation of the values. Specifically, the coefficient values presented should be interpreted as the increase in the probability of success given an increase of one unit in the independent variable (both for categorical and numerical variables). "Significance Single" refers to the significance level for the single regressions. "Significance Multiple" refers to the seventh regression, which is multivariate and includes all the covariates displayed in the first column. *, **, and *** refer to a significance level of 5%, 1%, and 0.1% respectively.

MVE - Market Value of Equity

The first test which is conducted involves regressing the natural logarithm of the target firm's market value of equity against the "SUCCESS" variable. The findings, presented in column 1 in table 6.1, demonstrate that deals involving larger firms are more likely to succeed. This result is significant at the $\alpha = 0.1\%$ level. The finding is consistent with Mitchell and Pulvino 2001 [2] who likewise find that larger firms are more likely to be acquired successfully. While less capital is required for acquiring a smaller firm, it may be that acquisitions involving larger firms are prepared more thoroughly and thus are more likely to succeed, as hypothesized in Mitchell and Pulvino 2001 [2]. What might be puzzling about this result is that firms with a larger equity value potentially also have a larger market share which might lead to an increase in the "antitrust approval risk" (depending on the nature of the target firm's operations). However, one should note that not only can acquiring firms engage in mergers within the same industry, but also in cross-industry mergers which should eliminate the antitrust approval risk. Although this paper finds that a substantial amount (37.1%) of the deals occur within the same industry, which would suggest increased scrutiny from antitrust approval authorities, it does not seem to have an impact on the success rate, which thus leaves the "MVE" coefficient significantly positive.

	Domestic		**PE**		**Industry**	
	Domestic	Foreign	PE	Non-PE	Same	Different
Value	1	0	1	0	1	0
Number of Deals	2182	866	497	2551	1132	1916
% Completion	84.3	90.1	88.1	85.5	89.6	83.8

Table 6.2: Displays an overview of the 3 dummy variables used for predicting the "SUCCESS" in table 6.1. "Number of Deals" denotes the number of deals which falls under each classification. "% Completion" refers to the percentage of deals which are completed in each state of the binary variable.

Industry

The second regression in table 6.1 contains the results of a regression containing a dummy variable which is equal to 1 if both the target and the acquiring firm are in the same industry and equal to 0 if they are not. Bloomberg has 3 different levels of industry classification. The first classification contains only 10 different major industry categories. The second classification "Industry Sector" contains 50 different industries. The third grouping includes hundreds of different classifications. The very specific groupings in the third classification are considered too narrow for the purposes of this paper, as it would result in very few companies being classified as being in the same industry. It is, therefore, the second classification by Bloomberg which governs when the dummy variable "Industry" is equal to 1 or 0. In total, it is found that 37.1% of all deals involve transactions where both the target and the acquiring firm are in the same industry. There is a notable difference in the number of failed mergers depending on whether the firms are in the same industry or not. In total, 10.4% of mergers fail when the companies on both sides of the table are in the same industry. In those cases where both the target and acquiring firms are not in the same industry, the data used in this thesis shows that a total of 16.2% of deals fail. The logistic regression, which is found in the 2^{nd} column in table 6.1, illustrates that when both the target and the acquiring firm are in the same industry, the probability that the merger process is resolved successfully is significantly higher at the $\alpha = 0.1\%$ level. A possible explanation behind this finding might be that when both firms in a merger operate within the same industry, the acquiring firm has a more in-depth understanding of the target and a takeover bid is therefore more informed. Baker and Savasoglu 2002 [3], also examine the impact of the target and acquiring firm being within the same industry as part of a multiple linear regression. In their paper, Baker and Savasoglu do not find that it is significant in explaining the probability that a takeover process is resolved successfully, which is in stark contrast to the findings of this paper. The different results may also be due to the different industry classifications used in this paper and Baker and Savasoglu 2002 [3]. An overview of the 10 most commonly represented industries for both target and acquiring firms is available in Appendix I.

Domestic or Foreign Acquirer

The third regression in table 6.1 illustrates how the acquirer's country of domicile impacts the probability that a deal is resolved successfully. The value presented for the "Domestic" coefficient is -0.058, which means that whenever the acquiring firm has its headquarters in the US, the overall probability that the outcome is successful decreases. The coefficient is significant at the $\alpha = 0.1\%$ level suggesting that mergers where the acquirer is a foreign entity are more likely to be completed successfully. When investigating the characteristics of the target firms, it is found that when foreign acquirers launch a bid, it tends to be on larger firms and the premium paid is usually higher. In particular, the market capitalization of firms targeted by foreign acquirers is on average 55% larger than it is for domestic acquirers, while the premium paid is on average 5% higher. It is therefore possible that some of the explanation for this variable being significant can be found in the "MVE" and "Premium" variables. It is likewise possible that foreign acquirers face more severe legal obstacles and processes which they have to undergo before being able to launch a bid, which will result in the bids being more informed and thus more likely to be completed successfully.

PE - Private Equity

The fourth regression in column 4 (table 6.1) displays the result of a regression containing the coefficient "PE" which is a dummy variable equal to 1 if the acquiring firm is characterized as a private equity firm. In order to classify the acquiring firms, a firm is designated as a private equity firm, if its "industry sector" label in Bloomberg is equal to "private equity". The variable related to the "PE" dummy yields 0.028, which means that the model predicts that whenever the acquiring firm is a private equity firm, the probability for a successful outcome increases. However, the coefficient is insignificant at all relevant rejection levels, meaning that it can be concluded that if the acquiring firm is a private equity firm, it does not have an overall impact on the outcome of the merger. Private equity firms engage in a lot of takeover activity and one could therefore assume that their bids are more well-informed and likely to succeed. However, this paper does not find that the "PE" variable holds any explanatory power over the probability of success.

Takeover Premium

Regression 5 in table 6.1 contains the results of the regression involving the takeover premium against the "SUCCESS" variable. The results of this test clearly demonstrate that the probability that a merger is successful increases in takeover premium. This result is significant at the $\alpha = 5\%$ level. One explanation for this relationship could be related to the financial theory of market participants being rational, meaning that the higher the bid, the more likely it is that the target shareholders actually accept the offer. Both Mitchell & Pulvino 2001 [2] and Baker & Savasoglu 2002 [3], examine the effects of including the takeover premium in a multivariate regression to predict the deal outcome. Both authors find that a higher premium is not significant in explaining merger outcomes. It should, however, be noted that the variable is included in a multivariate regression in both papers. None of the papers discuss the degree of multicollinearity between the coefficients, and it is, therefore, possible that the effect of a higher takeover premium is already explained by a different covariate.

MKT - Market Return

Before considering the risk-adjusted returns for a merger arbitrageur by applying models such as the CAPM, an initial regression considering the market impact on deal failure and success is first conducted in this section. The sixth test which is presented in table 6.1 concerns a regression of the market return on the dummy variable "SUCCESS". Previous literature, as presented in section 3, on the topic of merger arbitrage has concluded that merger arbitrage returns are negative during market declines due to the increased number of failed deals during economic crises.

In the regression presented in table 6.1, the coefficient "MKT_t" has a negative sign. The p-value shows that the variable is not significantly different from 0 at the $\alpha = 10\%$ level, which means that it cannot be concluded that the market return has a significant impact on the outcome of the deal. A question that arises from this result is whether deal failure may be positively related to the lagged market return instead of the actual market return. In order to obtain further understanding of how the return for the market in previous months affect the current probability for success, two additional single regressions were conducted, in which the "SUCCESS" variable was regressed against the market return lagged one month, and the market return lagged two months. Furthermore, a multivariate regression including both the current market return and the two lagged returns was conducted (table 6.3).

Coefficients	1	2	3	4
MKT_t	-0.091			-0.108
MKT_{t-1}		0.129		0.125
MKT_{t-2}			0.128	0.122
Significance Single	-	*	*	
Significance Multiple	-	*	-	
N	3048	3048	3048	3048

Table 6.3: Displays the four different single and multiple regressions, which are solely based on the market return with different lags in order to predict merger outcomes. "Significance Single" refers to the significance level for the single regressions. "Significance Multiple" refers to the fourth regression, which is multivariate and includes all of the covariates displayed in the first column. *, ** and *** refers to a significance level of 5%, 1% and 0.1% respectively.

Both the regression on the market return lagged one month and the market return lagged two months show significance beyond the $\alpha = 5\%$ level. Both regressions also have positive signs indicating that a declining market is associated with more failed deals. Although both variables are significant at the $\alpha = 5\%$ level, they are not significant beyond the $\alpha = 1\%$ level. When a large number of regressions are conducted, as is done in this thesis, it is important to be careful about not placing too much emphasis on results which are only significant at the $\alpha = 5\%$ level, as some regressions are bound to be significant by pure chance when many different ones are conducted. Nonetheless, finding a positive sign for the two lagged market returns can at least serve as a strong indicator that deal failures may be more prevalent during market declines.

Aggregate Regression

The last regression in table 6.1 is performed by combining all coefficients from column 1 into a multivariate regression in order to capture their joint impact on the outcome of the deal process. The "MVE" coefficient is significant at the $\alpha = 0.1\%$ level when regressed alone. However, when regressed jointly it is only significant at a $\alpha = 5\%$ level. The reason for this could be related to the multicollinearity issue, meaning that there exists explanation for the "MVE" coefficient in one or more of the other coefficients. The "Industry" coefficient shows an increase in the success probability, with the value of the probability being 0.058 when regressed solely compared to 0.085 when regressed jointly. Furthermore, it is still significant at the $\alpha = 0.1\%$ level, meaning that even combined with other coefficients this covariate is significant for the deal outcome. The "Domestic" covariate shows no difference in the significance level when regressed together with other covariates. The probability impact of the variable has a negative value (-0.058), compared to the single regression value (-0.086). However, the "Domestic" variable is significant beyond $\alpha = 0.1\%$, both when regressed jointly and individually. The "PE" and "Premium" coefficients become even more significant beyond the $\alpha = 1\%$ level in the multivariate regression, with a small increase in the impact they will have on the probability of a successful outcome of the deal. As when regressed alone, the market return shows no significance at any relevant threshold level.

Although the different covariates explain different drivers of what might cause the success rate to increase or decrease, it is safe to say (based on this analysis) that "Industry", "Domestic" and "Premium" are the most significant drivers which impact the probability of whether a deal process will succeed or be terminated. These findings are inconsistent with Mitchell and Pulvino 2001 [2], which finds that the "Premium" covariate is insignificant for determining the outcome. Furthermore, in their paper, "MVE" shows significance at the $\alpha = 1\%$ level. However, Baker and Savasoglu 2002 [3], finds that the "Premium" coefficient is significant at the $\alpha = 5\%$ level.

The reason why there might be a difference in the results among various papers, as well as this thesis, could be the result of several aspects. First, the time horizon which has been analyzed differs from paper to paper. The characteristics of the merger process could potentially have changed over time which would then change the impact and significance of the coefficients. This, therefore, causes the results to differ over time, and it is also what impacts the multivariate regression. For instance, this paper deviates in that it is using and analyzing drivers which have not been analyzed in previous papers, such as the "PE" and "Domestic" coefficients. Second, the "Premium", which refers to the takeover premium, is calculated differently. More specifically, Mitchell and Pulvino 2001 [2] calculates the takeover premium by taking the price one day after the announcement divided by the price 30 days prior to the announcement. However, Baker and Savasoglu 2002 [3] calculate the premium by taking the offer price divided by the price 20 days prior to the announcement date. This paper is using a hybrid between the two, by taking the offer price divided by the price 30 days prior to announcement. Furthermore, the results may differ due to the different methodologies applied across papers, in terms of the number of days prior to announcement which is used. If for instance, the merger arbitrage portfolio consists of a huge number of volatile firms, a large development in the share price could be seen prior to announcement, biasing the results of the takeover premium. Also, the volatility of the US stock market, in general, would potentially be a factor which must be adjusted for when calculating the takeover premium.

Given that only 5 out of 6 covariates exhibit significance in the last aggregate regression, a final regression is conducted without the single insignificant factor "MKT_t". The regression shows the same significance levels as previously for the "Industry", "Domestic", and "Premium" factors. The PE variable becomes significant at the $\alpha = 0.1\%$ level, while the MVE variable becomes significant at the $\alpha = 5\%$ level.

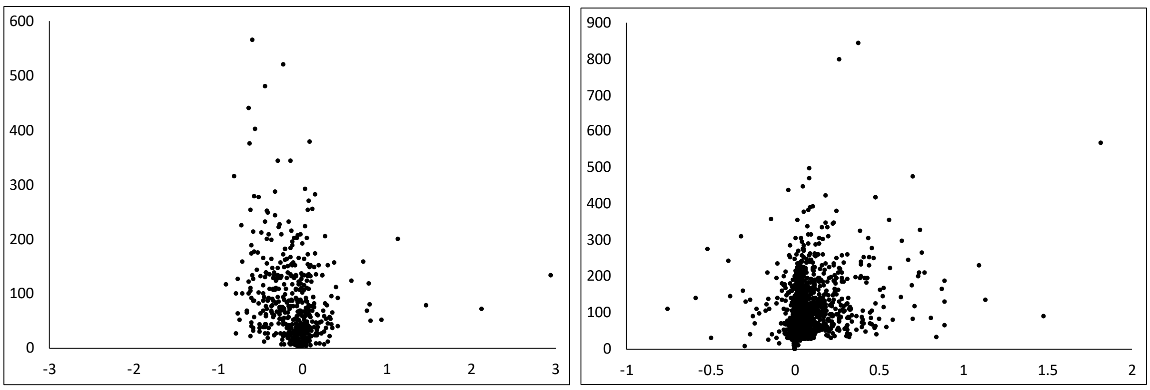
6.2 Analysis II: Return Characteristics

6.2.1 Distribution of Individual Returns

	Cash		**Stock**	
	Completed	Terminated	Completed	Terminated
1^{st} Quartile	3.79	-72.40	1.50	-80.86
Median Return	8.31	-28.58	6.43	-22.23
3^{rd} Quartile	17.23	20.29	16.67	46.43
Median Duration	64	66	59	98
N	2901	466	942	104

Table 6.4: Displays summary statistics about the distribution of returns, divided into cash and stock deals, which are further subdivided into completed and terminated deals. Statistics are presented for the median, 1^{st} and 3^{rd} quartile return. All returns are presented as percentages on an annualized basis.

Cash Deals

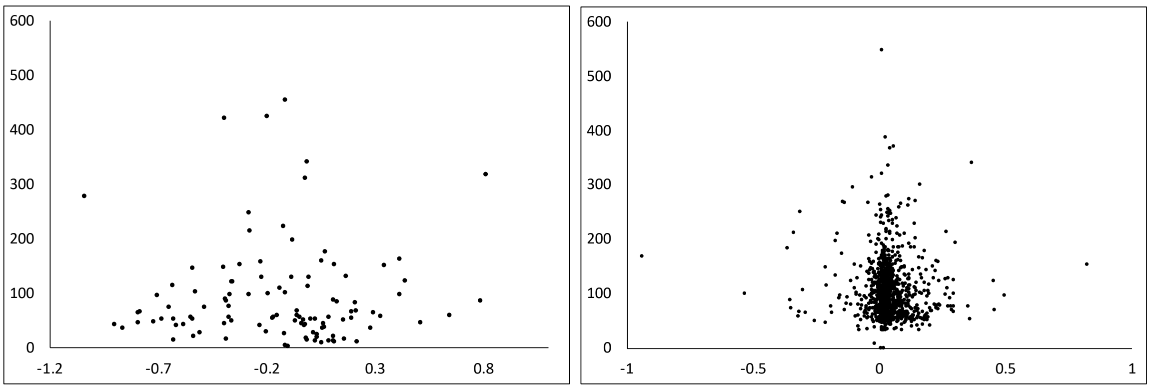


(a) Terminated (b) Completed

Figure 6.1: Comparison of the return distribution for positions in terminated ($N = 466$) and completed ($N = 2901$) cash deals. The figure plots the returns on the x-axis against the duration in trading days on the y-axis.

The returns produced by individual cash deals are depicted in figure 6.1, with additional statistics about the returns in table 6.4. In the sample of cash deals, the median deal returned 1.9% to the investor holding it, while the median holding period was 64 days. In annualized terms, the median return for a completed cash deal was 8.3% while the median return for terminated deals was -28.6%. The 1^{st} quartile value, shown in table 6.4 for terminated cash deals, illustrates particularly how devastating a failed deal can be to a merger arbitrageur because of the large negative annualized returns (-72.4%). The merger arbitrage portfolio is, therefore, sensitive to potentially large losses. However, only approximately 14% of all cash deals are resolved unsuccessfully, and the impact of terminated deals is therefore minor unless several deals happen to be terminated at a similar time. Given the relatively small positive return which is earned from a successful merger, and the large losses which are suffered upon a deal failure, a natural question to consider is the benefits of a diversified portfolio. Diversification is beneficial for any investor, but it may be particularly important for a merger arbitrageur, given the differences in the distributions of the completed and terminated offers.

Stock Deals



(a) Terminated (b) Completed

Figure 6.2: Comparison of the return distribution for positions in terminated ($N = 104$) and completed($N = 942$) stock deals. The figure plots the returns on the x-axis against the duration in trading days on the y-axis.

Figure 6.2 illustrates the difference in the return distribution for terminated and completed stock deals. The vast majority of completed stock deals result in a small positive return for the investor, as 67% of the completed stock deals lead to a return between 0% and 10% over the holding period. The median deal duration is 59 trading days for stock deals which are ultimately successful, and 98 trading days for deals which fail, as can be seen in table 6.4. The median successful deal offers the investor a position return of 2.39% (annualized 6.43%), while the median unsuccessful deal yields a negative return of -8.81% (annualized -22.23%). Due to the fact that the investor also holds a short position in the acquiring stock along with the long position in the target stock, the downside is potentially unlimited. The implication is that it is possible for the position to yield a return which is negative beyond 100%. As for the cash portfolio, the number of terminated deals are lower compared to completed deals with their relative size of approximately 10% and 90% respectively. Therefore, the impact from terminated deals will only have a marginal effect on the overall portfolio return. Since the investor does not know ex-ante which deals will be resolved unsuccessfully, the benefits of holding a large and diversified portfolio of deals are potentially large. If the risk that deals fail is idiosyncratic and not correlated across deals, the arbitrageur can potentially diversify his risks away by holding a large number of positions. To eliminate the downside risk, the investor will therefore require access to a large number of deals in which to invest, and for the probability that those deals fail to be uncorrelated.

A noticeable feature in figure 6.2 is that the return distributions in the two figures differ from each other. For the completed deals, the distribution appears to contain a larger degree of clustering with high density and smaller deviations. The majority of returns are closely distributed around the mean and median (presented in table 6.4) of the distribution. The cause of this may be a result of completed deals yielding approximately the same arbitrage spread throughout time. In contrast to the findings for the completed deals, the distribution of the terminated deals appear more widely distributed in figure 6.2, showing negative returns from -100% to +80%. This may be because it is not certain what the target stock will drop to if terminated. The target stock price could potentially drop back to its previous level prior to the bid announcement, although it may as well drop less or more than the previous level. For instance, depending on whether the terminated bid gets followed up by other potential bidders or not. There are likewise multiple reasons for why one might observe a positive return following deal termination. For example, if a target firm is a pharmaceutical company which just received an FDA approval for a product. The target shareholders will most likely turn down the previous bid and as a result of the FDA approval, the stock price would be assumed to increase, yielding a positive return following a termination. Another explanation could also be due to the fact that the acquiring firm could potentially default during a deal process. A short position in the acquiring firm would thus yield a positive return.

6.2.2 Historical Returns

Aggregate Merger Arbitrage Portfolio

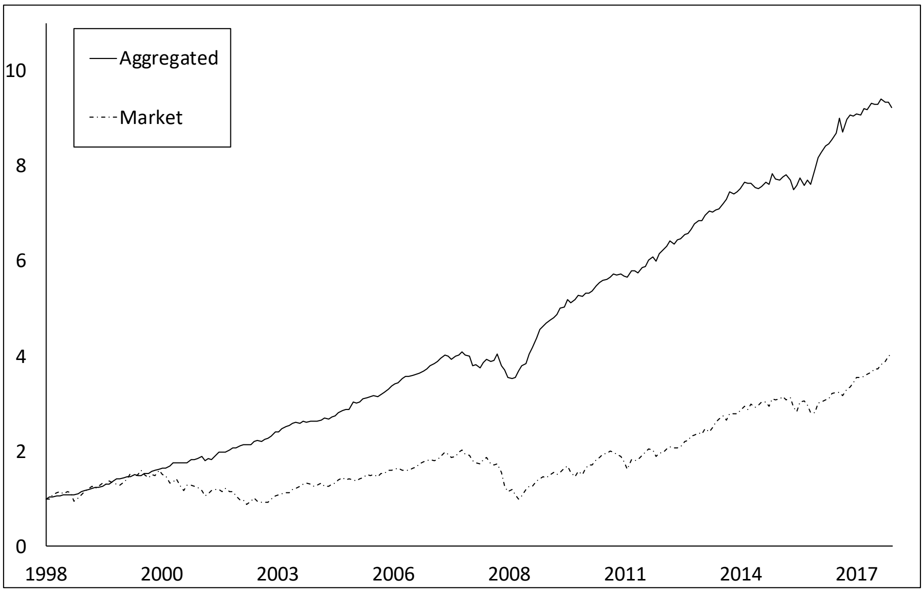


Figure 6.3: Displays the development of $1 invested in the aggregate equally weighted merger arbitrage portfolio and the equivalent investment in the market index from 1998 to 2017.

Years	Equally Weighted Aggregated	Equally Weighted Cash	Equally Weighted Stock	Value Weighted Aggregated	Value Weighted Cash	Value Weighted Stock	Max 10% VW Aggregated	Market Data Market Index	Market Data Risk-free
1998	19.33	18.04	19.53	8.71	10.94	9.15	7.36	22.26	4.85
1999	23.59	19.69	21.82	13.43	17.09	13.37	19.73	25.27	4.69
2000	19.76	15.40	18.89	20.59	30.93	19.73	21.12	-11.16	5.88
2001	8.36	11.35	-0.67	-12.62	9.10	-31.76	-2.28	-11.27	3.82
2002	16.85	18.01	11.83	28.60	13.29	39.82	16.65	-20.84	1.63
2003	15.94	21.10	2.24	10.14	22.85	2.82	9.46	33.14	1.02
2004	10.62	11.76	5.36	4.48	9.29	-5.89	5.50	12.99	1.19
2005	12.94	14.87	8.86	6.75	8.23	5.62	7.36	7.31	2.98
2006	15.34	16.86	8.11	6.12	11.64	-0.05	6.56	16.21	4.81
2007	6.85	7.30	3.39	-3.44	-2.28	-11.90	-1.21	7.27	4.67
2008	-11.46	-16.34	19.71	0.79	-4.70	-7.24	-6.82	-38.21	1.59
2009	36.11	56.61	5.66	27.80	27.87	14.84	17.80	31.29	0.09
2010	13.99	13.58	16.22	12.93	15.73	5.86	11.95	17.71	0.10
2011	4.88	5.15	3.76	3.85	4.17	3.48	3.55	-1.07	0.04
2012	12.56	12.93	6.91	-3.35	-3.96	-0.22	-1.93	15.76	0.06
2013	11.21	12.16	6.64	16.03	17.22	13.61	15.51	30.45	0.00
2014	6.42	8.58	1.77	-1.39	3.42	-4.33	3.99	10.51	0.00
2015	0.47	-1.47	7.83	-0.82	1.56	-11.07	0.85	-1.68	0.01
2016	17.85	20.26	5.64	11.01	11.71	9.91	9.29	12.67	0.21
2017	1.64	0.18	6.47	3.23	3.07	0.92	1.89	20.64	0.79
HPR	822.21	966.80	440.97	299.32	566.61	58.79	289.96	305.13	45.77
μ	11.32	12.70	8.78	7.29	10.00	3.21	7.01	8.96	1.92
σ	5.67	7.49	7.69	8.32	7.66	12.88	6.15	18.47	2.09
SR	1.99	1.69	1.14	0.87	1.30	0.25	1.14	0.48	-

Table 6.5: The table displays the historical percentage returns produced by the various merger arbitrage portfolios during each year. The first three parts contain the results of the equally weighted, value weighted and value weighted subject to a constraint of maximum 10% weight in any single investment. The final part of the table contains the historical returns of the CRSP value weighted index and the risk-free rate. HPR refers to the investment's holding period return. μ, σ, and SR refer to the mean, standard deviation, and Sharpe ratio respectively.

Table 6.5 contains information on the historical returns from the various portfolio approaches which are applied in this paper. The first part of the results in the table contains historical information about the returns for an investment in the aggregate equally weighted portfolio. During the time horizon which is applied in this paper, the aggregate equally weighted merger arbitrage portfolio has yielded an annual average return of 11.32% with a Sharpe ratio of 1.99. This investment has substantially outperformed an investment in the market index which has only returned 8.96% over the same time horizon, with a Sharpe ratio of 0.48. When annualizing the monthly Sharpe ratio reported in Baker and Savasoglu 2002 [3], the authors find a Sharpe ratio of 1.35. The Sharpe ratio found in the sample which is applied in this paper is therefore considerably higher. However, the analysis in Baker and Savasoglu 2002 [3] spans the time period from 1981 to 1996, which is not comparable with the time period selected for this paper. As this paper later demonstrates, it is likely that smaller illiquid firms have a significant positive impact on the large positive performance of the equally weighted portfolio.

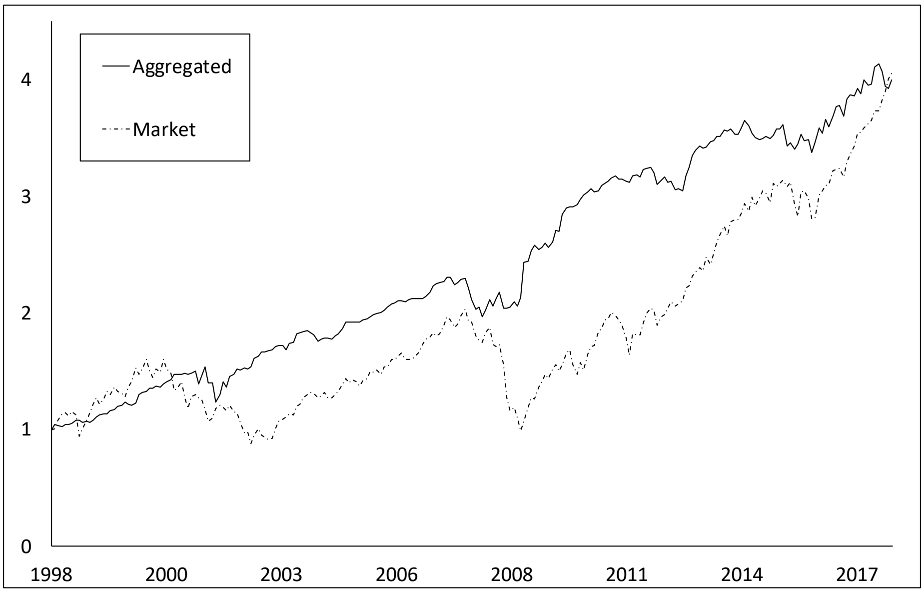


Figure 6.4: Displays the development of $1 invested in the aggregate value weighted merger arbitrage portfolio and the equivalent investment in the market index from 1998 to 2017.

Compared to the equally weighted merger arbitrage portfolio, the value weighted aggregate portfolio has produced a significantly lower annualized return of 7.29%, resulting in a Sharpe ratio of 0.87. While the annual return is slightly less than that of the market for the same period, the Sharpe ratio of the value weighted aggregate portfolio is still higher than the market. This is a direct result of the standard deviation of the aggregated value weighted merger arbitrage portfolio being lower than the standard deviation of the market. All of the papers which were reviewed in section 3 include analysis of the historical performance of a value weighted merger arbitrage portfolio. Mitchell and Pulvino find that a value weighted portfolio approach yield an annualized mean return of more than 16% with a Sharpe ratio of 1.06, while Baker and Savasoglu find a mean return of more than 18% with a Sharpe ratio of 0.8. Branch and Yang find in their research, an annual return of 23.5% and a monthly Sharpe ratio of 0.53, which when annualized becomes 1.82. The various mean returns and Sharpe ratios, in this paper and others, are measured during different time horizons and are as such not directly comparable. Compared to the previously mentioned papers, the Sharpe ratio found in this paper is in the lower end of the spectrum. The Sharpe ratio merely considers the mean and the variance of an investment. Its failure to capture the systematic risks which affect an investment will be addressed later in this paper.

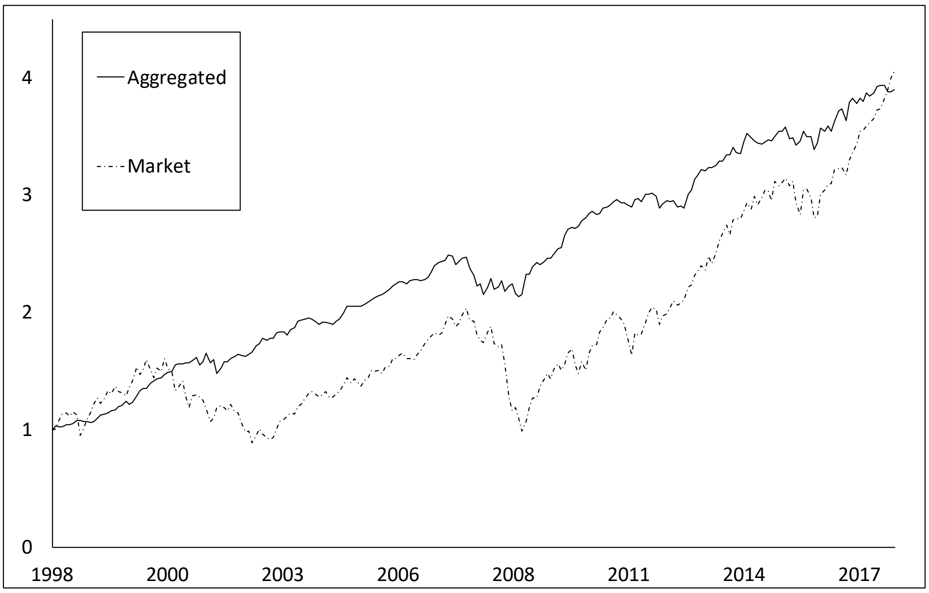


Figure 6.5: Displays the development of $1 invested in the aggregate value weighted merger arbitrage portfolio, which imposes a maximum ten percent constraint on a single asset, and the equivalent investment in the market index from 1998 to 2017.

Part 3 of table 6.5 presents the result of an approach which consists of constructing a value weighted portfolio with a constraint imposed that no firm may constitute more than 10% of the total weight in the portfolio, as mentioned in section 6.2.2. Applying this approach, the aggregated merger arbitrage portfolio yields an annualized return of 7.01% with a Sharpe ratio of 1.14. As demonstrated later in this chapter, in figure 6.8, the aforementioned simple value weighted approach often leads to the portfolio being dominated by a single large target firm. During those periods where a single firm weights more than 10% in the value weighted portfolio, the portfolio with a 10% cap is thus more broadly diversified, and this fact may likewise explain the lower standard deviation of the constrained portfolio. The standard deviation of the capped portfolio is 6.15% annualized, while it is 8.32% for the value weighted portfolio.

Equally Weighted Cash and Stock Portfolios

For each portfolio approach, the sample is further divided into a portfolio consisting solely of cash deals, and another composed entirely of stock deals.

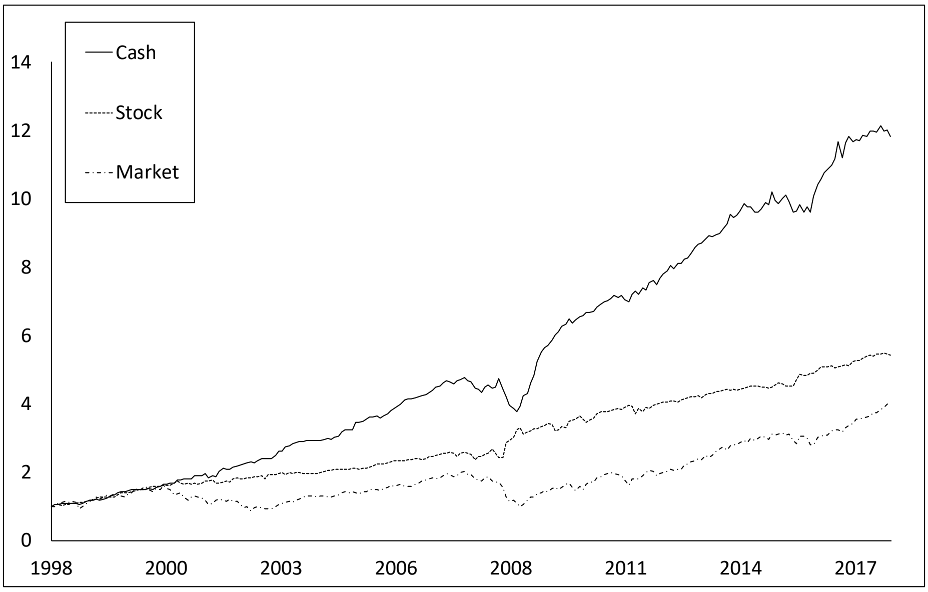


Figure 6.6: The historical development of $1 invested in three different portfolios: cash, stock and the market portfolio. The analysis spans the years 1998 to 2017, and the portfolios are constructed with an equally weighted approach.

Figure 6.6 demonstrates the profits an investor would have earned by placing $1 in either the equally weighted cash or stock merger arbitrage portfolio. The market index is likewise included in the figure for comparison. From table 6.5 it can be seen that the equally weighted cash and stock portfolios have produced returns of 12.70% and 8.78% respectively. In terms of standard deviation, the portfolios are similar, with the stock portfolio yielding a standard deviation of 7.69%, while the cash portfolio has a standard deviation of 7.49%. The implication of this is that the cash portfolio has maintained a higher Sharpe ratio (1.69) than the stock portfolio (1.14), as a result of the higher annual return produced by the cash portfolio. During the financial crisis in 2008 and 2009, the cash portfolio exhibits a substantial decline along with the market index, which may be the result of the portfolio holding only long positions in target firms. The stock portfolio, on the contrary, is increasing in value over the same period, which is likely due to its considerable short position in acquiring firms. In this case, the lower overall returns of the stock portfolio, therefore, appear to be balanced by a reduced sensitivity to overall market declines. To what degree such a relationship between the merger arbitrage portfolios and the market actually exists, will be elaborated upon later in this paper. The findings in this paper are in contrast to Baker and Savasoglu 2002 [3], who find that an equally weighted stock portfolio outperforms an equally weighted cash portfolio, over the time horizon from 1981 to 1998. However, it is worth noting that Baker and Savasoglu's sample is rather small with the authors themselves stating that their stock portfolio contains no assets at all during certain periods of their analysis.

Value Weighted Cash and Stock Portfolios

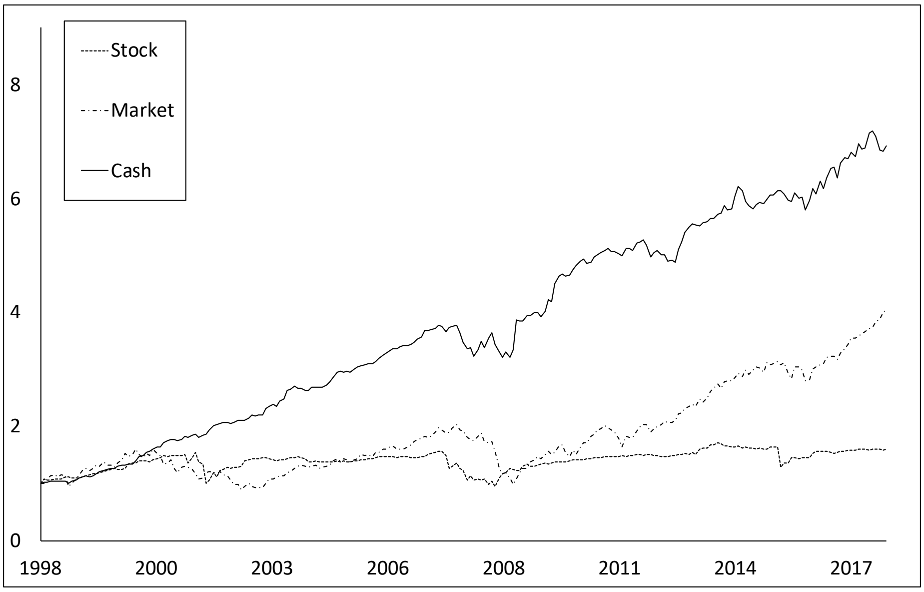


Figure 6.7: The historical development of $1 invested in three different portfolios: cash, stock and the market portfolio. The analysis spans the years 1998 to 2017, and the portfolios are value weighted.

Figure 6.7 contains a graphical illustration of the development of the value weighted cash and stock portfolios. It is clear that both of these portfolios have historically earned lower returns than their equally weighted counterparts. The holding period returns produced by the value weighted cash and stock portfolios are 10.0% and 3.2% respectively, along with standard deviations of 7.7% and 12.9%. While the value weighted stock portfolio earns a smaller return than the value weighted cash portfolio, it also has a higher standard deviation. These results indicate that the stock portfolio is worse than the cash portfolio for an investor, as it offers both lower returns and also carries higher risks. This becomes very clear when adjusting the returns for the risk taken on. The Sharpe ratio for the cash portfolio is 1.30, while for the stock portfolio it is 0.25. Both in term of returns and the risk-reward trade-off measured by the Sharpe ratio, the value weighted cash portfolio has therefore vastly outperformed its stock counterpart. In their paper, Baker and Savasoglu 2002 [3], find that cash and stock deals have offered an almost similar level of historical returns (19.44% to 20.04%) with identical standard deviations (16.77% and 15.31%), resulting in very similar Sharpe ratios (0.76 and 0.87). These results are significantly different for this paper. However, it is worth mentioning again that the time period differs for these two papers. Another point of concern may be that the sample size for the value weighted stock portfolio analyzed in Baker and Savasoglu 2002 [3] is very small, leaving the results quite uncertain.

Equally Weighted vs Value Weighted

When attempting to simulate a real-life merger arbitrage portfolio, both a value weighted portfolio and an equally weighted portfolio approach has several advantages and disadvantages. In reality, investment managers are unlikely to allocate a large portion of their capital to any single stock to ensure proper diversification. The strength of the equally weighted portfolio lies in that it captures this fact well, by ensuring the maximum weight on any one single share is kept low. However, a weakness of the equally weighted portfolio is that it puts a large emphasis on micro-cap companies which are only relevant to investors with little capital. For instance, an asset manager who can deploy $1 billion to a merger arbitrage strategy is unlikely to be able to place 1-3% of the capital in a target firm with a market capitalization below $100 million. The reason is that this large nominal allocation would itself create price pressure which affects the market price of the asset unfavorably for the manager.

The strength of the value weighted portfolio approach can be observed in the way it allocates more weight to exactly those shares which a real investment manager would also be able to invest most heavily in without facing liquidity constraints. The drawback of the value weighted method is that it often allocates too much of the hypothetical capital to a single share. The most dramatic illustration of this effect can be observed during the beginning of 2009. As the number of potential merger targets decreased significantly in the wake of the onset of the global financial crisis, Genentech with its massive market capitalization of almost \$ 100 billion constituted between 50% and 80% of the value weighted aggregate merger arbitrage portfolio while it was active. Figure 6.8 illustrates how the maximum weight allocated in the value weighted strategy changes over time.

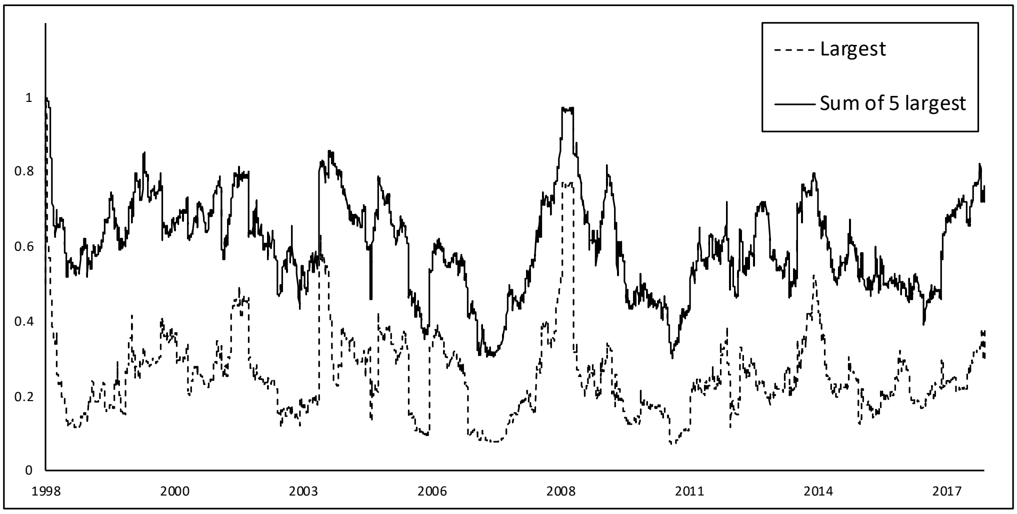


Figure 6.8: Displays the change in the maximum allocation over time in the value weighted portfolio, both for the largest weighted stock and also the sum of the five largest stocks.

These results could potentially leave the portfolio biased. In order to account for this large amount being invested in the largest firms, a maximum investment cap of 10% has also been applied to expand on the value weighted approach.

6.2.3 Strategy Risks

	Equally Weighted			**Value Weighted**			**Max 10% VW**	**Market Data**
	Aggregate	Cash	Stock	Aggregate	Cash	Stock	Aggregate	Market
μ	11.32	12.70	8.78	7.29	10.00	3.21	6.95	8.24
σ	5.67	7.49	7.69	8.32	7.65	12.88	6.13	15.55
γ	-0.46	0.04	1.65	-0.07	1.16	-2.21	-0.51	-0.77
κ	2.16	2.27	16.87	8.20	8.17	15.98	3.28	1.55
Max DD	13.72	21.30	9.24	19.65	15.04	39.96	14.33	51.45

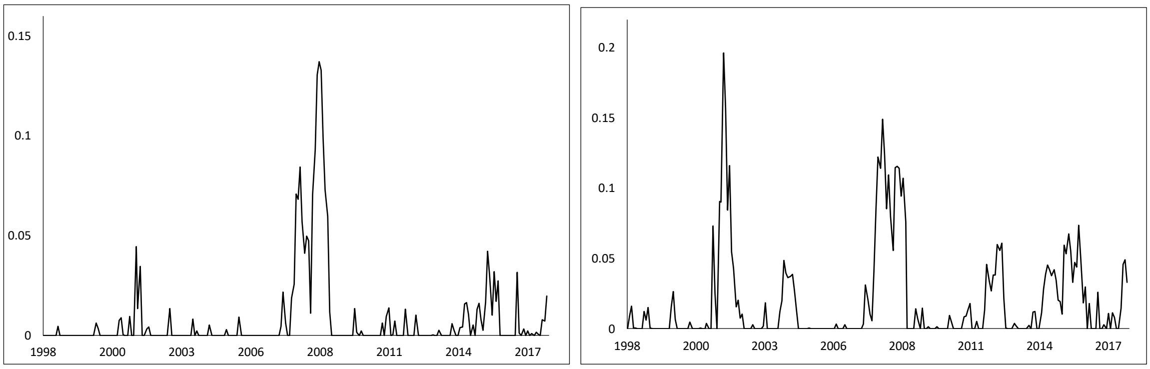
Table 6.6: Displays the four moments of the portfolio returns described in section 6.2.2. The first and second moment, μ and σ (mean and standard deviation), along with the maximum drawdown are displayed in percentages. The γ (skewness) is the third power and measures the symmetry of the distribution, where a normal distribution has a skewness of 0. The κ (kurtosis) is the fourth power and thus is always represented as strictly non-negative values. However, the table displays the excess kurtosis (excess of 3), and thus -0.2 is actual kurtosis of 2.8. Max DD is the largest drawdown from 1998-2017. The drawdowns are calculated as the monthly decline in portfolio value, from each portfolio's high water mark, i.e., the highest historical portfolio value at any given time.

The skewness γ measures the degree of asymmetry of the distribution. In the case of a zero skewness, the distribution has perfect symmetry, leaving the distribution on the left and right side of the mean equal to one another. One interesting observation in table 6.6 is that all of the aggregated portfolios, along with the market portfolio, exhibit negative skewness, which means that the distribution is left-skewed, i.e., it has more observations to the right of the mean with a large left tail. One reason why the skewness might be negative can be due to the fact that a larger relative number of deals are completed compared to terminated, clustering the majority of the observations slightly above the mean. However, one puzzling observation can be made when investigating the skewness of the cash portfolio which yields a positive skew. When applying the same rationale, one could assume that the cash portfolio should also yield negative skewness. However, this is not the case. In the equally weighted portfolio the skewness is only slightly positive (0.04), and in the value weighted approach the positive skew could be the result of the termination of large cap stocks, which according to figure 6.8 take up approximately 85% of the total portfolio at any given time.

The excess kurtosis $\kappa - 3$ is found to be positive for all portfolios, in addition to the market return, which means that all return distributions are of leptokurtic nature compared to a normal distribution. An interesting observation is that all of the portfolios have kurtosis which exceeds the one of the market (1.55). The highest recorded is the one for the stock portfolio applied with the equally weighted approach (16.87). Given these findings it could potentially mean that the merger arbitrage strategy is not as volatile on average compared to the market, leaving a significant amount of observations clustered around the mean, whereas for the market portfolio the observations are more widely distributed. Given that the skewness and excess kurtosis of the merger arbitrage portfolios are consistently different from zero, it is clear that the returns are not normally distributed. This is a potential issue which must be kept in mind as the various models applied to risk-adjust the returns in this chapter assume that returns are normally distributed.

The largest drawdown of the market over the past 2 decades was 51.45%, which is higher than the drawdown of any of the merger arbitrage portfolios which are analyzed in this thesis. This observation implies that the merger arbitrage strategy could have low sensitivity to the market returns. The largest observed drawdown for any portfolio is 39.96%, which is suffered by the value weighted stock portfolio. As mentioned previously, the stock portfolio contains a substantially smaller number of assets than the cash portfolio. The large loss which is experienced during the maximum drawdown for the value weighted stock portfolio is, therefore, a result of a single terminated deal process in a large cap stock. As mentioned in section 6.2.2, the weight of the stock deals in the aggregate portfolio is less than the weight of the cash deals the majority of the time. The aggregate portfolio is therefore more broadly diversified, which can help explain the smaller maximum drawdown of 19.65%. However, the aggregate portfolio is still heavily invested in a single asset at times. By imposing a maximum 10% cap on the aggregate value weighted portfolio, this issue is eliminated, resulting in a lower maximum drawdown of 14.33% due to the increased diversification.

Figure 6.9 demonstrates the drawdowns which an investor would have experienced over



(a) Equally Weighted (b) Value Weighted

Figure 6.9: The historical drawdown for an investment in the equally weighted and the value weighted aggregate portfolio. The drawdown is calculated as the percentage loss of the portfolio from its highest historical point.

the past two decades by applying either the equally weighted (a) or the value weighted (b) approach. The illustration shows that whenever the line hits 0, there is a new all-time high for the portfolio. For instance, the equally weighted portfolio suffered negative returns around 2007 taking almost 24 whole months to recoup its investment from the previous level. Furthermore, the value weighted portfolio, as the equally weighted, starts to suffer losses around 2007. However, the portfolio recoups its investment quicker compared than the equally weighted. Another observation, which can be made from the figures, is the fact that the volatility is larger for the value weighted approach. At first, one could imagine that small cap stocks should be more volatile, and since the equally weighted approach gives an equal weight to those stocks, it should show a significant impact on the overall volatility. However, even though the value weighted portfolio contains more large cap stocks, as can be seen from figure 6.8, it also places a very large weight on a few single stocks at times. When those individual heavily weighted stocks experience a deal termination, the portfolio as a whole will be significantly affected, causing a large single loss. The fact that the merger arbitrage portfolio experiences its most severe drawdowns during periods of economic crisis, suggests that there is a systematic risk which affects the merger arbitrage portfolio. To what degree this common market risk factor affects a merger arbitrageur will be studied further in the following section.

6.3 Analysis III: Risk Adjustments

This section will present the results of analyzing the different portfolios in relation to various risk factors which might influence the excess returns. More specifically, the section will first analyze the excess returns of the aggregate portfolio and examine the risk-adjusted returns it produces after adjusting for the risk factors contained in the CAPM and the Fama-French 3 factor model. Furthermore, the section will also divide the aggregate portfolio into a cash and a stock portfolio, which will then be scrutinized to identify the different risk characteristics of both offer categories.

This thesis will first present the results of linear regression modeling such as the CAPM and Fama-French 3 factor model, and later present the results of investigating the nonlinear relationship of the merger arbitrage portfolio to the market return. The nonlinear relationship will be investigated by using the piecewise linear models, as well as by using contingent claim pricing by applying the Black-Scholes-Merton option pricing formula.

6.3.1 Linear regression models

Aggregate merger arbitrage portfolio

Tables 6.7 and 6.8 demonstrate the results of regressing each respective portfolio's monthly excess returns against various factors. When regressing solely on the excess return of the market (CAPM), the beta coefficient β_{MKT} for the aggregate portfolios range from 0.107 for the value weighted portfolio with a 10% cap to 0.132 for the equally weighted portfolio. Although these beta estimates are by themselves not very large, they are all significant at the $\alpha = 0.01\%$ level. As a result of the significance level of the covariates, this paper can strongly conclude that the returns of the aggregate portfolios have an overall positive relationship with the market. An interesting observation to make is that the beta coefficients are small but positive, which supports the reasoning in

	CAPM			Fama French		
	Aggregate	Cash	Stock	Aggregate	Cash	Stock
α	0.007	0.009	0.008	0.007	0.009	0.008
P-value	***	***	***	***	***	***
β_{MKT}	0.132	0.218	-0.120	0.123	0.207	-0.120
P-value	***	***	***	***	***	***
β_{HML}				0.070	0.133	-0.080
P-value				*	***	-
β_{SMB}				0.077	0.120	-0.045
P-value				**	**	-
N	240	240	240	240	240	240
$R^2_{adjusted}$	0.127	0.199	0.053	0.153	0.247	0.060

Table 6.7: Displays the results from regressing the excess return of the various equally weighted portfolios against both the CAPM and the Fama-French 3 factor model. β_{MKT} refers to the excess return of the market, β_{HML} is the HML factor and β_{SMB} refers to the SMB factor. *, **, and *** refer to the 5%, 1% and 0.1% significance level.

section 6.2.3 regarding the low sensitivity between the returns of the aggregate portfolios and the market. For instance, in section 6.2.3 it was demonstrated how the aggregate merger portfolios had suffered substantial declines during several market drops, such as the most recent financial crisis, which also supports a positive market beta. However, in each case, the drawdowns were not nearly as severe as those experienced by the market portfolio, which supports the finding of a beta coefficient less than one.

Following the announcement of a deal, the target share commonly trades at a market price below the bid price, as shown in section 5. If all deals were always resolved successfully, the implication would be that the beta coefficient of the merger arbitrage portfolio was zero, and the returns for a merger arbitrageur would be unaffected by any market movements. As the beta coefficient is significantly larger than zero, it must be that the market itself influences events surrounding the merger process, which causes

	CAPM				**Fama French**			
	Aggregate	Cash	Stock	Max 10%	Aggregate	Cash	Stock	Max 10%
α	0.004	0.007	0.003	0.004	0.003	0.007	0.003	0.004
P-value	*	***	-	***	*	***	-	*
β_{MKT}	0.126	0.211	-0.042	0.107	0.120	0.215	-0.046	0.098
P-value	***	***	-	***	***	***	-	***
β_{HML}					0.066	0.136	-0.128	0.047
P-value					-	***	-	-
β_{SMB}					0.060	0.044	-0.040	0.069
P-value					-	-	-	*
N	240	240	240	240	240	240	240	240
$R^2_{adjusted}$	0.050	0.179	0.000	0.069	0.054	0.209	0.001	0.079

Table 6.8: Displays the results from regressing the excess return of the various value weighted portfolios against both the CAPM and the Fama-French 3 factor model. β_{MKT} refers to the excess return of the market, β_{HML} is the HML factor and β_{SMB} refers to the SMB factor. *,**,***, refers to 5%, 1% and 0.1% significance levels.

the merger arbitrage returns to differ depending on the market condition. Section 6.1 demonstrated how down markets tend to be followed by an increased number of failed deals, and section 6.2 illustrated how failed deals are associated with significant negative returns. Combined, these two findings illustrate how the merger arbitrage portfolio can have a positive beta in the CAPM regression as the market changes the probability that a deal is successful. A more subtle effect may be how the market return correlates with other events surrounding the merger process. Such an effect could, for instance, be upwards revisions in the offer price. If a rising market causes more positive revisions than a down market, a merger arbitrageur will earn higher returns than initially expected upon the deal being launched, which will likewise result in a more significant positive beta value.

If the real world conforms to the assumptions behind the CAPM, one should expect the alphas of the different aggregate merger arbitrage portfolios to be zero. As can be observed in the tables above, this is not the case, as the alphas for all of the 3 aggregate portfolios are positive and significantly higher than zero. Although all of the three aggregate portfolio approaches carry a similar loading on the β_{MKT} factor, the alphas appear to vary considerably. The value weighted portfolio and the value weighted portfolio with a 10% constraint have both achieved positive alphas historically, with the former earning an alpha of 4.56% and the latter, an alpha of 4.42%. The returns from the equally weighted aggregate portfolio, however, dwarfs both of these portfolios with an alpha of 8.56%. As mentioned previously, in section 6.2.2, a trait of the equally weighted portfolio approach is that it is hard to apply for most institutional investors. Although attractive, the high alpha of the equally weighted portfolio is therefore hard to attain. The high alpha implies that the merger arbitrage portfolios have historically produced significant risk-adjusted returns. If the assumption of efficient markets holds, this would, in turn, suggest that the CAPM is not a suitable model for examining the risks associated with merger arbitrage.

As presented in table 6.9, Baker and Savasoglu find that an equally weighted merger arbitrage portfolio had a beta coefficient of 0.22 for the period 1981 to 1996. This value is higher than the market beta of 0.13 found in this paper. For the value weighted portfolio, Baker and Savasoglu find a beta value of 0.30, while it is found to be 0.11 in this paper. In general, the merger arbitrage betas found in this paper for a modern time period, are therefore smaller than what is found in earlier research. A key factor influencing this could be the relative weights of stock and cash offers in the merger arbitrage portfolios. Both Baker and Savasoglu, as well as Mitchell and Pulvino, find that stock offers are generally associated with lower beta values than cash offers. Although neither of the two pairs of authors state the exact weights of each offer type in their portfolios, Baker and Savasoglu state that their portfolio at times contain no stock offers at all. An explanation for the lower beta in this paper could therefore be that there is a larger number of stock offers in the portfolio. A second possible explanation could be the different time horizons in which the two analyses are conducted. The difference could both be of random nature given the alternative estimation period or caused by a change

	Mitchell and Pulvino		Branch and Yang		Baker and Savasoglu		Maheswaran and Yeoh		Sudarsanam and Nguyen	
	EW	VW	EW	VW	EW	VW	EW	VW	EW	VW
CAPM										
α	n/a	0.088	n/a	0.204	0.108	0.093	0.136	0.102	0.077	0.1044
P-value	n/a	***	n/a	***	***	**	**	**	**	***
β_{MKT}	n/a	0.054	n/a	-0.183	0.22	0.3	0.052	-0.055	0.147	0.2738
P-value	n/a	*	n/a	**	***	*	-	-	*	***
Fama-French										
α	n/a	0.0948	n/a	n/a	0.088	0.07	0.144	0.1	0.074	0.098
P-value	n/a	***	n/a	n/a	***	-	**	*	**	***
β_{MKT}	n/a	0.0176	n/a	n/a	0.25	0.37	0.028	-0.071	0.199	0.348
P-value	n/a	*	n/a	n/a	***	**	-	-	**	***
β_{HML}	n/a	-0.09	n/a	n/a	0.18	0.32	-0.172	-0.017	0.081	0.141
P-value	n/a	-	n/a	n/a	*	**	-	-	-	-
β_{SMB}	n/a	0.077	n/a	n/a	0.22	0.26	-0.06	-0.08	0.221	0.305
P-value	n/a	*	n/a	n/a	**	*	-	-	***	***
N	n/a	432	n/a	104	192	192	112	112	251	251

Table 6.9: Displays the results which all of the previous research papers reviewed in section 3 have found, when regressing against the excess return of the market as well as the HML and SMB factors, further explained in section 4.3.1.2. Furthermore, EW and VW refers to the equally weighted and value weighted portfolios respectively. n/a are recorded in the table as those regressions which are left unperformed by the authors. *, ** and *** refer to the 5%, 1% and 0.1 % significance level respectively.

in the fundamentals of merger arbitrage returns over the past decades. Furthermore, Maheswaran and Yeoh [6] 2005 find, when investigating the Australian market, that the alphas are 0.1368 and 0.102 for the equally weighted and value weighted respectively. Moreover they record β_{MKT} of -0.055 and 0.052. However, the beta coefficients are not significantly different from zero at any reasonable rejection level, and thus Maheswaran and Yeoh argue that the merger arbitrage strategy in the Australian market is market neutral, meaning that the strategy is only subject to deal termination risk and not market risk. The most central point to why these results deviates from this thesis is the fact that the markets investigated are different, as well as the small sample size of only 112 mergers. Nguyen and Sudarsanam 2009 [7] find that a merger arbitrage portfolio in the UK has produced annualized alphas of 0.077 and 0.1044 with betas of 0.147 and

0.274 for the equally weighted and value weighted portfolio respectively. Branch and Yang only conduct analysis on the value weighted portfolio and find an α of 0.204 along with a β_{MKT} of -0.1863. Branch and Yang include collar offers when regressing their aggregate portfolio. More specifically, when regressing the collar portfolio solely against the excess return of the market, they find a β_{MKT} of -0.568, which will impact the beta coefficient of the aggregate portfolio negatively. This might be one explanation of why Branch and Yang's results are so different compared to other studies as well as this thesis.

Implementing the Fama-French 3 factor model, the market factor still holds significant explanatory power for the aggregate merger arbitrage portfolios, albeit the coefficient value is slightly lower for every one of the three aggregate portfolios. Tables 6.7 and 6.8 show that for the 3 aggregate merger arbitrage portfolios, the β_{SMB} covariate (explained in section 4.3.1.2) is significantly positive at the $\alpha = 1\%$ level for the equally weighted aggregate portfolio and the aggregate portfolio with a 10% limit constraint but not for the pure value weighted portfolio. Furthermore, the significance is higher for the equally weighted portfolio than the for the aggregate max 10% portfolio. Upon reflection, it is likely that the low significance for the equally weighted portfolio is caused by the fact that the equally weighted portfolio places a much more substantial weight on small-cap stocks than the value weighted approach does. The significance which is found for the value weighted portfolio when the 10% cap is imposed is also highly likely to be due to the more limited influence of stocks with very large market capitalizations. As can be observed in tables 6.7 and 6.8 the β_{HML} covariate (explained in section 4.3.1.2) is only significant at 5% level for the equally weighted portfolio, whereas for the value weighted portfolios with and without the max 10% cap it shows insignificance. This result is surprising as one would expect the opposite results, due to the fact that the value weighted portfolio is more heavily invested in large firms, which by default are more value stocks compared to growth stocks.

Moreover, when analyzing which regression model provides the best explanation for the excess returns of the various portfolios, the $R^2_{adjusted}$ is presented. Normally when analyzing to which degree a model explains the variation in the dependent variable, R^2 is presented. However, just adding more covariates will by itself increase the predictability and R^2. The $R^2_{adjusted}$ is accounting for the added covariates and is therefore applicable when comparing regression models which contain various numbers of covariates. Table 6.7 along with table 6.8 show that for all portfolios, the Fama-French 3 factor model provides a more suitable explanation for the excess portfolio returns. The rationale behind this result is that there are risk factors which impact the portfolio returns which are not captured by the market itself. Adding the β_{SMB} and β_{HML} covariates, therefore, provide a better explanation for the market returns.

In Mitchell and Pulvino 2001 [2], no analysis is conducted on an equally weighted portfolio, meaning that all of their comparable results are derived from a value weighted approach. The authors, however, do not find any significant beta loadings at all, which would suggest that the merger arbitrage strategy is factor neutral, both in terms of the market factor in CAPM and the 3 Fama-French factors. Due to the low insignificant factor loadings and the large excess returns, the alphas are naturally very large, suggesting that the merger arbitrage strategy has historically produced large risk-adjusted profits. Maheswaran and Yeoh 2005 [6] find that neither β_{MKT}, β_{SMB} or β_{HML} is significant when applying the Fama-French 3 factor model. These findings can support the hypothesis from their CAPM analysis that the merger arbitrage strategy is market neutral. When adjusting for these risks, they find economically significant alphas of 14.4% for the equally weighted and 10.0% for the value weighted. However, they are only significant at a 10% and 5% respectively. Maheswaran and Yeoh argue that the sample size is much lower in the equally weighted portfolio, and as a result, the α is higher as well as less significant.

Furthermore, when examining the β_{SMB}, Baker and Savasoglu 2002 [3] find, in conjunction with this thesis, that the equally weighted portfolio has a more significant factor loading than the value weighted portfolio. For the β_{HML}, Baker and Savasoglu find that the factor is significant for both a value and an equally weighted approach. This is not consistent with the research in this thesis which finds no significance for the β_{HML} for the value weighted approach. Like both this thesis and the other papers which are considered within this chapter, Baker and Savasoglu likewise find large significant alphas, no matter which approach is applied. The different findings may both be caused by a different time horizon over which the research is conducted, and what is at times a low amount of diversification for the value weighted portfolios. Furthermore, as can be seen in tables 6.7 and 6.8, the different factors have opposite signs for the cash and stock portfolios. Since the aggregate portfolios are simply mixtures of the two offer types, the signs and significance of each factor is therefore likely to be different among papers depending on the relative weight placed on cash and stock portfolios.

Equally Weighted Cash and Stock Portfolios

As can be seen in table 6.7, the β_{MKT} differs considerably for cash and stock offers. The equally weighted portfolio composed entirely of cash deals has a positive beta coefficient of 0.218, while the portfolio containing only stock deals has a beta of -0.12, both are significantly different from zero. The positive market exposure of the cash portfolio is likely due to the fact that the portfolio is composed entirely of long positions. Conversely, the stock portfolio is composed of both long and short positions, which combined result in a significantly negative beta. The alphas of both portfolio types are significantly positive at any relevant significance level, indicating that both offer types have been able to generate positive risk-adjusted returns. Furthermore, what can be seen from the table is that both portfolios have earned an almost equal alpha. Due to the fact that no other previous researchers reviewed in section 3.1 have conducted analysis on an equally weighted portfolio which is split into different deal types, no comparison across papers can be made.

Furthermore, as in the CAPM regression, the α of the Fama-French regression has the exact same values. The β_{MKT} for the stock portfolio is -0.12 and 0.207 for the cash portfolio. This suggests that the variation which is explained by the excess return of the market yields the same value even though more covariates are added to the model.

Adding the two additional factors β_{HML} and β_{SMB}, it is found that both factors are significant in explaining the returns for the cash portfolio but not for the stock portfolio. For both portfolios, the signs for the coefficients are the same as it is for β_{MKT}. The β_{SMB} is likely significantly positive for the cash portfolio, due to the fact that the cash portfolio is composed entirely of target shares, which in general are small cap stocks being acquired by large cap firms. Moreover, the $R^2_{adjusted}$ increases from 0.199 to 0.247 for the cash portfolio, as a natural result when adding two risk factors which both are of significance to explain the variation in the dependent variable. When comparing the regression models for the stock portfolio, the $R^2_{adjusted}$ yields 0.053 for the single regression, whereas it is 0.06 for the multivariate. An explanation of the small increase in explanation power can be due to the β_{HML} being significant only at the 10% level and β_{SMB} being insignificant. Even though the Fama-French regression explains slightly more regarding the total variation of the excess return of the stock portfolio, it also adds two more risk factors, which possibly adds to the multicollinearity issue, as well as adding noise. As a result, the excess return of the market alone provides a better explanation of the excess return for the stock portfolio.

Value Weighted Cash and Stock Portfolios

Similarly to the previous findings for the equally weighted approach, the β_{MKT} is found to be significantly positive for the cash portfolio. However, neither the α nor the β_{MKT} of the stock portfolio is found to be significant, as it was for the previous equally weighted method. As was the case for the aggregate portfolios, each value weighted portfolio produces a lower alpha than their equally weighted counterpart. This finding provides evidence towards the conclusion that a substantial amount of the risk-adjusted returns are produced by smaller firms which wield larger influence over the equally weighted portfolio than they do over the value weighted portfolio. Branch and Yang 2006 [5] is the only paper reviewed in section 3 which breaks the aggregate portfolio down and present findings for the cash and stock portfolio. They find a significant α which is similar, recorded at 0.18 and 0.168 for the cash and stock portfolio respectively. They find the β_{MKT} for the two portfolios to be 0.121 and -0.221 respectively. Their results have a strictly inverse relationship to this thesis' findings. More specifically, they find their β_{MKT}^{cash} to be insignificant and their β_{MKT}^{stock} to be significant at the 5% level.

For the cash portfolio, an interesting difference between the two portfolio approaches is that the β_{SMB} holds significant explanatory power for the equally weighted cash portfolio while it is insignificant for the value weighted cash portfolio. This finding is likely caused by the different relative weights, which the two approaches place on the different target firms, with the value weighted portfolio placing a much higher weight on large cap stocks. These few dominating large cap stocks are not as exposed to the β_{SMB} as the small cap stocks which hold more weight in the equally weighted portfolio, causing the β_{SMB} to be insignificant for the value weighted cash portfolio. For the stock portfolio, the alpha along with the coefficients are all insignificant demonstrating that the regression model is unable to explain the returns. This also indicates that the value weighted stock portfolio has produced positive historical returns while being factor neutral, both in terms of the CAPM and the 3 Fama-French factors. Following up on the reasoning Maheswaran and Yeoh 2005 do in their paper [6], it is most likely due to the small sample size and large weight one firm has in the overall weight.

6.3.2 Nonlinear Relationship

Previous research has hypothesized that a nonlinear relationship exists between the market return and the returns produced by merger arbitrage. Notably, researchers such as Mitchell and Pulvino 2001 [2] have demonstrated that the correlation between the market and a merger arbitrage strategy increases considerably during decreasing markets. In this section, the thesis considers to what extent the market beta of the different portfolios changes during down markets.

The thesis will first employ a broad framework to examine if a nonlinear relationship exists between the merger arbitrage strategy and the market. The first consideration is to make use of a number of different thresholds to separate the sample into an up-and a downstate. The next consideration is to examine the nonlinear relationship by utilizing return series from all of the previous portfolios.

	Equally Weighted			**Value Weighted**			**Max 10%**	
$\mathbf{R_{MKT} - r_f}$	Agg	Cash	Stock	Agg	Cash	Stock	Agg	N
$\leq -6\%$	0.03	0.22	-0.90	-0.07	0.13	-0.78	-0.18	21
$\leq -5\%$	0.13	0.31	-0.71	0.02	0.19	-0.57	-0.08	27
$\leq -4\%$	0.14	0.27	-0.61	0.09	0.16	-0.46	0.00	33
$\leq -3\%$	0.19	0.32	-0.42	0.08	0.15	-0.27	0.01	42
$\leq -2\%$	0.15	0.27	-0.37	0.09	0.14	-0.18	0.03	59
$\leq -1\%$	0.16	0.28	-0.32	0.07	0.14	-0.21	0.02	78
$\leq \pm 0\%$	0.15	0.28	-0.33	0.05	0.13	-0.22	0.01	91
Total	0.13	0.22	-0.12	0.13	0.21	-0.04	0.10	240

Table 6.10: Displays the monthly β_{MKT} as a function of different thresholds (ranging from 0% to -6%) for the excess return on the market, for the different portfolios. "N" denotes the number of observations recorded below the threshold. "Total" refers to the overall β_{MKT} for the whole sample without imposing any threshold constraint.

The first column in table 6.10 contains various thresholds ranging from 0 to -6%. Similarly, the correlation is estimated for each threshold which is presented in Appendix II. For each threshold, a regression is conducted solely on the part of the sample where the excess return of the market is below the specified threshold. Inconsistent with Mitchell and Pulvino 2001 [2], this paper does not find any significant evidence suggesting a nonlinear relationship between the excess return of the merger arbitrage strategy and the market when investigating monthly return estimates. There are multiple explanations for why the findings in this paper may be different for monthly returns. First, the sample period does not overlap which could indicate that the specific characteristics of merger arbitrage have changed since Mitchell and Pulvino conducted their research. Second, the large negative outliers may be the root cause of the relatively flat regression line, given that the monthly sample only contains 240 observations. Out of the 5 months where the market suffers the severest losses, the aggregate portfolios suffer only minor losses or no losses at all. Due to the nature of OLS regression, these sizeable negative market return outliers are highly influential in assuring that the betas of the aggregate merger arbitrage portfolios do not change as the threshold level decreases. Third, the relative weighting of cash and stock portfolios may have an impact. In particular, as shown in figure 6.10, the cash portfolio on average constitutes 57.5% of the total weight of the value weighted portfolio. In Mitchell and Pulvino's portfolio approach, 73% of the offers are cash offers.

Since betas and correlations are not found to increase significantly in down markets for the monthly return estimates, an extended analysis is conducted to analyze weekly return estimates, in order to investigate if the estimation period exhibits a stronger pattern. When investigating weekly return estimates, a highly significant change is found in the down market beta as the threshold decreases.

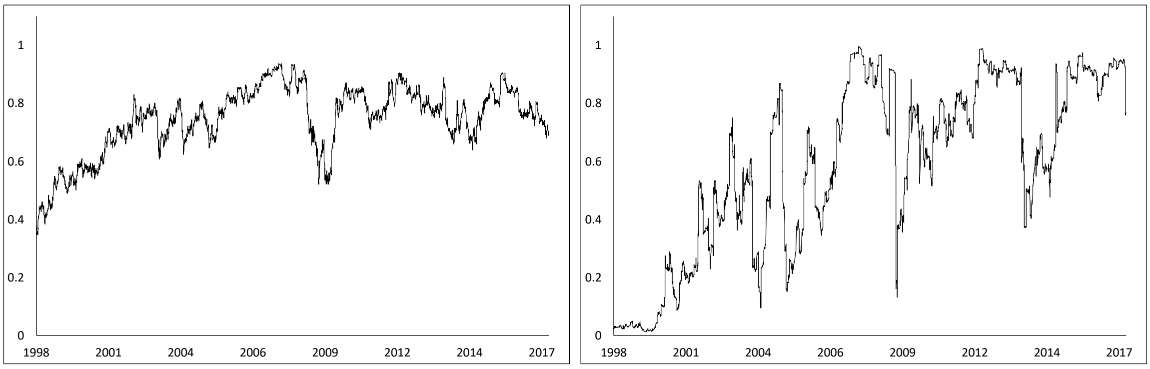
	Equally Weighted			**Value Weighted**			**Max 10%**	
$\mathbf{R_{MKT} - r_f}$	Agg	Cash	Stock	Agg	Cash	Stock	Agg	N
$\leq -6\%$	0.56	0.70	-0.34	0.58	0.80	-0.24	0.34	18
$\leq -5\%$	0.51	0.67	-0.37	0.47	0.72	-0.34	0.30	29
$\leq -4\%$	0.47	0.61	-0.27	0.36	0.59	-0.25	0.22	57
$\leq -3\%$	0.42	0.55	-0.18	0.30	0.48	-0.13	0.20	88
$\leq -2\%$	0.34	0.46	-0.14	0.25	0.39	-0.06	0.18	158
$\leq -1\%$	0.29	0.39	-0.12	0.20	0.32	-0.05	0.16	280
$\leq \pm 0\%$	0.23	0.34	-0.14	0.15	0.28	-0.08	0.14	461
Total	0.16	0.25	-0.10	0.13	0.23	-0.01	0.12	1043

Table 6.11: Displays the weekly β_{MKT} as a function of different thresholds (ranging from 0% to -6%) for the excess return on the market, for the different portfolios. "N" denotes the number of observations recorded below the threshold. "Total" refers to the overall β_{MKT} for the whole sample without imposing any threshold constraint.

As can be seen in table 6.11, the pattern reveals that the market exposure for a merger arbitrageur increases significantly during market declines. This is confirmed by a similar investigation of the changing correlations in Appendix III. For each of the 3 aggregate portfolios, the pattern is strong. More specifically, when decreasing the threshold level, the beta coefficient of the excess return of the market increases. These findings are consistent with Mitchell and Pulvino 2001 [2] who also provide evidence that the correlation between the returns of the merger arbitrage strategy and the market is increasing in decreasing markets, suggesting a nonlinear relationship. Although, as mentioned previously, this paper only finds the relationship to hold for weekly estimation periods, as a result of this, the further analysis will be conducted on weekly return estimates.

Furthermore, it can be seen in table 6.11 that for cash and stock portfolios, the relationship between the portfolio returns and the market evolves differently. In particular, it can be seen that the β_{MKTlow} for the cash portfolios increases substantially as the threshold is gradually decreasing, while for the stock portfolio the β_{MKTlow} increases in threshold level. The β_{MKTlow} for cash offers reaches a high of 0.8 for the value weighted portfolio when the threshold is set at -6%, while it is only 0.23 for the entire sample. For the stock portfolio, however, the β_{MKTlow} is decreasing in a decreasing threshold. It is recorded at -0.24 when the excess return of the market is below 6% whereas for the whole value weighted stock sample the β_{MKTlow} is estimated to be -0.01. In section 6.3.1 it was demonstrated how the market beta in the CAPM regression is significantly different for cash and stock offers. Notably, the tests showed that a portfolio of cash offers have historically had a significantly positive beta, while a portfolio consisting solely of stock offers have had a negative beta. This finding holds in down markets as well, as can be observed in table 6.11. Given that the cash and stock offers have significantly different betas, which are further magnified in a down market, the combined aggregate betas observed in table 6.11 will be highly dependent on the exact mixture of offer types during a market decline.

Figure 6.10 illustrates the relative weights of cash and stock offerings in the aggregate portfolios. From the graphs, it is clear that the cash offers have a greater overall impact on the aggregate portfolios, as they make up the majority of the aggregate portfolios most of the time. However, there are also periods during which the aggregate portfolios are mostly composed of stock offers. As mentioned previously, positions in cash offers tend to have higher positive betas while stock positions generally tend to have negative betas. The beta of the aggregate portfolio is therefore likely to be significantly influenced by the exact composition of offer types at any given time. Since the sample contains



(a) Equally Weighted (b) Value Weighted

Figure 6.10: The relative weight of the cash portfolio in the combined aggregate portfolios during the time period 1998 to 2017. The average weight for (a) and (b) are 73% and 57% respectively.

only a limited number of periods which can be defined as down markets, the changing betas in table 6.11 are therefore also dependent on the exact proportion of cash and stock offers at any given time.

Even though the patterns are consistent throughout all threshold levels, it is worth noting that for each decrease in the threshold level, the sample of down market returns becomes smaller. It is therefore likely that the beta estimates for the lower threshold levels are more heavily affected by noise and therefore less reliable.

6.3.3 Nonlinear regression model

If a linear relationship existed between the market and the merger arbitrage portfolios one should expect the slope to be the same, no matter which threshold level is selected. As can be seen in table 6.11 when investigating the relationship between the return of the portfolios and the return of the market, the β_{MKTlow} is nowhere equal to one another. This suggests a nonlinear relationship and, therefore, causes further analysis to be made. More specifically, the piecewise linear CAPM regression will be implemented to examine whether the merger arbitrage strategy is still able to produce risk-adjusted returns when considering the market state dependent correlations.

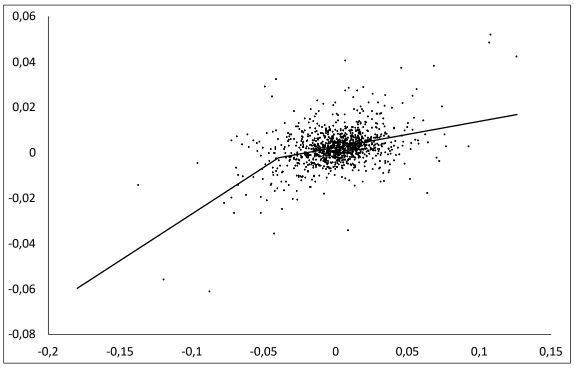
	Equally Weighted			**Value Weighted**			**Max 10%**
	Agg	Cash	Stock	Agg	Cash	Stock	Agg
				Threshold I			
α	0.0025	0.0027	0.0017	0.0015	0.0020	0.0003	0.0013
$\beta_{MKThigh}$	0.1079	0.1994	-0.0813	0.1069	0.1928	0.0231	0.1071
β_{MKTlow}	0.2833	0.3883	-0.2008	0.1907	0.3227	-0.0845	0.1542
				Threshold II			
α	0.0024	0.0026	0.0017	0.0015	0.0020	0.0004	0.0013
$\beta_{MKThigh}$	0.1102	0.2007	-0.0841	0.1049	0.1912	0.0184	0.1078
β_{MKTlow}	0.3437	0.4576	-0.1556	0.2317	0.3803	-0.1090	0.1700
				Threshold III			
α	0.0023	0.0025	0.0017	0.0014	0.0019	0.0004	0.0012
$\beta_{MKThigh}$	0.1148	0.2045	-0.0827	0.1048	0.1902	0.0184	0.1088
β_{MKTlow}	0.4103	0.5385	-0.1389	0.2828	0.4618	-0.1601	0.1891
N	1043	1043	1043	1043	1043	1043	1043

Table 6.12: Displays the piecewise linear model which is regressed on the excess return on the market. The thresholds I, II and III are set arbitrarily at -2%, -3% and -4% respectively.

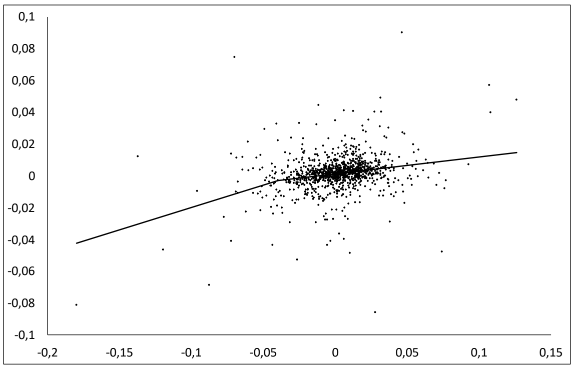
As mentioned in section 4.3.2.2 when estimating the threshold level for the model, different methods can be applied. Mitchell and Pulvino 2001, [2] set the threshold as the level which minimizes their sum of squared residuals. In particular, Mitchell and Pulvino set their threshold level to -4%, which leaves them with 15% of the total sample return estimates lying below their threshold level. When conducting the piecewise linear regression model by applying the method of minimizing the sum of squared residuals for the value weighted portfolio in this paper, a threshold level of -6.51% is found. However, less than 1% of the total sample of weekly returns fall below this threshold value of -6.51%, which therefore will make estimating the β_{MKTlow} uncertain.

Glosten and Jaganathan 1994 [13] argue in their paper that the estimation techniques for determining the threshold are not particularly straightforward, and there is space for economic interpretation of which threshold to select. This paper will therefore apply various thresholds for determining the market state and conduct multiple tests to examine the risk-adjusted returns of a merger arbitrage strategy. The purpose of applying multiple threshold levels is to ensure that the conclusions do not rely solely on a single arbitrary choice of the threshold level. In other words, if the merger arbitrage strategy produces risk-adjusted returns under many different thresholds, it is more likely that any conclusions about the strategy in general are of economic significance.

Table 6.12 shows the three different piecewise regression models conducted on thresholds of -2%, -3% and -4%. The first column displays the α and the different slopes which are calculated for each of the two market states, low and high. It is thus the threshold level in each panel which determines whether a given weekly return is a low or a high market state return.



(a) Equally Weighted



(b) Value Weighted

Figure 6.11: Displays the payoff distribution of the aggregate equally weighted (a) and value weighted (b) portfolios respectively with a -4% threshold. The x-axis displays the market returns while the y-axis displays the portfolio returns.

Mitchell and Pulvino 2001 [2] find that the distribution of the merger arbitrage return strategy mimics a portfolio of a short put option along with a long position in a government bond. In order for these results to be justified, the $\beta_{MKThigh}$ cannot be significantly different from zero. By examining the results in table 6.12, this thesis finds that the $\beta_{MKThigh}$ ranges from 0.1048 to 0.1148 for the various aggregate portfolios. Given that the slopes are significantly different from zero on both sides of the threshold for all aggregate portfolios, it is not reasonable to assume that the returns of the merger arbitrage portfolio are consistent with simply writing a short put option on the market index. For the aggregate portfolios, significantly positive slopes in both the up and the down market would suggest that the returns of the merger arbitrage portfolio are positively correlated to the market returns in both states. It is, however, important to notice that the slopes are not equal to one another, which suggests that a portfolio of various financial instruments is required in order to replicate the payoff.

Pricing the Replicating Portfolio Using the BSM-model

As mentioned in the previous paragraph, Mitchell and Pulvino find no evidence that their $\beta_{MKThigh}$ is significantly different from zero. Therefore, they are mimicking the merger arbitrage payoff with a replicating portfolio consisting of writing a put option on the market index and taking a long position in a hypothetical risk-free asset. This paper finds that the $\beta_{MKThigh}$ is significantly different from zero, and therefore needs to extend the replicating portfolio, adding more financial instruments to replicate the payoff. Whenever the $\beta_{MKThigh}$ is significantly different from zero, the replicating portfolio can be constructed by taking a long position in a risk-free asset, writing a put option on the market index and being long a call option on the same market index. Moreover, the price of the replicating portfolio can be stated as

$$V_0^{RP} = B_0 + C_0(S, K, \sigma, r_f, T-t) - P_0(S, K, \sigma, r_f, T-t)$$

This relationship is derived from the put-call parity and should be equal to the value of the underlying security. To replicate the merger arbitrage payoffs, a modification of the put-call parity is therefore required. This adjustment is accomplished by modifying the fractional holding in both the call option and the put option with the exact positions being determined by $\beta_{MKThigh}$ and β_{MKTlow} respectively. The strike price is determined by $\$100(1+rf+Threshold)$ and is thus varied for each estimated threshold. The result of this is that the portfolio's payoff profile is identical to the slopes which are illustrated in figure 6.11. The price of the replicating portfolio is therefore stated as

$$V_0^{RP} = B_0 + \Bigg[C_0(S, K, \sigma, r_f, T - t)\beta_{MKThigh}\Bigg] - \Bigg[P_0(S, K, \sigma, r_f, T - t)\beta_{MKTlow}\Bigg]$$

This thesis extends on the face value of the bond which is defined in Mitchell and Pulvino 2001 [2] as mentioned in section 4.3.2.2. Since this thesis finds a significant $\beta_{MKThigh}$, a call option is required to perfectly replicate the payoff of the strategy. As a result of this extension, the thesis needs to adjust the estimation of the face value of the risk-free asset. The extended calculation on the face value of the bond is quantified as

$$\$100\Bigg[1 + \alpha_{MKThigh} + \beta_{MKThigh} \cdot Threshold\Bigg]$$

It is worth noting here that this equation is the same as that which is applied in Mitchell and Pulvino 2001 [2] in the specific case where $\beta_{MKThigh} = 0$ and the last term is zero.

Table 6.13 contains the prices for the various replicating portfolios which are calculated using three different threshold levels. To estimate the weekly excess returns, the price of the replicating portfolio V_0^{RP} is compared to a comparable investment in the merger arbitrage portfolio of \$100. Given that the price of all replicating portfolios V_0^{RP} presented in table 6.13 is consistently higher than \$100, it is clear that the merger arbitrage portfolio produces excess returns no matter which of the three different portfolios or thresholds are examined. For instance, the price of the replicating portfolio for the equally weighted portfolio with a -2% threshold is \$100.16, which means it is priced 16 basis points higher compared to the \$100 investment in the merger arbitrage strategy, which therefore implies that the merger arbitrage strategy produces a weekly excess return of 16 basis points (8.32% annualized). Notably, the merger arbitrage portfolio has produced weekly excess returns between 7 basis points and 17 basis points depending on the chosen threshold and portfolio constellation. The aggregate maximum 10% portfolio has produced the lowest excess returns between 7 and 8 basis points, while the value weighted portfolio has produced slightly higher excess returns (in between 8 and 9 basis points). The equally weighted portfolio has outperformed both with excess returns which are almost twice that of the two value weighted portfolios, producing excess returns of 16 and 17 basis points depending on the threshold which is applied. In section 6.3.1, it was demonstrated how the merger arbitrage portfolios produce substantial risk-adjusted returns, both when subjected to the CAPM and Fama-French risk factors. Examining the aggregate merger arbitrage portfolios in the nonlinear setting provides further support to the conclusion that the merger arbitrage strategy has historically been able to produce significant economic returns.

		Equally Weighted	Value Weighted	Max 10%
Inputs				
r_f	0.020			
σ	0.180			
$T-t$	1/52			
S	100			
		Threshold I (-0.02)		
B_T		100.04	99.93	99.92
K		98.04	98.04	98.04
B_0		100.00	99.90	99.88
$C_0(S,K,\sigma,r_f,T-t)\beta_{MKThigh}$		0.24	0.24	0.24
$P_0(S,K,\sigma,r_f,T-t)\beta_{MKTlow}$		0.09	0.06	0.05
V_0^{RP}		100.16	100.08	100.07
		Threshold II (-0.03)		
B_T		99.91	99.83	99.80
K		97.04	97.04	97.04
B_0		99.87	99.79	99.76
$C_0(S,K,\sigma,r_f,T-t)\beta_{MKThigh}$		0.34	0.33	0.33
$P_0(S,K,\sigma,r_f,T-t)\beta_{MKTlow}$		0.05	0.03	0.02
V_0^{RP}		100.17	100.09	100.08
		Threshold III (-0.04)		
B_T		99.77	99.72	99.69
K		96.04	96.04	96.04
B_0		99.73	99.69	99.65
$C_0(S,K,\sigma,r_f,T-t)\beta_{MKThigh}$		0.46	0.42	0.44
$P_0(S,K,\sigma,r_f,T-t)\beta_{MKTlow}$		0.02	0.02	0.01
V_0^{RP}		100.17	100.09	100.08

Table 6.13: Illustrates the prices of the different replicating portfolios for three different threshold levels I, II and III which are set at -2%, -3% and -4% respectively. The inputs are constant for all of the models. r_f is the weekly sample average over the time period annualized. The σ is the volatility of the market index, calculated as the standard deviation of weekly returns multiplied by square root of 52. The S is the underlying market index level. $T-t$ refers to the time from 0 to one week.

As can be observed in table 6.13, the excess returns of all portfolios increase whenever the threshold decreases. These results seem counter intuitive at first, since it implies that whenever the β_{MKTlow} is increasing, the excess return of the strategy is also increasing. However, when investigating the drivers of the BSM model individually it can be noted that the call price is decreasing in strike price. As a lower threshold results in a lower strike price, the call price will increase as the threshold decreases. In addition to the increase in call price, whenever the threshold is decreasing the β_{MKTlow} is also increasing, causing the portfolio to invest a larger fraction in the call option. As with the call option the market beta related to the down market is increasing in decreasing markets, which implies that the negative position in the put option increases. However, the price of the put option itself decreases whenever the strike price is decreasing resulting in an overall increase in the portfolio value.

The thresholds presented in table 6.13 represent a diverse choice of various economic thresholds. When applying the original threshold of -6.51% which minimizes the SSE for the value weighted merger arbitrage portfolio, the three merger arbitrage portfolios produce annualized excess returns between 4.11% and 8.86% which is quite close to the results obtained previously with thresholds between -2% and -4%. When setting the threshold to 0%, the annualized excess returns are between 3.64% and 7.46%. Combined, these results demonstrate that the merger arbitrage strategy has produced positive risk-adjusted returns and is robust to different choices of the threshold level.

The analysis which is conducted in this paper differs in several aspects from the analysis conducted in Mitchell and Pulvino 2001 [2]. Mitchell and Pulvino notably conclude that the merger arbitrage strategy is comparable to writing put options on the market index. This paper finds instead that the merger arbitrage strategy is both similar to writing the aforementioned put options, while at the same time also holding a long position in call options on the market index with equal strike prices. Both this paper and Mitchell and Pulvino find that estimating excess strategy returns in a nonlinear setting results in significant abnormal returns.

6.4 Summary and Final Discussion

In all models and portfolio constructions which are investigated, the merger arbitrage strategy has managed to produce positive risk-adjusted returns. Firstly, in the most simple approach, the merger arbitrage strategy was shown to have attained a higher Sharpe ratio than the general market. Secondly, merger arbitrage was shown to have produced a positive alpha, both when applying the CAPM and the Fama-French 3 factor model. Finally, positive risk-adjusted returns were also found when examining the merger arbitrage strategy with a contingent claim performance evaluation.

Predicting the Merger Outcome

When conducting the regressions to predict the probability of a successful merger outcome, this paper applies logistic regressions with the specific parameters being estimated through the maximum likelihood estimation method. The paper acknowledges that there are multiple methods which can be applied to estimate these probabilities, for example, one could apply a probit regression model or make use of more advanced statistical methods. The two models aim at solving the same issue, however, they have different assumptions regarding the distribution of the errors.

When conducting the regression analysis presented in table 6.1, it can be noted that for the "PE" coefficient's significance increases when combined in the multivariate regression. This result appears peculiar due to the fact that a covariate should not explain more about the response variable when combined with other covariates. The changing significance may be due to confounding, i.e., the independent variables are not truly independent from each other, but share common characteristics. For example, PE firms offer lower premiums on average, and are notably never in the same industry as their target firms. The results are, therefore, likely to be influenced by these dependencies which make the results more uncertain from a statistical point of view.

In this thesis the most significant factors for determining the deal outcome are the "Industry" and "Domestic" covariates. However, these results are from regressing against a selected sample of factors (presented and explained in section 6.1), and do not necessarily need to be true for the entire universe of factors.

Linear vs Nonlinear Approaches

Clearly demonstrated when examining the relationship between the excess return of merger arbitrage strategy and the market, this paper finds evidence that a substantial increase in correlation occurs during a market decline. This result suggests that there exists a nonlinear relationship between the merger arbitrage strategy and the market returns, which therefore implies that nonlinear regression modeling is best suited when risk-adjusting the return estimates for the strategy. This hypothesis is supported through the provided results when conducting both linear and nonlinear analysis. Even though the estimations do not differ to a great extent, the contingent claim analysis still provides a slightly better fit for the return estimates of the portfolio. Furthermore, the linear regression models underlying assumptions regarding the distributions of the error terms, which does not hold for the sample, and therefore provide outputs which carry great uncertainty to them.

Overall, the piecewise linear regression model provides a better fit to the specific return data due to the additional kink. However, it will always be the case that any additional kink in the regression line results in a model which is better fitted to the data. A relevant issue is therefore to consider whether there is an economic rationale for including this kink. Due to the findings that the beta increases significantly during down markets, this is assumed to be a reasonable assessment.

Liquidity

No matter how the returns created from merger arbitrage are risk-adjusted, it is clear that the strategy has historically produced large excess returns. A key difference which is observed for both the linear and nonlinear regressions is that the equally weighted aggregate portfolio produces substantially higher returns than the value weighted portfolios. Since the difference between the equally and value weighted portfolio approaches is the relative weighting of large and small cap stocks, based on each asset's market value of equity (MVE), a natural question is whether the large increase in excess returns are derived from smaller illiquid stocks. When evaluating the explanatory power of merger success in section 6.1, the MVE variable was found to significantly increase the probability of success for individual deals.

To obtain further insight into this variable, which also serves as a proxy for liquidity, a test is conducted regressing each individual asset's excess return on their respective logarithm of MVE. The regression shows that returns are decreasing in the MVE, a finding which is significant at the $\alpha = 0.1\%$ level. The implication of this finding is, therefore, that the target firms which produce the largest returns to an arbitrageur are also the firms which are most illiquid. Although merger arbitrage does produce risk-adjusted returns, it is likely that the possibility of obtaining those returns decrease significantly for larger institutional investors who are unable to purchase a large amount of target shares. Furthermore, the increase in the probability of success caused by the MVE variable suggests that investors are compensated by a higher excess return in smaller target firms as they are more likely to be terminated.

Another interesting finding pertains to the arbitrage spread for different MVEs. Appendix VI demonstrates the average arbitrage spread on the day of announcement for different levels of the MVE. It is clear that for smaller merger targets, the arbitrage spread is considerably lower than it is for larger target firms. However, the probability that the merger is successful drops only very slightly. This means that it is possible for an investor to earn considerably higher returns from these small mergers. The caveat, however, is that since the market value of equity is small, these smaller firms will hardly be relevant targets for any but the smallest institutional investors.

Combined, all of these findings provide evidence that most of the profits which are available from the merger arbitrage strategy are derived from smaller, more illiquid stocks. It is likely that the merger arbitrage strategy faces more severe competition in larger and more liquid stocks due to the increased number of institutional investors who may drive abnormal profits down.

Development Over Time

To examine the extent to which the merger arbitrage strategy has changed over the time period 1998 to 2017, the sample is divided into two parts. A natural cutting point in the sample used for this period is the financial crisis. As a result, the time horizon has been divided into two periods: 1998-2007 and 2008-2017. An interesting observation when conducting these analyses is that the abnormal returns produced, both for equally and value weighted, decrease in the second period. More specifically, for the period 1998 to 2007, the annualized α is 13.9% for the equally weighted and 6.6% for the period 2008 to 2017. For the value weighted portfolio, the annualized α is 7.8% for the first period while it is 4.7% for the second period.

This finding illustrates that the risk-adjusted returns of merger arbitrage have decreased significantly over time. A possible implication of this finding can be that the amount of capital allocated to exploiting the merger arbitrage strategy has increased in the most recent decade. Another explanation could be that the correlation between the return estimates of the strategy and the market has increased. As can be seen in Appendix IV, the R^2 increases substantially in the latter time period. In particular, for the equally weighted portfolio, the R^2 is 0.02 for the period 1998-2007, while for 2008-2017 it is recorded at 0.299. Evidently, the market has more explanatory power over the response variable. Furthermore, the beta for both portfolio constructions is significantly larger in the second decade. The smaller alpha can thus be explained both by a decrease in the overall returns produced by merger arbitrage as well as the increased correlation with the market. Another finding is that the relative weight of cash deals is higher in the second decade. Section 4.3.1 demonstrated that cash deals are associated with higher betas and it is thus likely that this further explains the increase in the beta value over time.

7 Conclusion

This paper has analyzed merger arbitrage returns consistent with previous studies which this paper believes are key studies on the topic of merger arbitrage, in order to investigate how the strategy is able to produce risk-adjusted returns in a contemporary setting. This paper will now recall the research question from chapter 1

To what extent has merger arbitrage been able to generate significant risk-adjusted returns in the US stock market in the period from 1998 to 2017?

In section 6.2 and 6.3, a large amount of evidence is provided which demonstrates that merger arbitrage has outperformed the market when taking various risks into account. When adjusting for the market index risk with the CAPM, risk-adjusted returns are found to be between 4.42% and 8.56%. Moreover, when adding additional risk factors such as the Fama-French "SMB" and "HML" factors, the strategy still managed to produce excess returns between 3.60% and 8.40%. By applying a contingent claim pricing approach, the risk-adjusted returns are found to be between 3.64% and 8.84%. An equally weighted approach has vastly outperformed a value weighted approach across the analyzed time period, while a portfolio of cash offers has outperformed a comparable portfolio of stock offers. However, all of these results remain hypothetical and do not take into account issues related to real life implementation, such as transaction costs.

Although this paper finds that the merger arbitrage strategy has produced significantly risk-adjusted returns in the time period 1998-2017, returns have become lower than found by other researchers prior to 1998, which implies that the financial markets have become more efficient and the strategy more competitive.

8 Further Research

This paper has examined different variables related to the merger process to determine their explanatory power on the probability that a deal is successful. Logistic regressions have been conducted with different factors which the authors have chosen based on their intuition. An interesting topic for further research could be examining other factors, to identify which factors hold the most explanatory power over the deal outcome.

Previous research has mostly been concerned with examining the merger arbitrage strategy in the US market, although some literature treats the performance of the strategy in different large markets. It is likely that research conducted in countries which have smaller and less developed capital markets will be faced with more obstacles, as sample sizes are inevitably smaller and different regulations may interfere with the realistic implementation of a merger arbitrage strategy which is comparable to the one analyzed within this paper. As time progresses and more data becomes available, the prospects for conducting research on smaller markets will likewise improve.

This paper finds that the merger arbitrage strategy has managed to produce risk-adjusted excess returns. However, this paper has ignored the impact of transaction costs. Therefore, this paper cannot conclude that the merger arbitrage strategy is able to produce excess returns when transaction costs are accounted for. If the excess returns produced are equal to the average transaction costs a market participant is facing, the merger arbitrage strategy fails to produce excess returns. Incorporating transaction costs would, therefore, provide a more realistic implementation when studying merger arbitrage further.

In order to validate and collect results which are comparable with previous studies, this paper has applied the CAPM, Fama-French 3 factor model, piecewise linear model, and contingent claim analysis in order to risk-adjust the returns. However, further research could be conducted with the aim of constructing a risk-adjustment model which explains the returns of the merger arbitrage strategy to a greater extent.

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Appendices

Appendix I

Target		Acquirer	
Software	310	Private Equity	411
Banks	274	Banks	394
Internet	254	Software	210
Commercial Services	233	Pharmaceuticals	192
Retail	228	Telecommunications	178
Telecommunications	213	Investment Companies	153
Savings&Loans	200	Computers	138
Healthcare-Products	189	Internet	133
Pharmaceuticals	168	Commercial Services	123
Computers	166	Insurance	122

The 10 most represented industries for both target and acquiring firms.

Appendix II

	Equally Weighted			**Value Weighted**			**Max 10%**	
$\mathbf{R_{MKT} - r_f}$	Agg	Cash	Stock	Agg	Cash	Stock	Agg	N
$\leq -6\%$	0.72	0.80	-0.34	0.51	0.62	-0.30	0.45	18
$\leq -5\%$	0.70	0.80	-0.36	0.48	0.62	-0.27	0.43	29
$\leq -4\%$	0.62	0.71	-0.29	0.39	0.58	-0.21	0.35	57
$\leq -3\%$	0.60	0.68	-0.21	0.36	0.53	-0.11	0.33	88
$\leq -2\%$	0.55	0.63	-0.18	0.33	0.49	-0.06	0.32	158
$\leq -1\%$	0.51	0.60	-0.17	0.29	0.45	-0.05	0.32	280
$\leq \pm 0\%$	0.47	0.57	-0.21	0.25	0.43	-0.07	0.30	461
Total	0.45	0.56	-0.20	0.28	0.46	-0.01	0.34	1043

Displays the weekly correlation as a function of different thresholds (ranging from 0% to -6%) for the excess return on the market, for the different portfolios. "N" denotes the number of observations recorded below the threshold. "Total" refers to the overall correlation for the whole sample without imposing any threshold constraint.

Appendix III

$\mathbf{R_{MKT} - r_f}$	**Equally Weighted** Agg	Cash	Stock	**Value Weighted** Agg	Cash	Stock	**Max 10%** Agg	N
$\leq -6\%$	0.03	0.21	-0.58	-0.06	0.14	-0.36	-0.21	18
$\leq -5\%$	0.15	0.31	-0.51	0.02	0.21	-0.29	-0.10	29
$\leq -4\%$	0.18	0.31	-0.48	0.09	0.20	-0.26	0.01	57
$\leq -3\%$	0.27	0.39	-0.38	0.10	0.20	-0.17	0.02	88
$\leq -2\%$	0.24	0.37	-0.39	0.12	0.23	-0.13	0.05	158
$\leq -1\%$	0.27	0.39	-0.36	0.08	0.24	-0.15	0.03	280
$\leq \pm 0\%$	0.27	0.41	-0.400	0.07	0.22	-0.16	0.02	461
Total	0.36	0.46	-0.23	0.23	0.44	-0.05	0.25	1043

Displays the monthly correlation as a function of different thresholds (ranging from 0% to -6%) for the excess return on the market, for the different portfolios. "N" denotes the number of observations recorded below the threshold. "Total" refers to the overall correlation for the whole sample without imposing any threshold constraint.

Appendix IV

	Equally Weighted	Value Weighted
Panel I: 1998-2007		
α	0.0116	0.0065
β_{MKT}	0.0471	0.0199
N	120	120
R^2	0.0205	0.0012
Panel II: 2008-2017		
α	0.0055	0.0038
β_{MKT}	0.2156	0.2264
N	120	120
R^2	0.2992	0.1830

Displays the results from regressing the excess return of the equally and value weighted portfolio against the CAPM, split in two different time periods. β_{MKT} refers to the excess return of the market.

Appendix V

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.069226398
R Square	0.004792294
Adjusted R Square	0.004440879
Standard Error	0.085398354
Observations	2834

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.099453939	0.099453939	13.63713031	0.000225945
Residual	2832	20.65343285	0.007292879		
Total	2833	20.75288678			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.029740165	0.005193363	5.726571223	1.13247E-08	0.019557008	0.039923323	0.019557008	0.039923323
Ln(mve)	-0.003293439	0.000891842	-3.692848536	0.000225945	-0.005042165	-0.001544712	-0.005042165	-0.001544712

Appendix VI

MVE	Average Arbitrage Spread	Number of Deals
0-100	0.077	1075
101-200	0.054	478
201-500	0.044	661
501-1000	0.026	405
>1000	0.041	788