Research and Development of Risk Arbitrage Trading Systems

by

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Submitted to the
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Abstract

The risk arbitrage investment process involves betting on the outcome of announced mergers and acquisitions. We analyzed a sample of 1309 stock and cash mergers from 1996 to 2004 Q2 and developed insights into the risk arbitrage process. We found share price reactions for both the acquirer and target companies as a result of the merger announcement and compared these to factors such as type of merger, premium paid by the acquirer for the target, relative size of the deal to the size of the acquirer and target, and deal consummation time. We utilized this information to develop a merger return prediction model that predicts a merger's return given various deal characteristics. We constructed several portfolios, one using a trading strategy in which we invest equally in every announced deal, one where we invest only in deals that have a predicted return higher than two times the T-Bills rate, one where we invest in deals that have a predicted return higher than 0, and one where we invest in deals with a predicted return higher than one standard deviation of the predicted returns. A subsequent out of sample analysis of generating a predicted return model using data from 1996 to 1999 and predicting returns from 2000 to 2004 Q2 produces returns of 4.96%, 3.14%, and 5.87% for our three portfolios compared with 1.74% generated from investing in all deals from 2000 to 2004 Q2. Our study shows that our strategy focuses mainly on cash deals but our strategy still makes improvements in the Sharpe Ratio despite this limitation. Our analysis provides insights into mergers and how the market prices such deals. Furthermore, the trading strategies employed can be used as a basis for constructing a profitable risk arbitrage trading platform.

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Chapter 1

Introduction

The definition of arbitrage is the purchase of an asset or security at a certain price and the subsequent selling of that same asset or security at another price resulting in a net profit. Within the realm of finance, there are many types of arbitrage. There is convertible arbitrage, fixed income arbitrage, capital structure arbitrage, and risk arbitrage.

Convertible arbitrage involves the purchase of convertible bonds while shorting the underlying equity as a hedge. Fixed income arbitrage involves profit seeking through the exploitation of price differences between related fixed income securities, these could rage from something as simple as government bonds to more complex structures like mortgage-backed securities. Capital structure arbitrage is similar to convertible arbitrage. In this case, the arbitrageur takes advantage of discrepancies that occur between the prices of securities that are issued by the same issuer. An example of this would be exploiting the difference in value between a company's bond issuance and the value of its underlying equity issuance. The theory behind this is that relative performance of a company's debt and equity should be correlated since they both are claims to the same assets. Thus if one sees a company's bond outperforming its stock then he can take a long/short position in the hopes that the relative prices will eventually converge.

1.1 Risk Arbitrage Background

Risk arbitrage is considered an event driven process, which means that it is centered on actual events that take place. Risk arbitrage focuses on corporate events such as a company merger or acquisition announcement, spin off, or reorganization. However the broader term of event driven encompasses other things as well such as the release of macroeconomic data like the payroll number, consumer price index, producer price index, employment numbers, GDP, trade deficit announcements etc. Event driven strategies may also involve taking views on the effect of political situations or Federal Reserve actions. This thesis focuses solely on the analysis and development of risk arbitrage trading strategies; a study involving all types of possible arbitrage would be of much greater scope than what is feasible.

Arbitrage techniques have become increasingly prominent among financial professionals. Many hedge funds employ these techniques to help generate the lofty returns that their investors have come to expect in return for their high management and commission fees. Large investment banks have also been increasingly involved in the arbitrage business as margins from the traditional investment banking and advisory businesses have shrunk. Risk arbitrage in particular first gained popularity in the 1980s thanks in large part to the corporate takeover frenzy. Today it has become an indelible staple in many financial professionals' arsenal for generating profit.

As mentioned, risk arbitrage involves betting on the outcome of corporate events, the majority of which are mergers and acquisitions. A corporate merger is defined as a combination of the assets and liabilities of two firms to form a single business entity. The main difference between a merger and an acquisition is that

"acquisition" is defined as when a larger firm absorbs a smaller firm while "merger" refers to a combination between firms of relatively equal size. There is also the technicality of which firm is the acquiring firm and which firm is the target firm. In a hostile takeover or acquisition these are easy to identify, as it is usually the larger firm or the one taking the initiative that is deemed the acquirer. However, in a merger of firms that are approximate equals, the acquiring company is usually defined as the one whose shares continue to exist while the target firm is the one whose shares are being replaced by the acquiring firm.

Theoretically, the post-merger value of the two firms should be equal to the pre-merger value. However, the post-merger value of each individual firm will likely be different. Usually the target firm's value will increase because of the premium that the acquiring company usually pays.

The reason why companies merge in the first place is to take advantage of synergies, which take the form of revenue enhancement and cost savings. When two companies in the same industry merge, revenues will usually decline since the businesses overlap. However, the hope from both sides is that the amount of cost savings that occurs is able to offset the decline in revenue.

In risk arbitrage, the arbitrageur typically takes a situation with a finite number of outcomes, predicts the likelihood of each outcome, then invests accordingly. For example, a risk arbitrageur may be betting on whether or not a company merger will be successful. In this case, he may need to predict how likely it is that the merger vote passes and decide what directional view to take on the company's stock. If the shareholders approve the merger, the stock price may go up and thus the arbitrageur

should go long the stock if he feels the merger will be approved. On the other hand, if the shareholders reject the merger, the stock price may go down in which case the arbitrageur should short the stock in anticipation of this event. In essence the risk arbitrageur has to take into account all the factors that may cause a merger to be unsuccessful; such factors include execution risks, integration difficulties, and antitrust hurdles.

1.2 Previous Work

A large portion of our study was devoted to the analysis of initial shareholder reaction to deal announcement. Shleifer and Vishny [1] and Verter [2] analyzed merger characteristics from a shareholder reaction perspective in 1997 and 2003, respectively. We were able to obtain results consistent with theirs and used our results to act as motivation for the development of our predicted return model and risk arbitrage trading strategies.

Though the exact amount of return generated by risk arbitrage strategies for financial professionals is proprietary information, various academic researchers have performed studies that show the amount of return generated by risk arbitrage. Among the studies that make risk arbitrage seem most enticing were a pair of studies conducted by Dukes, Frohlich, and Ma [3] in 1992 and Jindra and Walking [4] in 2002. Focusing solely on cash tender offers between 1971 and 1985, these researchers found risk arbitrage strategies would generate returns exceeding 100%. Though this is astounding figure high enough to raise doubts in most people's minds, other work has substantiated these findings though finding returns not nearly as high. Baker and Savasoglu [5] were

able to document annual returns of 12.5% between 1981 and 1996. Perhaps the most comprehensive study of risk arbitrage was done by Mitchell and Pulvino [6] in 2001. Analyzing a sample of 4,750 mergers from 1963 to 1998, they found risk arbitrage to generate annual returns of 4% per year. One of this thesis' main inspirations, Akshay Naheta's study [7] employed trading strategies that generated returns in excess of 4.5%. We expanded upon this study by utilizing a larger data set, taking into account target share price reaction, and also studying how company leverage, defined as a company's debt value over its equity value, affects the risk arbitrage process. Regardless of what various academic studies have shown, risk arbitrage has proven to be a sustainable profit generating strategy for many finance professionals.

1.3 Thesis Contributions

In this thesis we find insights into the risk arbitrage process and develop suitable trading strategies that are able to apply these findings and generate positive risk-adjusted returns. Our data set is a sample of 1309 stock mergers and cash mergers from 1996 to 2004 Q2. Table 1 below illustrates the data set used for our analysis.

Table 1. Data set used for analysis, Source: GSI Online.

Deal Status	# of Deals	% of Deals	Aggregate Value
Completed	1178	90.0%	5.30E+12
Uncompleted	131	10.0%	1.00E+12
Total	1309	100%	6.30E+12

Of the 1309 deals analyzed, 1178 or 90% of them were completed and 131 or 10% of them were uncompleted. The aggregate value of the deals was $6.3 trillion with completed deals constituting $5.3 trillion or 84% of the total deal value and uncompleted deals constituting $1.0 trillion or 16% of the total deal value.

This was a study of market efficiency. Past researchers have found the markets to be fairly inefficient and thus realized the presence of profit opportunities. We determined and quantified how efficient the market is at pricing announced merger deals and from this information formulated trading strategies that take advantage of this information.

One of the key components to any merger deal is the initial shareholder reaction. We analyzed this reaction for both the acquirer and target companies of each deal and determined how market related and merger characteristics contribute to such reactions. Among the factors we looked at were the type of transaction, the premium paid by the acquirer for the target, the relative acquirer and target sizes to the deal value, and the deal consummation time.

Many risk arbitrage studies invest equally across all announced deals and generate their returns in such a way. We generated one such portfolio this way as well and found annual returns in excess of 3.5%. We also employed another more realistic trading strategy by first performing a multiple factor regression to obtain a merger prediction return model. Using the coefficients from this model, we then constructed a portfolio whereby we only invest in deals that have predicted returns exceeding the risk free rate. We found that such a trading strategy generated annual returns in excess of 5%. Our analysis shows that the expected return of a deal depends highly on the deal's

characteristics. Furthermore, it implies that one can utilize publicly available information at the time of deal announcement in formulating a decision of whether or not to invest in the deal. Not only do the results achieved in this thesis give greater insight into mergers and how the market prices such deals, they can also be used as a basis for constructing a profitable risk arbitrage trading platform.

Chapter 2

Company Share Price Reaction

We analyzed how both the acquirer and target company share prices react to the announcement of a merger between the two of them. We used data from the GSI Online's Mergers and Acquisitions Database, part of the Wharton Research Data Services (WRDS). The database contained information on deals of $1 million or more for public, private, US and non-US companies. The set included deals from January 1, 1996 to June 30, 2004. The GSI data set contained very few mergers that were cash and stock combinations so we omitted them and were left with only mergers that were either cash or stock. We used the information in these next few parts to aid in the building of our merger return prediction model which will be discussed in Chapter 3.

2.1 Overall Reaction

Table 2 below summarizes the acquirer and target company share price reaction after a full day of trading after deal announcement.

Table 2. Acquirer and target reaction after deal announcement.

Years	# of Deals	Acquirer Reaction	Target Reaction
1996-2004 Q2	1309	-2.5%	4.3%

We can see from Table 2 that the acquirer's share prices react negatively to a deal announcement, trading down 2.5% after a full day of trading after the deal

announcement. This is perhaps due to a cautious reaction by investors to the execution risks associated with a merger or acquisition. Another probable cause for this is the shorting of acquirer shares by risk arbitrageurs. Typically in a stock merger or acquisition, risk arbitrageurs will short some of the acquirer's shares, thus contributing to the decline in share price. It should also be noted that the acquirer shares do not rebound much from their initial reactions in the days following a deal announcement. This could be due to investors' continued concerns of execution risks as well as continued shorting by risk arbitrageurs as they increase their positions.

Contrary to the acquirer share price reaction, the target's share prices react positively to a deal announcement, trading up 4.3%. The reasoning behind this could be, once again, two fold. On one hand there are investors who react positively to such an announcement due to the premium usually associated with such deals and on the other hand there are risk arbitrageurs who take long positions on the target shares after deal announcement. Both of these factors could account for the increase in the target's share price. The target shares also do not decline much from their initial reaction in the days following deal announcement. This could be due to the continued positive reaction from investors to the premium offered for the target shares as well as continued buying by risk arbitrageurs building their positions.

2.2 Reaction by Consideration Type

Table 3 below summarizes the acquirer and target company share price reaction segmented into whether the deal was a cash or stock transaction.

Table 3. Acquirer and target reaction based on type of consideration.

Type of Transaction	# of Deals	% of Deals	Acquirer Reaction	Target Reaction
Cash	594	45.4%	-0.2%	4.8%
Stock	715	54.6%	-4.4%	3.8%

A little fewer than half the deals were cash while the rest were stock. As mentioned earlier, we omitted cash/stock combo deals due to the low incidence of them in our dataset. We see from Table 3 that the acquirer's shares trade down only 0.2% following a cash deal announcement. This substantiates what many risk arbitrage professionals already knew, that is that the acquirer share price reacts minimally to a deal announcement if it is an all cash deal. This could be explained by investors reacting less cautiously due to perceived lower execution risks because the acquirer is offering to pay for the target in cash thus creating little financial impact since the acquirer is spending its cash reserves and cash deals are usually smaller than stock deals. Another reason for the minimal acquirer share price reaction is that risk arbitrageurs do not short the acquirer shares in all cash deals. The risk arbitrage process for cash deals involves buying the target shares. Nothing is done with the acquirer shares. Thus we would expect that a deal announcement has little effect on the acquirer share price. However, for an all stock deal, the acquirer's shares trade down 4.4%. This could be explained by investor skepticism to the high execution risks involved in all stock transactions. As mentioned, stock deals are typically much larger than cash deals and the acquirer is not offering to buy the target using its cash reserves thus a greater level of execution risk is

involved. Risk arbitrageurs also short sell the acquirer shares for all stock deals so this selling could also be a contributing factor to the adverse share price reaction.

The target's shares trade up 4.8% following a cash deal announcement. This could be due to the positive reaction from investors at the high premiums usually offered for the target shares. Purchasing of target shares by risk arbitrageurs following deal announcement could also contribute to this rise in share price. For an all stock deal, the target's shares trade up 3.8% following deal announcement. While this is still a sizable increase, it is not as big as the reaction following a cash deal announcement. This difference could be attributed to the fact that usually all stock deals do not involve as high premiums as all cash deals and thus investor as well as risk arbitrageur reaction could be somewhat subdued.

2.3 Reaction by Premium Offered

Table 4 below summarizes the acquirer and target company share price reaction segmented by the premium offered for the target by the acquirer.

Table 4. Acquirer and target reaction based on premium offered.

Premium	# of Deals	% of Deals	Acquirer Reaction	Target Reaction
Less than 20%	603	46.1%	-1.3%	3.6%
20-39%	445	34.0%	-3.1%	4.7%
40-59%	155	11.8%	-4.0%	4.8%
60-79%	60	4.6%	-4.1%	5.1%
80% and up	46	3.5%	-5.0%	5.7%

Around 80% of the deals consisted of premiums less than 40% while only 20% of the deals consisted of premiums greater than 40%. We observe that the acquirer's shares react more negatively as the amount of premium offered increases, going from -1.3% to -5.0%. This could be due to the fact that the higher the premium offered, the more cautious investors are of a deal's execution risks because of the perceived notion that the acquirer is paying top dollar for the target. A company's stock price is usually a reflection of its future expected returns and investors tend to be skeptical of such returns when a company is paying a high premium for another company. Investors could view the additional premium as money that could be spent on improving other proven profit generating areas of the business rather than on the acquisition of another company.

Interestingly, we observe that the target's shares react in an opposite way of the acquirer's shares, going from +3.6% to +5.7%. That is, the higher the premium offered the more positive the target shares prices react. This makes intuitive sense because higher premiums will generally be perceived in a positive light by investors because it is a sign that their portfolio company is viewed favorably. High premium deals could also attract more buying from risk arbitrageurs as the higher premiums usually mean greater returns in the risk arbitrage investment process.

2.4 Reaction by Relative Size

Table 5 below summarizes the acquirer share price reaction segmented by relative size of the deal to the acquirer size.

Table 5. Acquirer reaction based on relative size.

Deal Equity Value/Acquirer Market Cap	# of Deals	% of Deals	Acquirer Reaction
Less than 20%	597	45.6%	-1.0%
20-39%	202	15.4%	-3.1%
40-59%	124	9.5%	-3.4%
60-79%	110	8.4%	-4.0%
80% and up	276	21.1%	-4.3%

Over 60% of the deals had relative sizes under 40% though it should be noted that a fairly large portion (21%) of the deals constituted over 80% of the acquirer size. We see that as the size of the deal increases relative to the acquirer size, the acquirer's share prices react more negatively, up to -4.3% for relative sizes of 80% or higher. This could be due to the higher amount of execution risk perceived by investors. Since deals of larger relative size are able to impact a company's financials and operations more, there is a larger amount of execution risk associated with them. Deals with small relative size do not affect the acquirer as much which leads investors to believe lower execution risks associated with such deals and consequently there is minimal impact on the company's share price. This could also be because deals of greater size usually have greater premiums associated with them and so this more negative share price reaction is partly due to the increase in premium offered.

Table 6 below summarizes the target share price reaction segmented by relative size of the deal to the target size.

Table 6. Target reaction based on relative size.

Deal Equity Value/Target Market Cap	# of Deals	% of Deals	Target Reaction
Less than 100%	309	23.6%	3.4%
100-120%	325	24.8%	4.1%
120-140%	293	22.4%	4.3%
140-160%	154	11.8%	4.8%
160-180%	81	6.2%	5.1%
180% and up	146	11.2%	5.3%

Nearly half of the deals were between 1 and 1.4 times the target size while nearly 24% of all deals had values less than the size of the target company. Once again we observe an opposite effect for the target's share prices, going from +3.4% to +5.3%. As the relative size of a deal increases, the more positive the target shares react. This could be because as the deal size increases relative to the target size, there is a much greater impact on the target and since target share prices generally trade upwards in the days following deal announcement, this effect is exaggerated. As the case with the acquirer relative size, this could also be because the size of the deal and the premium associated with it are positively correlated and so the increase in target share price reaction is partly due to the premium factor which was discussed earlier.

2.5 Reaction by Deal Consummation Time

Table 7 below summarizes the acquirer and target company share price reaction segmented by deal consummation time.

Table 7. Acquirer and target reaction based on deal consummation time.

Deal Consummation Time	# of Deals	% of Deals	Acquirer Reaction	Target Reaction
0-3 Months	441	33.7%	-2.4%	4.3%
3-6 Months	535	40.9%	-2.3%	4.1%
6-9 Months	224	17.1%	-3.0%	4.4%
9-12 Months	67	5.1%	-2.8%	4.5%
1 year and up	42	3.2%	-2.9%	4.4%

Nearly three quarters of all deals were consummated within 6 months while a little over 3% of deals took over one year. We see that there is no general trend in acquirer reaction associated with an increase in deal consummation time. From a theoretical standpoint, longer deals correspond to higher execution risks so we would expect to see more negative acquirer share price reaction. However, we do not observe such a reaction. This could be because *a priori* investors do not know how long a deal will take to complete unlike the other characteristics of a deal which are known at the time of deal announcement. Thus our study shows that investors are unable to obtain knowledge of deal consummation from deal characteristics.

We also observe no discernable trend in target reaction as deal consummation time increases. This once again could be attributed to investors having little knowledge regarding how long a deal with take to complete.

2.6 Summary of Company Reaction

Our study of 1309 mergers between 1996 and 2004 Q2 revealed many things important in our research of risk arbitrage. These findings are consistent with those described by Shleifer We used many of these findings as motivation for the

development of our predicted return model described later. A summary of our findings is below.

- Acquirer shares trade down 2.5% and target shares trade up 4.3% after a full day after deal announcement.
- Acquirer reaction for cash deals is minimal while for stock deals they trade down 4.4%. Target shares trade up 4.8% for cash deals and 3.8% of stock deals.
- As the premium offered increases, acquirer shares react more negatively, going from -1.3% to -5.0% while target shares react more positively, going from 3.6% to 5.7%.
- As the relative size of the deal to the acquiring company size increases, acquirer shares react more negatively, going from -1.0% to -4.3%. As the relative size of the deal to the target company size increases, target shares react more positively, going from 3.4% to 5.3%.
- Increase in deal consummation time has no effect on acquirer and target share price reactions.

Chapter 3

Risk Arbitrage Returns and Predicted Return Model

The investment process in risk arbitrage is to buy the target company's stock, hold it, and sell it to the acquirer at the time of deal consummation. This holds for a cash merger. In a stock merger, the idea is to short the acquirer's shares and long the target's shares.

The return for each deal is calculated in the following way. For a cash merger, we invest \$1 in the target and short \$1 of the S&P500. When the deal is completed, we sell the target share to the acquirer for the offer price. The gain realized from this is mainly due to the premium paid for the target shares by the acquirer. Shorting the S&P500 allows us to be market neutral and for this to be a self-financing portfolio. We also invest the proceeds from the short sale and earn a rate close to the risk-free rate. For a stock merger, we once again invest \$1 in the target and short \$1 of the S&P500. However, there is one more step. We also short $\frac{N_{acquirer}}{P_{target}}$ shares of the acquirer, which has a monetary equivalent of \$1. $N_{acquirer}$ refers to the number of acquirer shares that are being exchanged for each target share and P_{target} is the price of the target company's stock price after one full day of trading after deal announcement. The gain realized from this is due to the premium paid for the target shares as well as the interest earned at the risk free rate from investing our short sale proceeds.

Failure of a deal to be completed highly hurts a risk arbitrageur's return because a big portion of the profits earned are due to the premium offered. Some of the

roadblocks that could prevent a deal from going through are antitrust issues, management difficulties, shareholder dissent, and tax approval. Some deals are blocked on the grounds of antitrust issues. Many of the more popular deals seen in the news are have to overcome such hurdles before being approved. Management difficulties could also lead to a deal not going through. This is more of an integration problem in which both sides of management are unable to work together smoothly to ensure a deal goes through. Shareholder dissent can also be a big impediment to deal completion. If enough shareholders object to a deal then they can take legal measures to block it. Tax approval also sometimes plays a role as the IRS can block a deal on tax grounds.

3.1 Equally Weighted Portfolio

The equally weighted portfolio was constructed by investing an equal amount into each announced deal. We found the return for each calendar year in our data set. We noticed that cash deals generated much higher returns than non-cash deals. To further investigate this, we divided our data set into cash and non-cash deals. Table 8 below shows the yearly breakdown between cash and non-cash deals. Table 9 below shows the returns for the Equally Weighted Portfolio across all deals as well as divided into cash and non-cash deals.

Table 8. Cash/Non Cash breakdown per year.

Year	# Deals	# Cash Deals	% Cash Deals	# Stock Deals	% Stock Deals
1996	163	65	40.1%	98	59.9%
1997	192	63	32.8%	129	67.2%
1998	195	64	32.8%	131	67.2%
1999	234	98	41.9%	136	58.1%
2000	208	118	56.7%	90	43.3%
2001	124	75	60.5%	49	39.5%
2002	49	26	53.1%	23	46.9%
2003	83	49	59.6%	34	40.4%
2004 Q2	61	35	57.4%	26	42.6%
Total	1309	594	45.4%	715	54.6%

Table 9. Equally weighted portfolio (EWP) return by year.

Year	EWP Return	EWP Cash Deals	EWP Non Cash Deals
1996	4.83%	7.35%	3.14%
1997	9.61%	14.78%	7.09%
1998	14.65%	21.42%	11.34%
1999	23.43%	34.12%	15.73%
2000	9.54%	15.56%	1.65%
2001	-14.34%	-7.86%	-24.26%
2002	-0.10%	4.11%	-4.86%
2003	6.54%	8.41%	3.78%
2004 Q2	7.84%	12.74%	1.24%
Compounded Return	6.78%	10.67%	3.56%
β_{mkt}	0.142	0.167	0.124
Standard Deviation	10.33%	11.67%	11.41%
Sharpe Ratio	0.66	0.91	0.31

We observe from Table 8 that the yearly breakdown between cash and non-cash deals remains generally stable although there is a rise in the percentage of deals that are cash after 1999 and a subsequent decline in non cash deals. Interestingly, we see from Table 9 that the yearly returns are also lower in this period of time than 1996 through

1999. However, it still seems that whether a merger is a cash deal positively affects the returns since the returns on cash deals from 2000 to 2004 Q2 are still greater than returns on non-cash deals.

Over all the deals, we were able to generate a compounded annual return of 6.78% with a standard deviation of 10.33% and a corresponding Sharpe Ratio of 0.66. The cash deal portfolio generated a compounded annual return of 10.67% with a standard deviation of 11.67% and a Sharpe Ratio of 0.91 while the non-cash deal portfolio generated a return of 3.56% with a standard deviation of 11.41% and a Sharpe Ratio of 0.31. To get a better sense of how these returns are distributed within each year, we segmented each year into quarters. Figure 1 below shows how the distributions are distributed over each quarter.

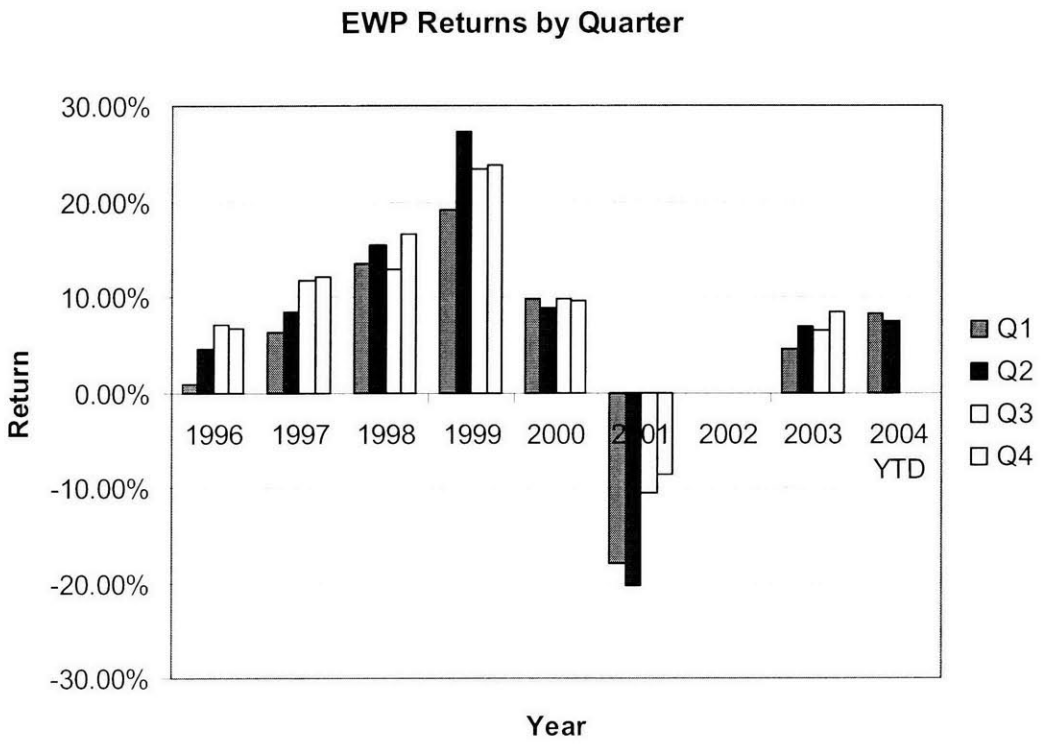

Figure 1. Quarterly equally weighted portfolio returns.

We observe that the second quarter of 1999 produced the greatest returns of any quarter with over 25% return while the second quarter of 2001 produced the lowest return of any quarter with nearly -20% return. The quarterly returns for 2002 were so small that they are not even visible on the figure.

The equally weighted portfolio method of investing assumes that we invest in every announced deal and we do so in an equal amount. However, this was an oversimplified trading strategy which could be improved if we were somehow able to determine which deals would be most profitable and then invest only in those. The method by which we did this was to develop a prediction return model with inputs

being various merger characteristics motivated by our initial findings and the output being the expected return.

3.2 Predicted Return Model

The merger characteristics we used to predict a deal's return were whether the merger was a cash deal or not, the relative size of the acquirer to the S&P500, the relative size of the target to the S&P500, the acquirer leverage, the target leverage, and the number of mergers that took place within the past six month window. Note that a company's leverage was defined as its amount of debt as reported in the balance sheet divided by its market capitalization. The predicted return for each deal was then calculated using the following equation:

$$\Pr edicted\_\mathrm{Re}turn = \beta_1 Cash + \beta_2 \ln(\frac{acquirer\_size}{S\&P500}) + \beta_3 \ln(\frac{target\_size}{S\&P500}) + \beta_4(\frac{acquirer\_debt}{acquirer\_equity}) + \beta_5(\frac{target\_debt}{target\_equity}) + \beta_6(\#mergers) + Intercept$$

Note that the Cash variable is a dummy variable equal to 1 if the deal was an all cash deal and 0 if it was an all stock deal. By running a regression on the return of a deal against these deal characteristics, we were able to obtain the values for the coefficients β_1 through β_6 as well as the intercept. We obtained an R^2 of 0.04572. The coefficients are shown in Table 10 below.

Table 10. Model intercept and coefficients of various merger characteristics.

Merger Characteristic	Coefficient	Standard Error
Cash	0.1836	0.0188
Acquirer/S&P500	-0.0127	0.0030
Target/S&P500	0.0073	0.0050
Acquirer Leverage	0.0602	0.0118
Target Leverage	0.0044	0.0011
# of Mergers	0.0846	0.0387
Intercept	-0.0424	0.0209

We observe that whether a merger is a cash deal or not has the greatest impact on its expected return with a coefficient of 0.1836 while the level of acquirer leverage and the number of mergers in the past six month window also contribute positively to a deal's return. Target leverage plays a positive albeit small role with a coefficient of 0.0044. We also see that the relative size of the target to the S&P500 plays a small positive role however its standard error is so large that it negates this.

3.3 Predicted Return Portfolio

Using these coefficients in our predicted return model, we were able to calculate predicted returns for each deal in our dataset. We opted to invest only in deals in which the expected return was greater than two times the T-Bills rate. Each deal was invested in equally and Table 11 below summarizes our results and places the returns next to the equally weighted portfolio returns for convenient comparison.

Table 11. Predicted return model portfolio (PRM) using twice the T-Bills rate as the cutoff and equally weighted portfolio returns by year.

Year	EWP Return	PRM Return
1996	4.83%	6.23%
1997	9.61%	8.78%
1998	14.65%	14.97%
1999	23.43%	21.54%
2000	9.54%	10.87%
2001	-14.34%	-2.61%
2002	-0.10%	5.73%
2003	6.54%	9.12%
2004 Q2	7.84%	8.14%
Compounded Return	6.78%	9.04%
β_{mkt}	0.142	0.147
Standard Deviation	10.33%	6.61%
Sharpe Ratio	0.41	0.99

We were able to generate a compounded annual return of 9.04% with a standard deviation of 6.61% and a corresponding Sharpe Ratio of 0.99. This is a sizable improvement over the equally weighted portfolio. An interesting year to note is 2001 in which the EWP had a return of -14.34%. Our PRM portfolio was unable to generate positive return that year but was still able to cut down on the negative return. It seems that our predicted return model allows us to be smarter about which deals to invest in rather than blindly investing in all announced deals. To get a better sense of this visually, we plotted the predicted return generated by our predicted return model and the actual return for each deal. This plot is shown in Figure 2 below.

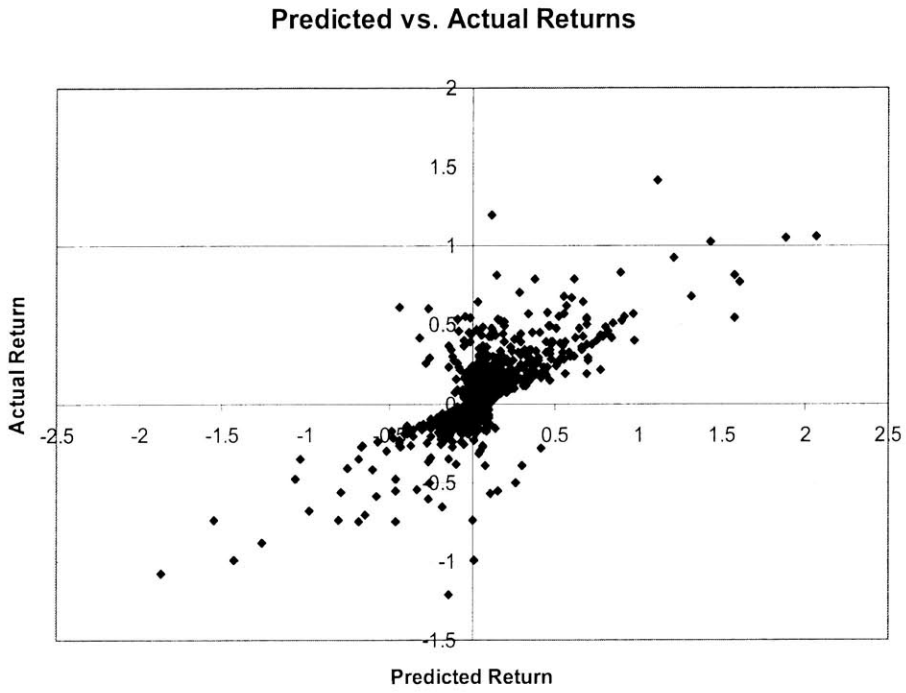

Figure 2. Graph of predicted returns vs. actual returns for all deals from 1996 to 2004 Q2..

We see from Figure 2 that there is a generally linear correlation between our predicted returns and the actual returns. However, for some deals our model predicted a negative return while the actual return turned out to be positive. These deals are depicted by the points in the second quadrant. These can be classified as missed opportunities since we would not invest in these deals based on our PRM strategy yet had we invested in them we would have generated positive returns. There are also some deals in which our model predicted a positive return while the actual return turned out to be negative. These deals are depicted by the points in the fourth quadrant. These are investing mistakes because we invest in most of these deals (the ones that have a

predicted return greater than twice the T-Bills rate) since our PRM model predicted a positive return but the actual return turned out to be negative.

We can observe how the PRM strategy allows us to be smarter about our investment decision since we do not invest in any of the deals depicted by points in the third quadrant while the EWP portfolio would have. All the deals that we invest in are depicted by points in the first and fourth quadrants and while we do make some investing mistakes as described earlier, most of our investments generate positive returns.

3.4 Additional Portfolio Analysis

One issue with most of our earlier analysis was that it was in sample, meaning that we tried fitting our model on the same years that we regressed on to get our model in the first place. To make our study more robust, we then performed a regression only on the deals from 1996 to 1999 and used the generated PRM coefficients to predict the returns for the deals from 2000 to 2004 Q2. We then invested in deals that had a predicted return greater than twice the T-Bills rate. Previously we performed the regression on all deals from 1996 to 2004 Q2 then predicted the returns for all the deals across that time period. This could be seen as looking into the future so we performed this additional analysis. The returns generated are shown in Table 12 below.

Table 12. PRM returns using the T-Bills cutoff for second half of data set using regression coefficients from first half.

Year	EWP Return	PRM Return
2000	9.54%	9.41%
2001	-14.34%	-4.12%
2002	-0.10%	3.47%
2003	6.54%	7.52%
2004 Q2	7.84%	7.95%

Compounded Return	1.74%	4.96%
β_{mkt}	0.139	0.126
Standard Deviation	9.78%	5.47%
Sharpe Ratio	0.18	0.91

We were able to generate a compounded annual return of 4.96% with a standard deviation of 5.47% and a corresponding Sharpe Ratio of 0.91. While these returns are smaller than the ones generated using a PRM that factored in all deals from 1996 to 2004 Q2, they are still greater than the returns generated by our EWP strategy.

As mentioned earlier, we felt that whether a deal was cash or not largely contributed to its risk arbitrage return. We decided to investigate this further by continuing our out of sample study and performing our PRM analysis separately on all cash deals then separately on all non cash deals and compare these results to the EWP. Another thing that we changed in this portion is that we no longer invest in deals that have a predicted return greater than two times the T-bills rate but rather deals that have a predicted return greater than zero or deals that have a predicted return greater than one standard deviation away from the mean of all the predicted returns.

A more visual interpretation of our predicted return vs. actual return for cash and non cash deals is shown is Figures 3 and 4 below. A detailed interpretation of these scatter plots is given on page 31.

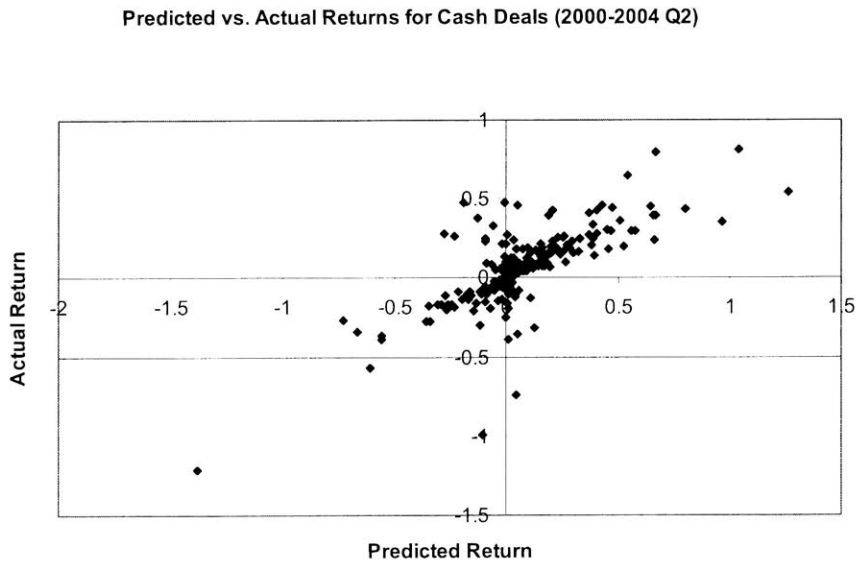

Figure 3. Graph of predicted returns vs. actual returns for cash deals.

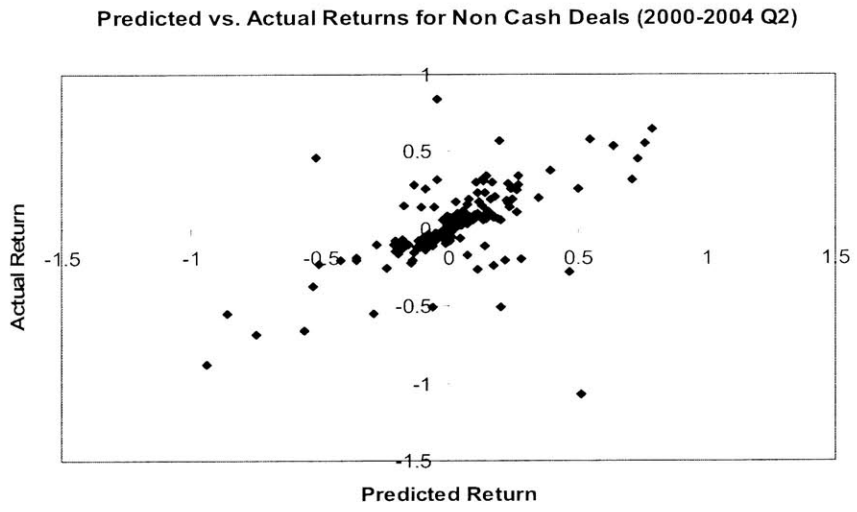

Figure 4. Graph of predicted returns vs. actual returns for non cash deals.

Table 13. Total deals from 2000 to 2004 Q2.

Total Deals for 2000-2004 Q2					
Year	# Deals	# Cash Deals	% Cash Deals	# Stock Deals	% Stock Deals
2000	208	118	56.7%	90	43.3%
2001	124	75	60.5%	49	39.5%
2002	49	26	53.1%	23	46.9%
2003	83	49	59.6%	34	40.4%
2004 Q2	61	35	57.4%	26	42.6%
Total	525	303	57.8%	222	42.2%

Table 13 above merely shows the breakdown of deals between 2000 and 2004 Q2. It is the latter portion of Table 8. Table 14 and 15 below shows the breakdown of all the deals that our two portfolio strategies invest in.

Table 14. Deals invested in using the PRM > 0 cutoff from 2000 to 2004 Q2.

Invested Deals for PRM Return (> 0)					
Year	# Deals	# Cash Deals	% Cash Deals	# Stock Deals	% Stock Deals
2000	126	74	58.73%	52	41.27%
2001	69	41	59.42%	28	40.58%
2002	31	19	61.29%	12	38.71%
2003	61	36	59.02%	25	40.98%
2004 Q2	31	22	70.97%	9	29.03%
Total	318	192	60.4%	126	39.6%

Table 15. Deals invested in using the PRM > σ cutoff from 2000 to 2004 Q2.

Invested Deals for PRM Return (> σ)					
Year	# Deals	# Cash Deals	% Cash Deals	# Stock Deals	% Stock Deals
2000	66	53	80.30%	13	19.70%
2001	41	33	80.49%	8	19.51%
2002	19	16	84.21%	3	15.79%
2003	28	23	82.14%	5	17.86%
2004 Q2	20	17	85.00%	3	15.00%
Total	174	142	81.6%	32	18.4%

As can be observed from Table 14 and Table 15, it seems that as we raise the cutoff our investing strategy contains a higher percentage of cash deals than stock deals. This can be seen since cash deals comprise over 80% of our second strategy's portfolio while only 60% of our first strategy's portfolio. Also our strategy using a cutoff of PRM return > 0 invests in approximately 61% of all the deals, 63% of all the cash deals, and 57% of all the stock deals. Our strategy using a cutoff of PRM return > σ invests in approximately 33% of all deals, 47% of all the cash deals, and only 14% of all the stock deals. Tables 16, 17, and 18 below show our portfolio returns using our new cutoff standards for all deals, cash deals, and non cash deals, respectively.

Table 16. Portfolio returns using differing cutoffs for all deals from 2000 to 2004 Q2.

All Deals			
Year	EWP Return	PRM Return (> 0)	PRM Return (> σ)
2000	9.54%	8.58%	10.32%
2001	-14.34%	-10.67%	-3.97%
2002	-0.10%	2.68%	4.80%
2003	6.54%	6.80%	8.90%
2004 Q2	7.84%	7.83%	9.82%
Compounded Returns	1.74%	3.14%	5.87%
β_{mkt}	0.139	0.124	0.143
Standard Deviation	9.78%	8.00%	5.97%
Sharpe Ratio	0.18	0.39	0.98

Table 17. Portfolio returns using differing cutoffs for cash deals from 2000 to 2004 Q2.

Cash Only Deals			
Year	EWP Return	PRM Return (> 0)	PRM Return (> σ)
2000	15.56%	13.98%	15.48%
2001	-7.86%	-5.74%	-3.89%
2002	4.11%	4.87%	5.42%
2003	8.41%	7.48%	9.13%
2004 Q2	12.74%	11.64%	13.57%
Compounded Returns	6.54%	6.34%	7.87%
β_{mkt}	0.142	0.135	0.140
Standard Deviation	9.17%	7.68%	7.69%
Sharpe Ratio	0.71	0.83	1.02

Table 18. Portfolio returns using differing cutoffs for non cash deals from 2000 to 2004 Q2.

Non Cash Deals			
Year	EWP Return	PRM Return (> 0)	PRM Return (> σ)
2000	1.65%	0.90%	-10.72%
2001	-24.26%	-17.89%	-4.30%
2002	-4.86%	-0.79%	1.49%
2003	3.78%	5.82%	7.84%
2004 Q2	1.24%	-1.48%	-11.43%
Compounded Returns	-4.56%	-2.67%	-3.23%
β_{mkt}	0.154	0.149	0.148
Standard Deviation	11.51%	8.96%	8.20%
Sharpe Ratio	-0.40	-0.30	-0.39

Our cutoff of PRM Return > σ gives us a substantial increase in Sharpe Ratio as opposed to the cutoff of PRM Return > 0 as well as the EWP portfolio. However, this advantage is not so apparent when limiting ourselves to cash only deals as seen in Table 16. The compounded returns are all within 1.5% of each other for all three portfolio strategies. This could be that since the PRM Return > σ strategy invests mainly in cash deals anyway, limiting our samples to only cash deals does not positively affect its returns as much as the other strategies. Table 18 provides even more interesting results in that the PRM Return > 0 strategy actually outperforms the PRM Return > σ strategy. We hypothesize that this is due to the PRM Return > σ strategy missing many profitable (although small) deals due to its cutoff and loses money on the deals that it does invest in. Our results are a bit disheartening since they seem to suggest that our PRM strategy offers little benefit over a strategy that simply invests only in cash deals. However, we should note that the EWP strategy for all cash deals has a Sharpe Ratio of 0.71 while our PRM strategy for all deals has a Sharpe Ratio of 0.98 so there is some improvement.

3.5 Thoughts on Risk Arbitrage Returns

Many previous studies on risk arbitrage concluded that it is able to generate positive returns. In our study, even blindly investing in all announced deals generates positive returns although this strategy would not be so profitable over the past few years. Investing in only in cash deals increases the return since in cash deals the acquirer usually pays a greater premium for the target than in non-cash deals.

One thing we notice is that the PRM strategy lowers the standard deviation of the returns which contributes to the higher Sharpe Ratio. This can be explained by observing Figure 2. The selective deal investing as explained earlier inherent in the PRM strategy cuts down on the variance of the returns we generate and thus our PRM portfolios have a higher Sharpe Ratio than the EWP portfolios. The PRM strategy shows that one can construct a strategy that generates positive returns and improves upon the method of investing in all announced deals. This suggests that there are market inefficiencies in the pricing of mergers and one is able to take advantage of them by analyzing deal characteristics and developing a trading platform that selectively invests in announced deals.

Chapter 4

Summary and Future Steps

4.1 Summary

In this thesis we were able to quantify the risk arbitrage investment process. We first computed various merger statistics and used the results as motivation for the development of a model that could predict risk arbitrage returns. This model takes various deal characteristics as inputs and outputs the predicted return for each deal. We showed that constructing a portfolio based on this model improves upon a portfolio strategy in which one invests in all announced deals. The results obtained in this thesis can be used as the foundation for the development of a risk arbitrage trading platform.

4.2 Future Steps

While we analyzed many deal characteristics that could impact a deal's return, there are many more that were not considered. One factor that could impact a deal is the quality of corporate governance. Andrew Metrick, Paul Gompers, and Joy Ishii [8] studied the balance of power between managers and shareholders and found that a company's stock performed better if it were a so called "democracy firm," meaning shareholders had strong rights. They also found that a company's stock performed worse if it were a "dictatorship firm," meaning weak shareholder rights. They concluded that one could generate annual returns of 8.5% by taking a long position on democracy firms and a short position on dictatorship firms. Since takeovers are often seen as a method for disciplining bad managers, this poses an interesting avenue to

explore; perhaps the quality of corporate governance of the two merging companies especially that of the target, has an effect on the probability of success of a merger.

Quantifying any potential anti-trust or integration problems that may occur could improve our predicted return model as well. It also would not hurt to have a longer data set so that we could test our predicted return model on more years and develop more insight into yearly return variation.

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