THE JOURNAL OF FINANCE • VOL. LVI, NO. 6 • DEC. 2001

Characteristics of Risk and Return in Risk Arbitrage

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ABSTRACT

This paper analyzes 4,750 mergers from 1963 to 1998 to characterize the risk and return in risk arbitrage. Results indicate that risk arbitrage returns are positively correlated with market returns in severely depreciating markets but uncorrelated with market returns in flat and appreciating markets. This suggests that returns to risk arbitrage are similar to those obtained from selling uncovered index put options. Using a contingent claims analysis that controls for the nonlinear relationship with market returns, and after controlling for transaction costs, we find that risk arbitrage generates excess returns of four percent per year.

After the announcement of a merger or acquisition, the target company's stock typically trades at a discount to the price offered by the acquiring company. The difference between the target's stock price and the offer price is known as the arbitrage spread. Risk arbitrage, also called merger arbitrage, refers to an investment strategy that attempts to profit from this spread. If the merger is successful, the arbitrageur captures the arbitrage spread. However, if the merger fails, the arbitrageur incurs a loss, usually much greater than the profits obtained if the deal succeeds. In this paper, we provide estimates of the returns to risk arbitrage investments, and we also describe the risks associated with these returns.

Risk arbitrage commonly invokes images of extraordinary profits and incredible implosions. Numerous articles in the popular press detail large profits generated by famous arbitrageurs such as Ivan Boesky and even larger losses by hedge funds such as Long Term Capital Management. Overall, existing academic studies find that risk arbitrage generates substantial excess returns. For example, Dukes, Frohlich, and Ma (1992) and Jindra and Walkling (1999) focus on cash tender offers and document annual excess returns that far exceed 100 percent. Karolyi and Shannon (1998) conclude

* Harvard Business School and Kellogg School of Management, respectively. We are grateful to seminar participants at the Cornell Summer Finance Conference, Duke University, Harvard University, the University of Chicago, the University of Kansas, the New York Federal Reserve Bank, the University of North Carolina, Northwestern University, the University of Rochester, and the University of Wisconsin-Madison for helpful comments, and to three anonymous referees, Malcolm Baker, Bill Breen, Emil Dabora, Kent Daniel, Bob Korajczyk, Mitchell Petersen, Judy Posnikoff, Mark Seasholes, Andrei Shleifer, Erik Stafford, René Stulz, Vefa Tarhan, and especially Ravi Jagannathan for helpful discussions. We would also like to thank the many active arbitrageurs who have advanced our understanding of risk arbitrage.

that a portfolio of Canadian stock and cash merger targets announced in 1997 has a beta of 0.39 and an annualized return of 26 percent, almost twice that of the TSE 300. In a similar study using a much larger sample of U.S. cash and stock mergers, Baker and Savasoglu (2002) conclude that risk arbitrage generates annual excess returns of 12.5 percent.

These findings suggest that financial markets exhibit systematic inefficiency in the pricing of firms involved in mergers and acquisitions. However, there are two other possible explanations for the large excess returns documented in previous studies. The first explanation is that transaction costs and other practical limitations prevent investors from realizing these extraordinary returns. The second explanation is that risk arbitrageurs receive a risk premium to compensate for the risk of deal failure. In this paper, we attempt to empirically distinguish between these three alternative explanations.

To assess the effect of transaction costs, we use a sample of 4,750 mergers and acquisitions between 1963 and 1998 to construct two different series of risk arbitrage portfolio returns.[1] The first portfolio return series is a calendar-time value-weighted average of returns to individual mergers, ignoring transaction costs and other practical limitations (value-weighted risk arbitrage returns are subsequently referred to as VWRA returns). The second portfolio return series mimics the returns from a hypothetical risk arbitrage index manager (subsequently referred to as RAIM returns). RAIM returns include transaction costs, consisting of both brokerage commissions and the price impact associated with trading less than perfectly liquid securities. RAIM returns also reflect practical constraints faced by most risk arbitrage hedge funds. However, unlike actively managed hedge funds, no attempt to discriminate between anticipated successful and unsuccessful deals is made when generating RAIM returns. Comparing the VWRA and RAIM return series indicates that transaction costs have a substantial effect on risk arbitrage returns. Ignoring transaction costs results in a statistically significant alpha (assuming linear asset pricing models are valid) of 74 basis points per month (9.25 percent annually). However, when we account for transaction costs, the alpha declines to 29 basis points per month (3.54 percent annually).

The second possible explanation for the extraordinary returns to risk arbitrage documented in previous studies is that they simply reflect compensation for bearing extraordinary risk. Although previous studies that report excess returns attempt to control for risk, they make the implicit assumption that linear asset pricing models are applicable to risk arbitrage invest-

[1] The sample includes stock swap mergers, cash mergers, and cash tender offers. Constructing returns from individual mergers allows us to avoid the sample selection issues inherent in recent studies that use hedge fund returns to assess the risk/reward profile of risk arbitrage. For example, Fung and Hsieh (1997), Ackermann, McEnally, and Ravenscraft (1999) and Agarwal and Naik (1999) provide analyses of hedge fund returns. Fung and Hsieh (2000) present a discussion of the sample selection biases inherent in using these returns.

ments. However, this assumption is problematic if the returns to risk arbitrage are related to market returns in a nonlinear way. Building on Merton's (1981) work on the ability of fund managers to time the market, Glosten and Jagannathan (1994) show how to evaluate the performance of investment strategies that exhibit nonlinear relationships with market returns. They argue that these types of strategies must be evaluated using a contingent claims approach that explicitly values the nonlinearity. As an example, Fung and Hsieh (2001) demonstrate the presence of extraordinary types of risk in a potential hedge fund strategy referred to as "trend following." They show that the payoff to the trend following strategy is related to the payoff from an investment in a lookback straddle. Glosten and Jagannathan's (1994) argument is also supported by Bhagat, Brickley, and Loewenstein's (1987) analysis of interfirm cash tender offers. They argue that investing in the target company's stock after the tender offer announcement is like owning the stock plus a put option on the target's stock. Results from their analysis indicate that, when using the Capital Asset Pricing Model (CAPM) to control for risk, there are significant excess returns to investing in tender offers. They conclude that the CAPM does not fully capture the risk associated with tender offer investments.

In this paper, we investigate whether the reason that linear asset pricing models fail to capture the risk from investing in merger stocks is that the returns to merger stock investments are correlated with market returns in a nonlinear way. Results from our analysis indicate that, in flat and appreciating markets, risk arbitrage generates returns 50 basis points per month (6.2 percent annually) greater than the risk-free rate with essentially a zero market beta. However, in months where the stock market experiences a decrease of 4 percent or more, the market beta of the risk arbitrage portfolio increases to 0.50. Thus, our RAIM portfolio generates moderate returns in most environments but, in rare cases, generates large negative returns. This pattern is robust across time periods and is invariant to changes in assumptions used to estimate transaction costs. We conclude that risk arbitrage is akin to writing uncovered index put options. Given this optionlike feature, standard empirical asset pricing models cannot be used to assess the risk/reward performance associated with risk arbitrage, and the alphas reported in previous studies do not represent excess returns. Instead, the risk/reward profile of risk arbitrage must be evaluated using a contingent claims approach similar to the one suggested by Glosten and Jagannathan (1994). The contingent claims approach, rather than linear models, should also be used when generating benchmarks for evaluating active risk arbitrage hedge fund managers.

This paper is the first to document the high correlation between risk arbitrage returns and market returns in down markets. However, the highly nonlinear relationship between risk arbitrage returns and market returns does not explain the excess returns found in previous studies. Using a contingent claims analysis and assuming that there are no transaction costs, we estimate excess returns of 10.3 percent. This is greater than, not less than, the 9.25 percent estimate obtained using CAPM to measure the excess return generated by risk arbitrage investments. When returns that incorporate transaction costs and other practical limitations are used, the contingent claims analysis implies excess returns of 4 percent annually, far less than the excess returns reported in previous studies. These results suggest that not accounting for transaction costs and other practical limitations is the primary explanation for the large excess returns reported in previous studies. This does not mean that the nonlinear relationship between risk arbitrage returns and market returns is inconsequential. Risk arbitrage is appropriate only for those investors that are willing to incur negative returns in severely depreciating markets and limited positive returns in flat and appreciating markets.

To confirm that our findings are not an artifact of the assumptions that we use to estimate transaction costs, we repeat our nonlinear analysis using returns from active risk arbitrage hedge funds over the 1990 to 1998 time period. Results using this sample of hedge fund returns are remarkably similar to those obtained using returns from our RAIM portfolio.

The remainder of this paper is organized as follows. Section I describes typical arbitrage investments. Section II provides a brief overview of existing risk arbitrage research and outlines three explanations of the returns from this strategy. The data used in this paper are described in Section III. Section IV describes the construction of the time series of risk arbitrage returns. Results are presented in Sections V and VI. Section VII concludes.

I. Description of Typical Investments

There are two primary types of mergers, cash mergers and stock mergers. In a cash merger, the acquiring company offers to exchange cash for the target company's equity or assets. In a stock merger, the acquirer offers its common stock to the target shareholders in lieu of cash. The arbitrageur's investment depends on the form of payment to the target shareholders. In a cash merger, the arbitrageur simply buys the target company's stock. Because the target's stock typically sells at a discount to the payment promised by the acquirer, profits can be made by buying the target's stock and holding it until merger consummation. At that time, the arbitrageur sells the target's common stock to the acquiring firm for the offer price. There are two sources for the return from this investment. The primary source of profit is the difference between the purchase price of the target's stock and the ultimate offer price. The secondary source of profit is the dividend paid by the target company.

In a stock merger, the arbitrageur sells short the acquiring firm's stock in addition to buying the target's stock. In this case, there are three sources of the arbitrageur's profit. The primary source of profit is the difference between the price obtained from the short sale of the acquirer's stock and the price paid for the target's stock. The second source of profit is the dividend paid on the investment in the target's stock. However, this is offset by div-

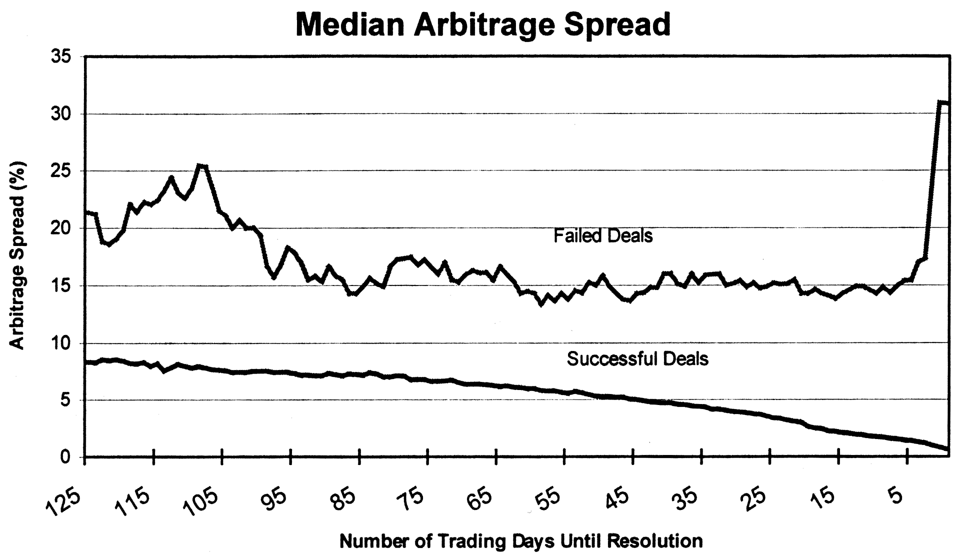

Figure 1. This figure plots the median arbitrage spread versus time until deal resolution. The arbitrage spread is defined to be the offer price minus the target price divided by the target price. For failed deals, the deal resolution date is defined as the date of the merger termination announcement. For successful deals, the resolution date is the consummation date.

idends that must be paid on the acquirer's stock, since it was borrowed and sold short. The third source of profits in a stock deal comes from interest paid by the arbitrageur's broker on the proceeds from the short sale of the acquirer's stock. For individual investors, the interest rate is typically zero. However, for institutions and hedge funds, short proceeds earn interest at a rate close to the risk-free rate.

More complicated deal structures involving preferred stock, warrants, debentures, and other securities are common. From the arbitrageur's perspective, the important feature of all of these deal structures is that returns depend on mergers being successfully completed. Thus, the primary risk borne by the arbitrageur is that of deal failure. Figure 1 displays a representative picture of the losses and gains from risk arbitrage. This figure tracks the median arbitrage spread (the percentage difference between the target's stock price and the offer price) over time, measured from the deal resolution date. For unsuccessful deals, the spread remains relatively wide during the life of the merger. When a merger deal fails, the median spread widens dramatically, increasing from 15 percent to more than 30 percent on the termination announcement day. A much different pattern exists for risk arbitrage investments in successful merger transactions. In successful deals, the arbitrage spread decreases continuously as the deal resolution date approaches. Upon successful consummation of the merger, the spread collapses to zero. The fact that spreads are much wider for unsuccessful transactions suggests that the probability of deal failure is incorporated into the stock prices of target firms.

II. Possible Explanations of Risk Arbitrage Returns

Most of the previous studies that attempt to assess the profitability of risk arbitrage conclude that it generates substantial risk-adjusted returns. Excess returns are greatest in those studies that focus on cash tender offers. Using a sample of 761 cash tender offers between 1971 and 1985, Dukes et al. (1992) conclude that an investor who purchased the target's stock on the day of the tender offer announcement and sold the stock subsequent to the tender offer resolution would have earned a daily return of 0.47 percent. This corresponds to an annualized return well over 100 percent, although the authors concede that it would be difficult for an investor to repeat these returns on a continuing basis. Jindra and Walkling (1999) report similar results. Using a sample of 361 cash tender offers between 1981 and 1995, they find that an arbitrageur who purchased the target stock one day after the acquisition announcement and sold one week later would have generated an annualized *excess* return between 102 percent and 115 percent. Bhagat et al. (1987) document tender period excess returns of 2.0 percent (18 percent annually, based on an average tender period of 29 days) obtained by buying the target's stock the day after the tender offer announcement and selling one day prior to the offer's expiration.

Studies that use transactions other than cash tender offers also document high returns from risk arbitrage investments. Larcker and Lys (1987) study returns to target stocks that were the subject of SEC 13D filings. Although their sample includes both cash transactions and stock swap mergers, their analysis focuses on the returns obtained from buying the target. They do not examine the typical arbitrage investment that also involves short selling the acquirer's stock. Nevertheless, they find excess returns of 5.3 percent and raw returns of 20.08 percent over the transaction period. Based on the median transaction period of 31 trading days, these numbers correspond to an annualized excess return of 51.9 percent and an annualized raw return of 337 percent. Like Larcker and Lys, Karolyi and Shannon (1998) also study both cash and stock mergers. From a sample of 37 Canadian mergers in 1997, they conclude that a risk arbitrage portfolio would have generated a beta of 0.39 and an annualized return of 26 percent, almost twice the return achieved by the TSE 300 in 1997. Baker and Savasoglu (2002) use a much larger sample over the 1978 to 1996 time period and conclude that risk arbitrage generates excess returns of 1 percent per month (approximately 12.5 percent annualized).

Results presented in previous risk arbitrage studies are consistent with more recent papers that examine hedge fund returns. Both Aragwal and Naik (1999) and Ackermann et al. (1999) find that risk arbitrage hedge funds generate return/risk profiles that are superior to other hedge fund strategies. However, as Fung and Hsieh (2000) point out, survival biases present in existing hedge fund databases make it difficult to obtain accurate measurements of performance and risk characteristics of specific strategies.

The magnitudes of the returns reported in previous studies suggest that there exists a severe market inefficiency in the pricing of merger stocks. Yet two studies that use a different approach to examine risk arbitrage returns reach the opposite conclusion. Brown and Raymond (1986) use 89 takeover attempts to examine the ability of the arbitrage spread to distinguish between those deals that will ultimately succeed and those that will ultimately fail. Although they report neither returns nor estimates of risk, they find, consistent with market efficiency, that deal failure probabilities are accurately reflected in the target's and acquirer's stock prices. Samuelson and Rosenthal (1986) perform a similar analysis using a sample of cash tender offers. They conclude that the target's stock price measured well before resolution of the tender offer is a good predictor of the stock price at the conclusion of the tender offer. Based on this, they argue that there are few opportunities to earn excess returns by investing in tender offer targets.

In this paper, we use a long time series of risk arbitrage portfolio returns to attempt to distinguish between market inefficiency and two alternative explanations of returns to risk arbitrage investments. The first alternative explanation is that transaction costs and other practical limitations prevent the average investor from realizing the extraordinary gains documented in previous studies. Of the practical limitations, one of the most important stems from the use of event time, rather than calendar time, to calculate risk arbitrage returns. The event-time approach involves calculating the rate of return obtained from investing after the merger announcement and selling after deal resolution. Returns from individual deals are first "annualized" and then averaged across deals. The problem with this approach is that it assumes that the risk arbitrage portfolio can earn event-time returns continuously. Particularly for transactions that are consummated quickly, this assumption can lead to large annualized returns. For example, on December 2, 1996, Zycon Corporation agreed to be acquired by the buyout firm Hicks, Muse, Tate, and Furst for $16.25 per share. Three days later, Hadco Corporation entered a competing bid of $18 per share. An arbitrageur that purchased Zycon stock one day after the original bid would have made a three-day return of 9.5 percent and an annualized return of 1,903 percent. Large returns such as this weigh heavily in the averaging process used to calculate event-time returns. Yet, as some authors point out, it is not realistic to assume that an investor could achieve these returns on a continuing basis (Dukes et al. (1992), Karolyi and Shannon (1998)). To address this issue, we calculate average risk arbitrage returns based on calendar time rather than event time. That is, we simulate a hypothetical risk arbitrage portfolio (discussed in detail below) that correctly models the investment holding period.

The second possible explanation for the extraordinarily large documented returns to risk arbitrage is that they represent compensation to investors for bearing extraordinary amounts of systematic risk. Because most announced mergers are successfully consummated, risk arbitrage investments usually generate small positive returns. Conditional on successful consummation, these returns depend on the initial arbitrage spread and not on overall stock market returns. Therefore, returns to risk arbitrage should contain very little systematic risk. However, risk arbitrage returns may be positively correlated with market returns during severe market downturns. This will be true if the probability of deal failure increases in depreciating markets. For example, an acquirer that agrees to pay $50 per share for a target company when the S&P 500 index is 1300 may be willing to pay only $30 if the S&P 500 falls to 800. If the acquirer reneges on the deal, the risk arbitrage investment is likely to generate a negative return. This effect will be compounded if investments were made under the belief that risk arbitrage investments are "market neutral." Shleifer and Vishny (1997) argue that even though the hedge fund managers that typically invest in merger situations may understand the risk/return profile associated with risk arbitrage, their investors may not. Consequently, investors may redeem their capital at precisely the wrong time, forcing risk arbitrage hedge fund managers to "bail out of the market when their participation is most needed."[2]

To distinguish between the market inefficiency story and the risk story, we perform two analyses. First, we estimate the CAPM and the Fama and French (1993) three-factor asset pricing model:

$$\begin{aligned}(R_{Risk\,Arb} - R_f) &= \alpha + \beta_{Mkt}(R_{Mkt} - R_f)\\ (R_{Risk\,Arb} - R_f) &= \alpha + \beta_{Mkt}(R_{Mkt} - R_f) + \beta_{SMB}SMB + \beta_{HML}HML,\end{aligned} \tag{1}$$

where $R_{Risk\,Arb}$ is the monthly return to a portfolio of risk arbitrage investments, R_f is the risk-free rate, R_{Mkt} is the return to the value-weighted CRSP index, *SMB* is the difference in returns between a portfolio of small stocks and a portfolio of big stocks, and *HML* is the difference in returns between a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks. The intercept, α, measures the average monthly abnormal return to the risk arbitrage portfolio, which is zero under the null of market efficiency, given the model. If the estimated α is significantly positive, this suggests that the risk arbitrageur earns excess returns, assuming that the model is correct.

The second analysis consists of estimating the following piecewise linear CAPM-type model:

$$\begin{aligned}R_{Risk\,Arb} - R_f = (1-\delta)[\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(R_{Mkt} - R_f)]\\ + \delta[\alpha_{Mkt\,High} + \beta_{Mkt\,High}(R_{Mkt} - R_f)],\end{aligned} \tag{2}$$

where δ is a dummy variable if the excess return on the value-weighted CRSP index is above a threshold level and zero otherwise. To insure continuity, we impose the following restriction on the model:

$$\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(Threshold) = \alpha_{Mkt\,High} + \beta_{Mkt\,High}(Threshold). \tag{3}$$

[2] Shleifer and Vishny (1997), p. 37.

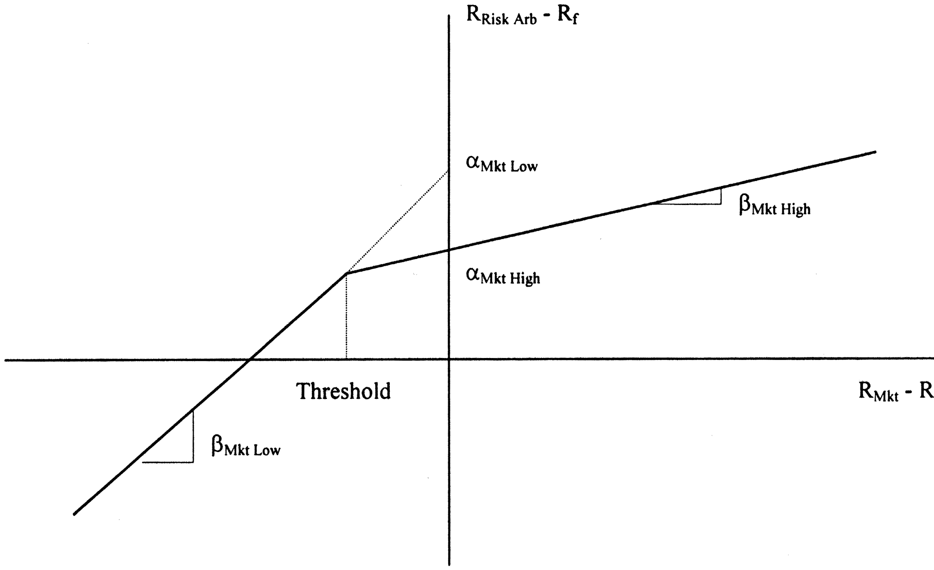

Figure 2. This figure depicts the piecewise linear model specified in equations (2) and (3). $R_{Risk\,Arb}$ is the monthly return obtained from the risk arbitrage portfolio, R_f is the monthly risk-free rate, and R_{Mkt} is the monthly return obtained from the CRSP value-weighted index. The market beta is allowed to vary depending on market returns. $\beta_{Mkt\,Low}$ is the slope coefficient when the difference between the market return and the risk-free rate is less than the threshold. $\beta_{Mkt\,High}$ is the slope coefficient when the difference between the market return and the risk-free rate is greater than the threshold.

If risk arbitrage is akin to writing uncovered index put options, we should observe an optionlike feature in risk arbitrage returns. During flat and appreciating markets, $\alpha_{Mkt\,High}$ estimated from the above regression should be positive (the put premium) and the estimate of $\beta_{Mkt\,High}$ should be close to zero. However, during market downturns, risk arbitrage returns should be negative, implying that $\beta_{Mkt\,Low}$ should be greater than zero. Figure 2 provides a graphical depiction of the model specified by equations (2) and (3), assuming a negative threshold.

III. Data Description

Unlike many previous studies that focus on specific types of transactions such as cash tenders, we study arbitrage returns to cash tenders, cash mergers, and stock swap mergers. There are two advantages to including multiple types of mergers in the sample. First, it allows us to simulate a realistic investment strategy that is similar to strategies pursued by risk arbitrage hedge funds. To keep investors' money employed, these hedge funds typically invest in a broad range of merger situations, not just cash deals. Second, it provides a sample that is large enough to study the time-series characteristics of risk arbitrage returns, especially returns realized during severe market downturns. This is necessary to accurately measure the systematic risk inherent in risk arbitrage.

The data set for this study includes all CRSP firms that were delisted during the period 1963 to 1998 because of a merger or acquisition, and also includes all CRSP firms that received unsuccessful merger and acquisition bids that were covered by the Dow Jones News Service or the *Wall Street Journal*. Critical transaction information such as announcement dates, preliminary agreement dates, termination dates, entry of a second bidder, and transaction terms was obtained by reading Dow Jones News Service and *Wall Street Journal* articles relating to each merger transaction. The final sample consists of 9,026 transactions.

Of these 9,026 transactions, we exclude 4,276 transactions. There are two reasons for dropping observations. First, many of the 9,026 transactions contain complicated terms. For example, the merger agreement might call for the target's shareholders to exchange their shares for a combination of cash, preferred stock, and warrants. Determining the value of the "hedge" in such a transaction is not possible since market values of hybrid securities are generally unavailable. Because our goal is to simulate the returns to a diversified risk arbitrage portfolio, we limit the sample to those transactions where the arbitrageur's investment is straightforward. The resulting sample includes cash mergers, cash tenders, and simple stock swap transactions.[3] The second reason for omitting transactions is because of lack of accurate data. In many cases, the exact terms of the transaction cannot be determined from our reading of the Dow Jones News Service and *Wall Street Journal* articles. In other cases, the terms reported in the *Wall Street Journal* or Dow Jones News Service imply wildly unrealistic returns.

Table I contains a summary of the 4,750 mergers used in this study, broken down by announcement year and transaction type. The sample contains relatively few mergers in the 1960s; however, the number of mergers increases substantially beginning in the late 1970s. The percentage of transactions that use cash as the medium of exchange also increases substantially in the late 1970s. There is no apparent pattern over time in the average duration of transactions. For the entire sample, the average time from bid announcement to transaction resolution is 59.3 trading days. However, for deals that ultimately fail, the average transaction time is 39.2 days, whereas it is 64.2 days for deals that ultimately succeed. A final feature worth noting is that target companies are significantly smaller than acquiring companies. Measured one day after the merger announcement, the average market eq-

[3] It is possible that the complicated transactions that we drop are systematically different from the simple transactions that we retain. To get an idea of whether there are systematic differences between these two groups, we examined the average takeover premium, acquirer stock price reaction, the percentage return obtained from taking a long position in the target (without the corresponding hedge) from announcement through consummation, failure probability, target size, acquirer size, and percentage of friendly transactions for the two groups. For all of these variables, differences between the two groups are not significantly different from zero at or below the five percent level.

Table I

Sample Summary

This table includes a summary of the mergers used in this paper. Only those mergers that used 100 percent cash or 100 percent stock are included in the sample. Transactions that used a combination of securities (e.g., cash plus warrants, preferred plus common stock) are omitted. Transaction duration is measured as the number of trading days from the date of the merger announcement to the date that the merger is either consummated or canceled. Target and acquirer equity market values are measured on the day after the merger announcement. Standard deviations are in parentheses.

Year	Number of Mergers Announced	Number of Cash Transactions as Percent of Total	Average Transaction Duration	Average Target Market Equity Value ($ Millions)	Average Acquirer Market Equity Value ($ Millions)
1963	30	47%	70 (48)	55.9 (52.2)	585.9 (1,091.5)
1964	25	52%	58 (37)	80.2 (147.8)	357.5 (509.5)
1965	29	72%	53 (45)	66.1 (113.6)	279.7 (527.3)
1966	31	55%	70 (89)	88.2 (86.8)	583.7 (856.3)
1967	40	50%	54 (48)	132.4 (168.9)	466.4 (559.8)
1968	58	40%	79 (197)	147.2 (272.6)	426.6 (574.9)
1969	31	26%	89 (86)	107.1 (163.4)	563.8 (1,116.6)
1970	32	22%	70 (35)	86.3 (116.7)	581.9 (948.2)
1971	24	38%	65 (48)	111.1 (108.9)	725.2 (1,128.3)
1972	28	32%	94 (131)	82.2 (99.7)	853.3 (1,092.1)
1973	89	57%	69 (71)	44.9 (48.6)	374.5 (643.1)
1974	99	68%	50 (66)	58.2 (93.3)	411.5 (716.1)
1975	82	61%	65 (66)	71.2 (178.2)	513.7 (1,227.8)
1976	110	54%	63 (49)	60.6 (134.8)	679.3 (1,367.8)
1977	182	76%	59 (55)	83.7 (142.2)	409.9 (824.5)
1978	191	82%	63 (65)	81.3 (132.5)	473.4 (1,228.1)
1979	214	88%	59 (62)	98.3 (144.4)	501.9 (1,970.5)
1980	158	82%	68 (64)	143.0 (222.5)	1,047.8 (3,702.8)
1981	151	83%	56 (56)	513.8 (1,676.2)	713.9 (2,164.4)
1982	147	86%	56 (47)	167.0 (413.8)	383.9 (757.9)
1983	168	82%	66 (67)	151.2 (248.4)	450.2 (991.1)
1984	249	90%	48 (45)	529.4 (2,006.4)	494.9 (1,363.4)
1985	221	89%	59 (58)	596.9 (1,600.8)	1,071.9 (2,955.0)
1986	333	89%	50 (68)	354.5 (703.5)	755.4 (1,798.5)
1987	306	86%	50 (54)	404.9 (1,157.5)	1,199.3 (4,327.2)
1988	428	94%	40 (44)	696.6 (1,741.1)	900.5 (3,651.4)
1989	284	90%	50 (49)	543.3 (1,299.7)	1,031.6 (3,389.4)
1990	115	82%	66 (69)	349.0 (860.4)	1,888.7 (5,285.4)
1991	91	45%	87 (63)	437.7 (966.1)	2,728.8 (5,947.3)
1992	80	41%	101 (65)	261.2 (414.7)	2,000.0 (2,902.2)
1993	89	49%	94 (58)	335.9 (859.8)	1,831.1 (2,047.7)
1994	119	49%	80 (64)	521.5 (1,380.6)	3,116.9 (5,257.6)
1995	157	58%	70 (55)	734.6 (1,299.9)	5,139.3 (13,900.0)
1996	129	46%	65 (50)	808.7 (2,653.0)	7,278.9 (20,000.0)
1997	114	62%	52 (40)	801.4 (1,813.5)	5,696.1 (16,800.0)
1998	116	58%	47 (41)	1,175.8 (2,087.4)	9,504.7 (31,000.0)
Complete Sample	4,750	73%	59.3 (62.4)	390.7 (1,236.1)	1,548.7 (7,627.7)

uity value of target firms is \$391 million and the average market equity value of acquiring firms is \$1.55 billion.

IV. Risk Arbitrage Return Series

The analyses reported in this paper are based on monthly risk arbitrage returns. Monthly returns are obtained by compounding daily returns using two approaches, each of which is described below. In both approaches, we begin by calculating daily returns at the close of market on the day after the merger announcement. Daily returns are calculated for every transaction-day up to and including the "resolution day." For successful deals, the resolution day is defined to be the day on which the target's stock is delisted from CRSP. For failed deals, the resolution day is the day after deal failure is publicly announced. Using the day after the announcement as the beginning date insures that arbitrage returns are not inadvertently biased upward by the takeover premium. Similarly, using the day after deal failure is announced as the resolution date for failed transactions insures that the arbitrage returns are not biased upward by inadvertently exiting failed deals before the failure is announced.

Transactions in which the terms of the deal are revised before deal consummation are treated as multiple transactions. An investment in the transaction under the original terms is made at the close of market on the day following the announcement. This position is closed at the close of market on the day following the announcement of the bid revision. At the same time, an investment is made in the revised transaction and is held until the transaction resolution date. Transactions in which there are multiple bidders are handled in a similar manner. That is, one target can generate multiple transactions. Positions in a given transaction are held until the bidder announces that it is terminating its pursuit of the target, or when the target is delisted from CRSP, whichever occurs earlier.

For transactions where cash is used as the method of payment, the following equation is used to calculate daily returns:

$$R_{it} = \frac{P_{it}^{T} + D_{it}^{T} - P_{it-1}^{T}}{P_{it-1}^{T}}, \tag{4}$$

where R_{it} is the daily return, P_{it}^{T} is the target's stock price at the close of the market on day t, D_{it}^{T} is the dividend paid by the target on day t, and P_{it-1}^{T} is the target's closing stock price on day $t-1$ (subscript i refers to transaction number, t refers to transaction time in days, and T refers to "target").

Because the risk arbitrage position for stock deals consists of a long position in the target and a short position in the acquirer, calculating daily returns is more complicated for stock deals than for cash deals. The return for stock deals consists of the sum of the returns from the long position in the target's stock and the short position in the acquirer's stock. In addition to appreciation (or depreciation) of the stock prices and dividends for both the target and the acquirer, the interest earned on short proceeds must be accounted for.[4] To determine the daily return, the change in the value of the position in a particular deal is divided by the position value on the previous day. The calculation below assumes that short proceeds earn interest at the risk-free rate.

$$R_{it} = \frac{P_{it}^{T} + D_{it}^{T} - P_{it-1}^{T} - \Delta(P_{it}^{A} + D_{it}^{A} - P_{it-1}^{A} - r_f P_{i1}^{A})}{Position\ Value_{t-1}}, \tag{5}$$

where superscript T refers to the target, superscript A refers to the acquirer, Δ is the hedge ratio (equal to the number of acquirer shares to be paid for each outstanding target share), r_f is the daily risk-free rate, and P_{i1}^{A} is the acquirer's stock price at the close of market on the day following the merger announcement.

Monthly return time series are calculated from daily returns using two different methodologies, described in detail below. The first method is similar to that used in studies that use a calendar-time (not event-time) approach (e.g., Baker and Savasoglu (2002)). It consists of the average return across all merger deals at a given point in time, but ignores transaction costs and other practical aspects associated with risk arbitrage investments (VWRA returns). The second approach generates the return time series from a hypothetical risk arbitrage index manager (RAIM returns). Because they include transaction costs, and because capital is invested in cash when there is not enough merger activity to employ the simulated fund's capital, RAIM returns are lower than VWRA returns.

A. Value-weighted Average Return Series (VWRA)

For every active transaction month in the sample period, monthly returns are calculated by compounding daily returns. An active transaction month is defined for every transaction to be any month that contains a trading day between the transaction's beginning date and its resolution date (defined above). If a transaction is active for only part of a month, the partial-month return is used. This effectively assumes that capital is invested in a zero-return account for that portion of the month that the transaction is not active.[5] Portfolio monthly returns are obtained by calculating a weighted average of transaction-month returns for each month, where the total market equity value of the target company is used as the weighting factor. This approach mitigates the bias that is induced by calculating monthly returns by

[4] Although large funds receive interest on short proceeds, individual investors typically do not (unless they have a substantial amount of capital invested with their broker). Results presented in this paper assume that the risk-free rate is paid on short proceeds. Results from unreported analyses indicate that annual returns are reduced by approximately two percent if interest is not paid on short proceeds.

[5] Whether or not this is a reasonable assumption is debatable. The alternative is to calculate the weighted average of returns for transaction days across all days. This approach generates higher returns, but makes the implicit assumption that capital is never idle.

compounding equal-weighted daily returns (Canina et al. (1998)). The equation below specifies the monthly return calculation procedure:

$$R_{month\,j} = \sum_{i=1}^{N_j} \frac{V_i \left[\prod_{t=m}^{M} (1 + R_{it}) - 1 \right]}{\sum_{i=1}^{N_j} V_i}, \tag{6}$$

where j indexes months between 1963 and 1998, i indexes active deals in a month (there are N_j active deals in month j), and t indexes trading days in a transaction month. Because the target's market equity is used as the weighting factor, a greater proportion of the portfolio is invested in larger, and presumably more liquid, targets. However, this approach in no way controls for illiquidity in the acquirer's stock. Thus, returns calculated using the weighted averaging procedure may be unrealistic in that they assume that there is an ample supply of the acquirer's stock available to be shorted. Of course, this is only a problem with stock-for-stock mergers where the acquirer's stock is difficult to borrow. In cash tenders and mergers, the typical risk arbitrage investment does not involve trading in the acquiring firm's equity, and therefore, the liquidity of the acquirer's stock is inconsequential.

There are two other features of the VWRA approach that are worth noting. First, this method effectively assumes that the arbitrage portfolio is invested in every transaction. Because of the fixed costs associated with investing in a transaction, this is a feature that large risk arbitrage hedge funds are unable to implement. Second, it assumes that there are no transaction costs associated with investing in a transaction.[6] Both of these assumptions are clearly unrealistic. However, the time series of returns generated from this approach provide a benchmark that is useful for comparing results from this study to those documented in other papers.

B. Risk Arbitrage Index Manager Returns (RAIM)

The second time series of risk arbitrage returns used in this paper attempts to correct for the unrealistic assumptions embedded in the first method by simulating a risk arbitrage portfolio. Note that in this portfolio, the hypothetical arbitrageur does not attempt to discriminate between anticipated successful and unsuccessful deals. To generate this time series of returns,

[6] For successful deals, there are no transaction costs associated with closing a position. In the case of a cash deal, the target's stock is traded for the cash consideration. In a stock deal, the number of shares of the acquirer's stock that is exchanged for the target's stock is exactly equal to the number of acquirer's shares initially shorted. Thus, for both successful cash deals and successful stock deals, no securities are sold and no transactions costs are incurred. Transaction costs are incurred when closing out positions in failed deals.

the portfolio is seeded with $1 million of capital at the beginning of 1963.[7] As mergers are announced, the $1 million is invested subject to two constraints. The first constraint is that no investment can represent more than 10 percent of the total portfolio's value at the time the investment is made. This is a standard rule of thumb followed by risk arbitrage hedge funds and is intended to insulate the fund from a catastrophic loss caused by failure of a single deal. The second constraint limits the fund's investments in illiquid securities. It does this by restricting the amount invested in any single deal such that the price impact on both the target and acquirer's stock is less than 5 percent. To implement this constraint, the following price impact model developed by Breen, Hodrick, and Korajczyk (1999, Equation 1) is used:

$$\frac{\Delta P}{P} = \beta(NTO), \tag{7}$$

where $\Delta P/P$ is the price impact equal to the percentage change in price resulting from a trade with net turnover equal to *NTO*. Net turnover is defined as one-tenth of the buyer initiated volume minus seller-initiated volume divided by shares outstanding. β is the illiquidity coefficient, obtained by calculating predicted values using regression results presented in Table 5 of Breen et al. A detailed description of their procedure is provided in the Appendix of this paper. It is, however, worth noting here that their results may not accurately reflect the true costs of trading over the time period studied in this paper. Breen et al. use the period from January 1993 through May 1997 to estimate their price impact model. To the degree that financial markets have become more liquid over time, their results may understate the true price impact of trading in earlier time periods. Their results also focus on "typical" event periods, not merger situations. If merger events substantially increase or decrease the price impact associated with trading merger stocks, using the Breen et al. results will, respectively, understate or overstate the true price impact. With these caveats in mind, we use their analysis both to restrict position sizes in illiquid securities and to calculate transaction costs associated with price impact. To calculate the allowable size of every investment, we invert equation (7) and perform the following calculation for both the target and the acquirer:

$$\text{Maximum Number of Shares} = N = \frac{\Delta P}{P\beta}(10)(\textit{Shares Outstanding}), \tag{8}$$

where price impact, $\Delta P/P$, is set equal to 5 percent and β equals the predicted value from the Breen et al. model. To determine the size of an investment, the most restrictive stock (e.g., target or acquirer) is used as long as

[7] The choice of initial capital is not inconsequential. Particularly in the early 1960s, there was a dearth of mergers. If restrictions are placed on the amount that can be invested in any one deal (due to illiquidity or diversification requirements), a significant amount of the initial capital must be invested in cash, thereby distorting the returns from risk arbitrage.

the resulting position is less than 10 percent of the simulated fund's total capital. If both the target's stock and the acquirer's stock are extremely liquid, the 10 percent diversification constraint binds. In this case, as long as the simulated fund has sufficient cash, it invests 10 percent of total capital in the deal.

In addition to limiting the magnitudes of investments, the cost associated with the price impact (which we refer to as indirect transaction costs) predicted by the Breen et al. (1999) model are subtracted from total capital. However, because the total cost can be reduced by splitting an order for N shares into n_{trade} transactions, the following cost model is used:

$$\text{Indirect Transaction Cost} = \frac{(N)(\Delta P)}{n_{trade}} = \frac{N^2 P\beta}{(10)(Shares\ Outstanding)(n_{trade})}, \tag{9}$$

where N is the total number of shares traded, P is the stock price, and n_{trade} is the number of individual trades used to trade N shares of stock. Based on conversations with practicing risk arbitrageurs, we use $\mathrm{n}_{\mathrm{trade}}$ equal to 10 as an estimate of the typical number of trades used to make an investment.

In addition to indirect transaction costs associated with price impact, we also model direct transaction costs consisting of brokerage fees, transaction taxes, and other surcharges. Prior to 1975, direct trading costs, which were regulated by the NYSE and enforced by the SEC, were substantial. They are described in detail in the Appendix. Because risk arbitrage requires frequent trading, these fees turn out to be important components of risk arbitrage returns. Based on conversations with investment professionals that traded in the mid-1970s, brokerage fees dropped substantially after deregulation and continue to drop, albeit at a decreasing rate. Jarrell (1984) estimates that, for institutions, per share direct transaction costs decreased by 50 percent between 1975 and 1980. Because of the relatively high turnover associated with risk arbitrage investments, risk arbitrageurs probably experienced even more substantial reductions in trading costs. To calculate returns for the index portfolio after 1975, we assume per-share transaction costs (outlined in Table AII of the Appendix) that decrease to \$0.10 per share between 1975 and 1979, to \$0.05 per share between 1980 and 1989, and to \$0.04 per share between 1990 and 1998.

Table II presents the annualized time series of monthly returns for both the VWRA and RAIM portfolios. As expected, the VWRA portfolio significantly outperforms the RAIM portfolio. Whereas the VWRA portfolio generates a compound annual return of 16.05 percent, the RAIM portfolio generates a compound annual return of 10.64 percent. Of the 5.41 percent difference, approximately 1.5 percent can be attributed to direct transaction costs (e.g., brokerage commissions, surcharges, and taxes), and 1.5 percent can be attributed to indirect transaction costs (e.g., price impact). The remaining 2.5 percent can be attributed to limitations in position sizes caused by illiquidity in

Table II

Annual Risk Arbitrage Return Series

This table presents the annual return series for the value-weighted risk arbitrage (VWRA) portfolio, the risk arbitrage index manager (RAIM) portfolio, the annual CRSP value-weighted index, and the annual risk-free rate. VWRA portfolio returns are obtained by taking the weighted average of returns from all active merger deals, ignoring transaction costs. RAIM returns include transaction costs and other practical limitations associated with risk arbitrage investments. The ratio of the sum of target firms' equity values and the end-of-year total market value is also presented. All annual returns are obtained by compounding monthly returns. Annual standard deviations are obtained by multiplying the standard deviation of monthly returns by the square root of 12.

Year	Value-weighted Risk Arbitrage (VWRA) Return	Risk Arbitrage Index Manager (RAIM) Return	CRSP Value-weighted Average Return	Risk-free Rate of Return	$ Value of Announced Deals/Total Market Value
1963	14.51%	6.64%	20.89%	3.13%	0.40%
1964	10.27%	4.44%	16.30%	3.48%	0.35%
1965	9.09%	3.30%	14.38%	3.94%	0.47%
1966	11.46%	−4.03%	−8.68%	4.69%	0.69%
1967	14.45%	9.06%	28.56%	4.05%	1.16%
1968	−8.65%	−2.88%	14.17%	4.75%	1.72%
1969	22.10%	3.18%	−10.84%	6.49%	1.10%
1970	14.18%	5.70%	0.08%	6.17%	0.30%
1971	19.93%	5.79%	16.20%	4.15%	0.15%
1972	16.65%	3.52%	17.34%	3.93%	0.13%
1973	20.38%	−7.45%	−18.77%	7.17%	0.39%
1974	12.95%	12.93%	−27.86%	7.97%	0.42%
1975	12.83%	12.29%	37.37%	5.63%	0.29%
1976	19.93%	19.20%	26.77%	4.91%	0.36%
1977	28.56%	8.27%	−2.98%	5.25%	0.72%
1978	20.40%	18.03%	8.54%	7.41%	0.93%
1979	17.15%	13.85%	24.40%	10.42%	0.82%
1980	29.30%	38.54%	33.23%	11.33%	0.47%
1981	38.44%	35.15%	−3.97%	14.50%	0.68%
1982	38.41%	31.99%	20.42%	10.38%	0.42%
1983	17.35%	12.67%	22.70%	8.86%	0.45%
1984	21.45%	8.13%	3.28%	9.62%	0.63%
1985	15.65%	15.00%	31.46%	7.38%	0.50%
1986	13.32%	20.61%	15.60%	5.93%	0.68%
1987	13.81%	3.81%	1.76%	5.17%	0.63%
1988	27.23%	27.63%	17.62%	6.50%	0.61%
1989	6.83%	5.36%	28.44%	8.16%	0.32%
1990	6.69%	4.38%	−6.02%	7.53%	0.11%
1991	18.19%	12.13%	33.59%	5.32%	0.07%
1992	9.12%	4.48%	9.03%	3.36%	0.07%
1993	14.16%	12.31%	11.49%	2.90%	0.09%
1994	17.07%	12.58%	−0.62%	3.98%	0.12%
1995	12.57%	10.96%	35.73%	5.47%	0.11%
1996	11.32%	15.39%	21.26%	5.14%	0.06%
1997	9.48%	11.64%	30.46%	5.11%	0.06%
1998	12.64%	4.09%	22.49%	4.70%	0.06%
Compound annual rate of return	16.05%	10.64%	12.24%	6.22%	
Annual standard deviation of returns	9.29%	7.74%	15.08%	0.73%	
Sharpe ratio (annual)	1.06	0.57	0.40	0.0	

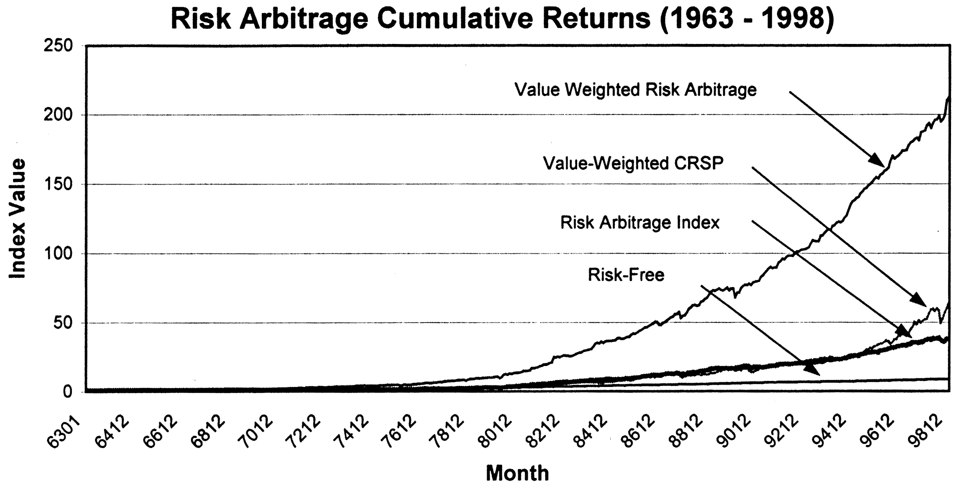

Figure 3. This figure shows the value, over the 1963 to 1998 time period, of $1 invested at the beginning of 1963 for four different investments: (1) value-weighted risk arbitrage (VWRA), (2) value weighted CRSP index, (3) risk arbitrage index manager (RAIM), (4) Treasury bills. Because of transaction costs and other practical issues, the VWRA returns would not have been obtainable; they are included for comparison purposes. The RAIM returns take transaction costs and other practical issues into account and are representative of the returns that could have been obtained from an index of merger arbitrage investments. The horizontal axis labels correspond to months (i.e., 9812 is December, 1998).

the merging firms' stocks. Thus, ignoring transaction costs and the price impact associated with investing in thinly traded equities imposes a substantial upward bias to calculated returns.[8]

Also shown in Table II are the annualized CRSP value-weighted average return and the risk-free rate of return. Over the 1963–1998 time period, the CRSP value-weighted index had a compound annual return of 12.24 percent, almost 400 basis points *less* than the VWRA average and only 160 basis points greater than the RAIM average. Annual standard deviations and Sharpe ratios are also presented in Table II. Even though the compound annual return of the RAIM portfolio is lower than the market return, the low volatility associated with risk arbitrage returns results in a Sharpe ratio that exceeds that of the market.

Returns summarized in Table II are shown graphically in Figure 3. This figure shows the value of $1 invested at the beginning of 1963 in various strategies, including treasuries, equities, and risk arbitrage. The effect of ignoring transaction costs on risk arbitrage returns is obvious by comparing the returns from the VWRA portfolio to the returns from the RAIM port-

[8] To make sure that the large returns associated with the value weighting procedure are not driven by the choice of weights, risk arbitrage returns are also calculated using an equal weighting procedure. Whereas the VWRA average return is 16.05 percent, the equal weighted average is 18.08 percent.

folio. It is also evident from Figure 3 that returns to risk arbitrage are much less volatile than market returns.

V. Results

To determine whether the returns to risk arbitrage reflect market inefficiencies or rewards for bearing rare-event risk, we estimate equations (1) through (3) over the 1963 to 1998 time period. Because the RAIM portfolio return series is more realistic, we focus our discussion on results obtained using this return series as the dependent variable.

A. Risk Factors

Panel A of Table III presents results for the entire 432 month (36 year) sample. The first regression presents results from estimating the CAPM. Results from this regression indicate that the alpha is positive 29 basis points per month and is significantly different from zero. Furthermore, the estimated market beta is only 0.12. This result indicates that over a broad range of market environments, risk arbitrage returns are independent of overall market returns.

Similar results are obtained when the Fama and French (1993) three-factor model is used. The alpha is 27 basis points per month and the market beta is 0.11, both significantly different from zero. The SMB coefficient is also statistically different from zero in this regression. Because the arbitrage trade in a stock transaction consists of a long position in a relatively small target and a short position in a relatively large acquirer, the correlation between RAIM returns and SMB is not surprising.

Panels B and C of Table III report results from estimating equation (1) after limiting the sample to months where the market return minus the risk-free rate is less than −3.0 percent and −5.0 percent, respectively. The estimated alphas using these subsamples of data increase dramatically. As shown in Panel B, when the excess market return is the only independent variable, the estimated alpha is 260 basis points per month (36.1 percent annualized) and the beta is 0.51. The adjusted R^2 increases dramatically when the sample is limited to months with negative market returns (from 0.057 to 0.306) suggesting that the systematic risk in risk arbitrage is driven by time periods where market returns are negative. Including the Fama–French factors reduces the alpha to 206 basis points per month (27.72 percent annualized), but it is still statistically different from zero at the 1 percent level.

The coefficient estimates in Table III suggest that the relationship between risk arbitrage returns and market returns is nonlinear. To further assess the degree of nonlinearity in risk arbitrage returns, we estimate the piecewise linear model specified in equations (2) and (3) and depicted in Figure 2.[9] The piecewise linear analysis is performed only for the market

[9] A formal test of the null hypothesis that the risk arbitrage market beta is the same in appreciating and depreciating markets rejects at the 0.001 level (see Jagannathan and Korajczyk (1986) for a description of the procedures used to test for nonlinearity in return series).

Table III

Time Series Regressions of Risk Arbitrage Returns on Common Risk Factors

This table presents results from the following two regressions of risk arbitrage returns on common risk factors:

$$R_{Risk\,Arb} - R_f = \alpha + \beta_{Mkt}(R_{Mkt} - R_f)$$

$$R_{Risk\,Arb} - R_f = \alpha + \beta_{Mkt}(R_{Mkt} - R_f) + \beta_{SMB}R_{SMB} + \beta_{HML}R_{HML},$$

where $R_{Risk\,Arb}$ is the monthly return on a portfolio of risk arbitrage transactions, R_f is the monthly risk-free rate, R_{Mkt} is the monthly return on the value-weighted CRSP index, R_{SMB} is the Fama–French small minus big monthly return series, and R_{HML} is the Fama–French high book-to-market minus low book-to-market return series. Two different time series of risk arbitrage returns are used. The first is based on a risk arbitrage index manager (RAIM) portfolio beginning in 1963 and ending in 1998. This return series is net of transaction costs. The second, which ignores transaction costs, is the value weighted average of returns to individual merger investments (VWRA), averaged across transactions in each month. The target firm's market capitalization is used as the weighting factor. Panel A of the table presents results for the entire time period. Panel B presents results after restricting the sample to those months with market returns more than three percent less than the risk-free rate. Panel C presents results after restricting the sample to those months with market returns more than five percent less than the risk-free rate. Standard errors are in parentheses.

Dependent Variable	α	β_{Mkt}	β_{SMB}	β_{HML}	Adj. R^2	Sample Size
Panel A: Complete Sample						
RAIM portfolio returns	0.0029	0.1232			0.057	432
	(0.0010)**	(0.0236)***				
RAIM portfolio returns	0.0027	0.1052	0.1221	0.0357	0.076	432
	(0.0011)*	(0.0265)***	(0.0380)**	(0.0434)		
VWRA portfolio returns	0.0074	0.0540			0.006	432
	(0.0013)***	(0.0293)				
VWRA portfolio returns	0.0079	0.0176	0.0774	−0.0904	0.014	432
	(0.0013)***	(0.0331)	(0.0475)	(0.0542)		
Panel B: Market Return—Rf < –3%						
RAIM portfolio returns	0.0260	0.5074			0.306	76
	(0.0059)***	(0.0869)***				
RAIM portfolio returns	0.0206	0.4041	0.2996	0.1824	0.396	76
	(0.0058)***	(0.1035)***	(0.1063)**	(0.1258)		
VWRA portfolio returns	0.0368	0.5194			0.219	76
	(0.0076)***	(0.1107)***				
VWRA portfolio returns	0.0356	0.5532	0.0219	0.1994	0.214	76
	(0.0079)***	(0.1417)***	(0.1456)	(0.1723)		
Panel C: Market Return—Rf < –5%						
RAIM portfolio returns	0.0232	0.4830			0.222	35
	(0.0134)	(0.1479)**				
RAIM portfolio returns	0.0116	0.2884	0.4761	0.2774	0.424	35
	(0.0120)	(0.1588)*	(0.1722)**	(0.2035)		
VWRA portfolio returns	0.0354	0.5103			0.251	35
	(0.0132)	(0.1450)				
VWRA portfolio returns	0.0298	0.5000	0.0934	0.2735	0.257	35
	(0.0137)	(0.1804)	(0.1956)	(0.2311)		

*, **, *** indicate significance at the 0.05, 0.01, and 0.001 levels, respectively.

model; nonlinearities associated with the Fama and French (1993) SMB and HML factors are not assessed.

One problem with implementing the piecewise linear model is determining the location of the threshold (i.e., the kink point). To avoid using a completely ad hoc method of determining the threshold, we present results obtained by setting the threshold equal to −4.0 percent, the value that minimizes the sum of squared residuals.

Panel A of Table IV presents results using the complete sample covering the 1963–1998 time period. Results from this panel indicate that in most market environments, risk arbitrage produces a return that is 53 basis points per month (6.5 percent annually) greater than the risk-free rate and a beta that is close to zero. However, when the market return is more than 4 percent below the risk-free rate, the risk arbitrage market beta increases to 0.49.

Panels B, C, and D of Table IV show that in all subperiods, market betas are significantly different in up and down markets. Furthermore, except for the 1963 to 1979 time period when merger activity was relatively low, the intercept terms are large and significantly different from zero. Note however, that because of the nonlinear relationship between risk arbitrage returns and market returns, these intercepts cannot be interpreted as excess returns. Scatter plots of RAIM returns versus market returns for various subperiods are shown in Figure 4. This figure shows that the nonlinear relationship between risk arbitrage returns and market returns is not time-period dependent.

The increase in market beta in depreciating markets is caused, at least in part, by the increased probability of deal failure following a severe market downturn. Table V shows results from a probit regression that estimates the probability of deal failure. For purposes of this analysis, deal failure is defined to be any deal where the arbitrageur lost money. Thus, mergers where the terms were revised downward but that were ultimately consummated are treated as failed deals. As shown in this table, the probability that a merger will fail is a decreasing function of market returns in the previous two months. That is, deals are more likely to fail following market downturns. Based on the coefficient estimates in Table V, a 5 percent decrease in either the contemporaneous market return or the lagged market return increases the probability of deal failure by 2.25 percent. Table V also shows that hostile deals have a 12.8 percent greater probability of failure than friendly deals. In our data set, "hostile" refers to deals in which articles in the Dow Jones News Service or *Wall Street Journal* report that target management rejected the bid in question.[10] Leveraged buyouts also have higher failure probabilities.[11]

[10] Schwert (2000) uses the same definition for one of the four hostility variables in his examination of the economic distinction (based on accounting and stock price data) between hostile and friendly deals. Schwert also notes that hostile deals have a lower likelihood of deal completion.

[11] In addition to the probit model described in Table V, we also examined the effect of a market decline on the ratio of failed deals in the month to active deals in the month. Results from this analysis are consistent with those obtained from the probit model. A 5 percent decline in the market in the previous month increases the fail/active ratio from 0.050 to 0.059, an increase of 18 percent. This effect is significant at the 0.1 percent level.

Table IV

Piecewise Linear Regressions: Risk Arbitrage Returns Versus Market Returns

This table presents results from the following piecewise linear regression relating risk arbitrage returns to market returns:

$$R_{Risk\,Arb} - R_f = (1-\delta)[\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(R_{Mkt} - R_f)] + \delta[\alpha_{Mkt\,High} + \beta_{Mkt\,High}(R_{Mkt} - R_f)],$$

where $R_{Risk\,Arb}$ is the monthly return on a portfolio of risk arbitrage transactions, R_f is the risk-free rate, R_{Mkt} is the monthly return on the value-weighted CRSP index, and δ is a dummy variable equal to one if the market return is greater than a threshold and zero otherwise. To insure continuity, the following restriction is imposed:

$$\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(Threshold) = \alpha_{Mkt\,High} + \beta_{Mkt\,High}(Threshold).$$

Results are presented for a threshold equal to −4 percent, that being the threshold that maximizes the adjusted R^2 for the complete sample. Panel A presents results using the entire 432 month sample between 1963 and 1998. Panels B, C, and D present results for various subperiods. Standard errors are in parentheses.

Dependent Variable	$\alpha_{Mkt\,High}$	$\beta_{Mkt\,Low}$	$\beta_{Mkt\,High}$	Adj. R^2	Sample Size
Panel A: Complete Sample					
RAIM portfolio returns	0.0053	0.4920	0.0167	0.124	432
	(0.0011)***	(0.0673)***	(0.0292)		
VWRA portfolio returns	0.0101	0.4757	−0.0678	0.065	432
	(0.0013)***	(0.0840)***	(0.0364)		
Panel B: 1963–1979					
RAIM portfolio returns	0.0025	0.3849	−0.0206	0.044	204
	(0.0016)	(0.1175)***	(0.0435)		
Panel C: 1980–1989					
RAIM portfolio returns	0.0095	0.5825	0.0987	0.233	120
	(0.0024)***	(0.1115)***	(0.0589)		
Panel D: 1990–1998					
RAIM portfolio returns	0.0054	0.4685	−0.0287	0.127	108
	(0.0016)***	(0.1134)***	(0.0467)		

*** indicates significance at the 0.001 level.

As previously described, capturing the arbitrage spread in a cash deal requires the arbitrageur to buy the target's stock. However in a stock merger, capturing the arbitrage spread requires the arbitrageur to purchase the target's stock and simultaneously short sell the acquirer's stock. As long as the target's value and the acquirer's value are equally affected by the decrease in overall market value, the market decrease will not cause the acquirer to overpay for the target. However, in a cash deal, the decrease in the target's

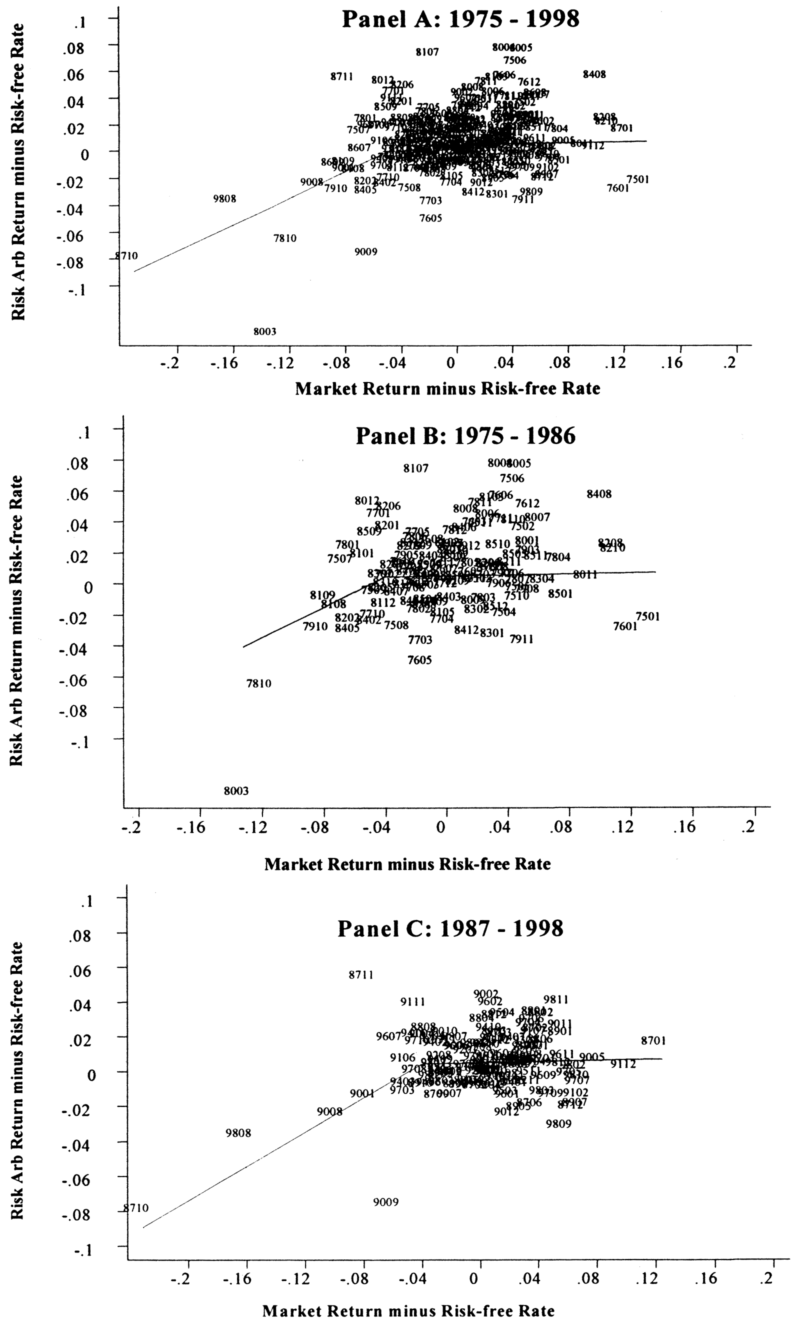

Figure 4. This figure plots risk arbitrage index manager (RAIM) returns against market returns for three subsamples of data. Panel A presents returns from 1975 to 1998, Panel B presents returns from 1975 to 1986, and Panel C presents returns from 1987 to 1998. Data labels correspond to months (i.e., 9808 is August, 1998). Fitted lines from a piecewise linear regression are also shown.

Table V

Effect of Market Returns on the Probability of Deal Failure

This table presents results from the following probit model:

$$Fail = \alpha + \beta_1 R_{Mkt} + \beta_2 R_{Mkt-1} + \beta_3 R_{Mkt-2} + \beta_4 LBO + \beta_5 Cash\ Dummy$$

$$+ \beta_6 Premium + \beta_7 Size + \beta_8 Tender + \beta_9 Hostile,$$

where *Fail* is a dummy variable equal to one if the arbitrage return is negative and zero otherwise; R_{Mkt} is the monthly return on the value-weighted CRSP index for the month corresponding to the deal resolution date; R_{Mkt-1} is the monthly return on the value weighted CRSP index for the month prior to the deal resolution date; R_{Mkt-2} is the monthly return on the value weighted CRSP index two months prior to the deal resolution date; *LBO* is a dummy variable if the acquirer was private; *Cash Dummy* is a dummy variable if the acquirer offered to pay 100 percent cash for the target; *Premium* is the takeover premium equal to the target stock price one day after the announcement of the merger divided by the target stock price 30 days prior to the merger announcement; *Size* is the logarithm of the target's market equity value; *Tender* is a dummy variable equal to one if the offer was a cash tender; and *Hostile* is a dummy variable equal to one if articles in the Dow Jones News Service or *Wall Street Journal* report that target management rejected the bid in question. Standard errors (in parentheses) are calculated assuming independence across years. No assumptions are made regarding the independence of transactions that terminate in the same year.

Independent Variable	Coefficient Estimate	Marginal Effect
R_{Mkt}	−1.6481	−0.4444
	(0.6493)**	
R_{Mkt-1}	−1.7034	−0.4593
	(0.3402)***	
R_{Mkt-2}	−0.6164	−0.1662
	(0.5649)	
LBO	0.1748	0.0485
	(0.0656)**	
Cash dummy	0.1797	0.0465
	(0.0914)*	
Takeover premium	0.0086	0.0023
	(0.0405)	
Size	−0.0554	−0.0149
	(0.0179)**	
Tender dummy	−0.2360	0.0651
	(0.0796)**	
Hostile dummy	0.4221	0.1286
	(0.0629)***	
Constant	−0.5543	
	(0.1957)**	
R^2	0.040	
Number of observations	4,740	

*, **, *** indicate significance at the 0.05, 0.01, and 0.001 levels, respectively.

Table VI

Piecewise Linear Regressions: Cash versus Stock Transactions

This table presents results from the following piecewise linear regression relating risk arbitrage returns to market returns:

$$R_{Risk\,Arb} - R_f = (1 - \delta[\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(R_{Mkt} - R_f)] + \delta[\alpha_{Mkt\,High} + \beta_{Mkt\,High}(R_{Mkt} - R_f)],$$

where $R_{Risk\,Arb}$ is the monthly return on a portfolio of risk arbitrage transactions, R_f is the risk-free rate, R_{Mkt} is the monthly return on the value-weighted CRSP index, and δ is a dummy variable equal to one if the market return is greater than a threshold and zero otherwise. To insure continuity, the following restriction is imposed:

$$\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(Threshold) = \alpha_{Mkt\,High} + \beta_{Mkt\,High}(Threshold).$$

Results are presented for a threshold equal to -4 percent, that being the threshold that maximizes the adjusted R^2 for the complete sample. Panel A presents results obtained after restricting the sample to cash transactions; Panel B presents results for stock transactions. Standard errors are in parentheses.

Dependent Variable	$\alpha_{Mkt\,High}$	$\beta_{Mkt\,Low}$	$\beta_{Mkt\,High}$	Adj. R^2	Sample Size
		Panel A: Cash Transactions 1975–1998			
RAIM portfolio returns	0.0046	0.7745	0.1024	0.295	288
	(0.0014)***	(0.0822)***	(0.0371)**		
		Panel B: Stock Transactions 1975–1998			
RAIM portfolio returns	0.0051	0.1528	−0.0766	0.052	288
	(0.0008)***	(0.0477)**	(0.0215)***		

** and *** indicate significance at the 0.01 and 0.001 levels, respectively.

value is not offset by a commensurate decrease in the price paid by the acquirer. Thus, the arbitrageur is long market risk in cash deals and is market neutral in stock deals.

Given the increase in the probability of deal failure associated with cash deals and depreciating markets, the "down-market" beta in our piecewise linear regressions should be greater when the sample is limited to cash transactions. Table VI presents results from estimating the piecewise linear regressions after segmenting the data by means of payment. Panel A of Table VI presents results for cash transactions and Panel B presents results for stock transactions. This table confirms that the down-market beta is much greater when the sample is limited to cash transactions (0.77) than when it is limited to stock transactions (0.15).

B. Deal Flow

In addition to the systematic risk factors specified in equations (1) through (3), factors specific to the mergers and acquisitions market may also affect returns to risk arbitrage. In particular, institutional rigidities may restrict the flow of capital into risk arbitrage investments resulting in periodic imbalances between the supply of mergers and the demand for investments in merger stocks. The resulting imbalances would be greatest in periods when the volume of announced deals is high.

To determine whether the supply of transactions affects risk arbitrage returns, we constructed two variables that measure merger and acquisition activity. The first variable is the number of announced transactions in the month; the second variable is the total market value of transactions (measured by target market value) announced in the month, divided by the total market value (NYSE, Nasdaq, AMEX). We included each of these variables in our piecewise linear regressions.

Results (available on request) from these regressions suggest that the link between risk arbitrage returns and merger activity is weak. Although there is a positive correlation between the number of mergers and risk arbitrage returns, the significance (both economic and statistical) of the relationship varies across time periods. The same is true of the relationship between risk arbitrage returns and the dollar volume of announced transactions. This lack of robustness leads us to conclude that "deal flow" is not a strong determinant of risk arbitrage returns.

C. Sensitivity Analysis

Calculating the RAIM returns used in this paper requires numerous assumptions regarding transaction costs and limitations associated with implementing the merger arbitrage strategy. It is possible that the results described thus far are an artifact of these assumptions. To test whether our assumptions are generating the nonlinear relationship between RAIM and market returns, we performed the analysis using alternative assumptions for diversification constraints, initial capital, and transaction costs. Results from these analyses are presented in Table VII. Scenarios 1 through 4 in Table VII present results for various levels of transaction costs. Comparing scenarios 1 and 2 indicates that direct transaction costs (e.g., brokerage commissions) decrease returns by approximately 1.37 percent annually. The effect of indirect transaction costs (price impact) can be estimated by comparing returns from scenarios 2 and 3. Scenario 2 includes indirect transaction costs estimated using the Breen et al. (1999) price impact model and scenario 3 assumes that indirect transaction costs are zero. Based on this comparison, indirect transaction costs decrease annual returns by 1.49 percent. If instead of eliminating indirect transaction costs we double them (scenario 4), returns are reduced by 2.51 percent. Comparing the 13.50 percent return in scenario 3 (no transaction costs) with the VWRA annual return of 16.05 percent reported in Table II (no transaction costs or practical limitations) indicates that practical limitations reduce annual returns by 2.5 percent per year.

Scenario 5 provides an estimate of the return generated by the interest paid on short proceeds. Whereas scenario 1 presents returns assuming that

Table VII

RAIM Sensitivity Analysis

This table presents results for alternative assumptions in the risk arbitrage index manager (RAIM) portfolio. Diversification constraint refers to the maximum percentage of the portfolio's total value that can be invested in a single transaction. Beginning capital is the amount of capital that the fund is seeded with at the beginning of 1963. Direct transaction costs are brokerage commissions and surcharges; indirect transaction costs are costs associated with price impact. Compounded annual returns for the 1963–1998 time period, and results from a piecewise linear regression of risk arbitrage returns on market returns are presented. The piecewise linear regression equation is

$$R_{Risk\,Arb} - R_f = (1-\delta)[\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(R_{Mkt} - R_f)] + \delta[\alpha_{Mkt\,High} + \beta_{Mkt\,High}(R_{Mkt} - R_f)],$$

where $R_{Risk\,Arb}$ is the monthly return on a portfolio of risk arbitrage transactions, R_f is the risk-free rate, R_{Mkt} is the monthly return on the value-weighted CRSP index, and δ is a dummy variable equal to one if the market return is greater than a threshold and zero otherwise. To insure continuity, the following restriction is imposed:

$$\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(Threshold) = \alpha_{Mkt\,High} + \beta_{Mkt\,High}(Threshold).$$

Results are presented for a threshold equal to −4 percent, that being the threshold that maximizes the adjusted R^2 for the complete sample. Standard errors are in parentheses.

	Scenario							
	1	2	3	4	5	6	7	8
Diversification constraint (%)	10	10	10	10	10	20	5	10
Beginning capital	\$1 million	\$1 million	\$1 million	\$1 million	\$1 million	\$1 million	\$1 million	\$10 million
Interest rate on short proceeds	Risk-free rate	Risk-free rate	Risk-free rate	Risk-free rate	Zero	Risk-free rate	Risk-free rate	Risk-free rate
Transaction costs	Direct and indirect	Indirect only	None	Direct plus 2 × indirect	Direct and indirect	Direct and indirect	Direct and indirect	Direct and indirect
Annual return, 1963–1998	10.64%	12.01%	13.50%	8.13%	8.62%	10.05%	9.15%	6.85%
$\alpha_{Mkt\,High}$	0.0053	0.0064	0.0076	0.0035	0.0036	0.0053	0.0043	0.0021
	(0.0011)***	(0.0011)***	(0.0011)***	(0.0011)**	(0.0011)**	(0.0013)***	(0.0009)***	(0.0007)***
$\beta_{Mkt\,Low}$	0.4920	0.5108	0.5241	0.5057	0.5017	0.5823	0.5758	0.4342
	(0.0673)***	(0.0673)***	(0.0660)***	(0.0697)***	(0.0711)***	(0.0789)***	(0.0565)***	(0.0453)***
$\beta_{Mkt\,High}$	0.0167	0.0144	0.0067	0.0089	0.0402	0.0144	0.0239	0.0004
	(0.0292)	(0.0292)	(0.0286)	(0.0302)	(0.0309)	(0.0343)	(0.0245)	(0.0196)
Adj. R^2	0.124	0.132	0.140	0.120	0.126	0.125	0.125	0.190

** and *** indicate significance at the 0.01 and 0.001 levels, respectively.

the risk-free rate of return is obtained on short proceeds, scenario 5 presents returns assuming that no interest is paid on short proceeds. The 2.02 percent difference in annual returns represents the portion of risk arbitrage returns that are generated by interest payments on short proceeds.

Results from scenarios 6 and 7 show the effect of altering the diversification constraint. It is common for merger arbitrage hedge funds to limit the maximum percentage of the portfolio's total value that can be invested in a single transaction. Results presented in Tables III, IV, and VI assume that the limit is 10 percent of the portfolio. Scenarios 6 and 7 allow this limit to vary from 20 percent down to 5 percent. Increasing the limit to 20 percent has a negligible effect on annual returns whereas decreasing it to 5 percent has a substantial effect; it decreases returns by 1.49 percent annually. Much of this decrease can be attributed to the lack of transactions in the 1960s and early 1970s. When the diversification constraint is very strict and there are few available deals, the RAIM portfolio is heavily invested in cash. This results in a decrease in overall returns. However, regardless of the level of the diversification constraint, the basic finding that betas are high in depreciating markets and close to zero in flat and appreciating markets remains.

The final analysis presented in Table VII involves the size of the initial capital base. Scenario 8 presents results obtained when initial capital is \$10 million instead of \$1 million. This causes annual returns to decrease by 3.79 percent. As is the case when the diversification constraint is tightened, much of this decrease is caused by the lack of merger activity in the 1960s and early 1970s. Nevertheless, this result suggests that the merger arbitrage strategy may be capacity constrained.

D. Contingent Claims Analysis Using Black–Scholes

Overall, results presented in Tables III through VII provide strong evidence supporting the notion that risk arbitrage is analogous to writing uncovered index put options. This suggests that standard measures of performance such as Jensen's alpha and the Sharpe ratio may not be appropriate for analyzing risk arbitrage returns. Rather than using a linear asset pricing model, the risk and reward associated with risk arbitrage would be better assessed using a contingent claims analysis. For example, the one month return to a \$100 investment in a risk arbitrage portfolio can be replicated by a portfolio consisting of a long position in a risk-free bond and a short position in index put options. The face value of the bond is equal to $(\$100)(1 + r_f + \alpha_{Mkt\,High})$ and the number of put options is determined by the market beta in depreciating markets ($\beta_{Mkt\,Low}$ in Figure 2 and Table IV). The put option strike price is equal to $(\$100)(1 + \mathit{Threshold} + r_f)$. Thus, for a threshold of -4 percent and a risk free rate of 51 basis points per month (the sample average), the strike price is \$96.51.

To determine whether risk arbitrage generates excess returns, the cost of the replicating portfolio can be compared to the \$100 investment in risk arbitrage. If the cost of the replicating portfolio exceeds \$100, then risk arbitrage generates excess returns. Using coefficient estimates from Panel A of Table IV, and assuming Black–Scholes applies, the cost of the replicating portfolio is equal to the present value of the risk-free bond minus the put premium received from selling 0.492 index put options:

$$\text{Cost of Replicating Portfolio} = \frac{\$100 + \$0.51 + \$0.53}{1.0051} - (0.492)P(X, S, r_f, \sigma, T - t), \tag{10}$$

where $P(X, S, r_f, \sigma, T - t)$ is the Black–Scholes price of an index put option with a strike price of $X = \$96.51$, an index level of $S = \$100$, a risk-free rate of 6.3 percent (the sample average), a market volatility of 0.15 (standard deviation of monthly market returns multiplied by the square root of 12), and a time until expiration of one month. Using these parameter estimates implies that the put option is worth \$0.40 and the cost of the replicating portfolio is \$100.33, \$0.33 more expensive than the risk arbitrage portfolio. Thus, risk arbitrage generates excess returns of 33 basis points per month (4.0 percent annually) after controlling for transaction costs and other practical limitations.

Our analysis of risk and return in risk arbitrage uses a monthly time horizon. However, there is no reason, a priori, to base the analysis on monthly returns. In fact, annual returns shown in Table II suggest that risk arbitrage almost always generates positive returns when the horizon is one year. To determine whether the nonlinearity in returns exists when an annual horizon is used, the piecewise linear regression analysis was performed using annual returns. Results from this regression indicate that the market beta is 0.17 in both appreciating and depreciating markets. The implied excess return from this regression is 3.6 percent per year, very close to the estimate obtained using monthly returns. These results are consistent with the notion that the excess return in risk arbitrage reflects compensation for providing liquidity in merger stocks, especially during market downturns.

E. Contingent Claims Analysis Using Actual Put Prices

Jackwerth (2000) argues that a change in investors' risk aversion level after the October 1987 crash created the opportunity to profit from a trading strategy consisting of selling index put options. Because this increase in risk aversion does not enter the Black–Scholes formula, we also modeled the replicating portfolio over the 1987 to 1996 time period using actual S&P 500 index put option prices. In each month, we built a portfolio consisting of a risk-free bond with a face value of $\$100(1 + r_f)$ and a short position in index put options. To get option prices, we first calculated implied volatilities using prices from options that had one month until expiration and were approximately 4 percent out of the money. Option prices were adjusted to correct for this approximation by using implied volatilities from the actual option prices, together with Black–Scholes and the correct strike price (Strike = \$100 −

$\$100(0.04 - r_f)$). At the end of each month, we calculated the payoff from our option position. This payoff, combined with the payoff from the risk-free bond is used to calculate portfolio monthly returns. The number of options sold was adjusted to mimic the risk arbitrage payoff profile.

Returns from this procedure are compared to returns from risk arbitrage over the same sample period (1987 to 1996). Results from this comparison indicate that risk arbitrage produces excess returns of approximately 29 basis points per month (3.5 percent annually). This estimate is lower than the estimate obtained using the Black–Scholes formula; the difference stems from the gap between actual market volatility and volatilities implied by index put option prices. Nevertheless, even when these higher volatilities are taken into consideration, risk arbitrage generates significant excess returns.

F. Contingent Claims Analysis versus CAPM

Because of the nonlinear relationship between risk arbitrage returns and market returns, linear asset pricing models are not appropriate for estimating excess returns associated with risk arbitrage. However, it would be interesting to know the magnitude of the error that one would make by incorrectly using CAPM. To estimate this error, we calculate the excess return using the contingent claims approach and CAPM for various subsamples of our data.

Results from our analysis suggest that, in general, CAPM provides an accurate assessment of excess returns. The largest differences between the CAPM-estimated excess return and the contingent-claims estimate occurs for subsamples with severe nonlinearities and large "up-market" intercepts. For example, when the sample is limited to cash deals in the 1980s, CAPM underestimates the excess return by 8 basis points per month (1.0 percent annually) relative to the contingent claims approach. Conversely, for subsamples where the relationship between risk arbitrage returns and market returns is closer to being linear, the difference in excess return estimates is small. When the sample is limited to stock transactions in the 1990s, CAPM overestimates the excess return by only 3 basis points per month (0.35 percent annually). This finding has implications for evaluating hedge-fund managers. Alphas estimated using linear asset pricing models will generate greater errors for fund managers that accept greater risk in depreciating markets and generate large monthly "put premiums" in flat and appreciating markets.

To determine whether the large excess returns reported in previous studies result from inaccurate measures of risk, we performed our contingent claims analysis using VWRA returns. These returns assume that there are no transaction costs or other practical limitations. Using results from Panel A of Table IV, the VWRA portfolio generates excess returns of 82 basis points per month (10.3 percent annually). Although this is far smaller than excess returns estimated in most other studies, it is greater than—not less than—

the 74 basis-point-per-month (9.25 percent annually) excess return obtained using CAPM (Table III). Thus, transaction costs, not inaccurate measures of risk, explain most of the large excess returns found in other studies.

VI. Hedge Fund Returns

A. Characteristics of Risk and Return

In addition to examining the profile of risk arbitrage returns generated by our index portfolio, we also examine the merger arbitrage return series published by Hedge Fund Research (HFR), a research and consulting firm that tracks the hedge fund industry. Their merger arbitrage monthly return series is compiled by averaging the net-of-fees returns from a sample of active merger arbitrage hedge funds over the 1990 to 1998 time period. Panel A of Figure 5 shows a scatter plot of HFR merger arbitrage returns versus market returns. For comparison purposes, RAIM returns versus market returns over the same period are shown in Panel B of Figure 5. Figure 5 shows that the payoff profile generated using our index approach is similar to that generated by HFR's sample of active hedge fund managers.

Table VIII presents piecewise linear regressions using HFR returns. To facilitate comparisons between these results and those presented in Table IV for the index portfolio, we use a threshold (kink point) excess market return of −4 percent. As is the case with the RAIM returns, −4 percent is the threshold that minimizes the sum of squared residuals. To gauge the sensitivity of the results to the choice of threshold, results are also presented using thresholds of −3 percent and −5 percent.

Results obtained using HFR returns are similar to those obtained using our index risk arbitrage portfolio returns—the market beta increases dramatically during market downturns. In depreciating markets, the HFR market beta is 0.60, slightly greater than the 0.47 market beta obtained using our RAIM portfolio returns. The intercepts are also similar—61 basis points per month using HFR index returns compared to 54 basis points per month using RAIM portfolio returns. In flat and appreciating markets, the HFR hedge fund index generates a positive market beta equal to 0.10. This compares to a beta of −0.03 using returns generated from our RAIM portfolio. Thus, in addition to being short a fraction of a put option on the market index, active managers are also long 0.10 call options on the market index.

B. Correlation Between Hedge Fund Returns and RAIM Returns

The similarity between our RAIM portfolio returns and hedge fund returns suggest that the RAIM returns may be a useful benchmark for evaluating the value added by active risk arbitrage hedge fund managers. To examine the differences and similarities between our RAIM returns and

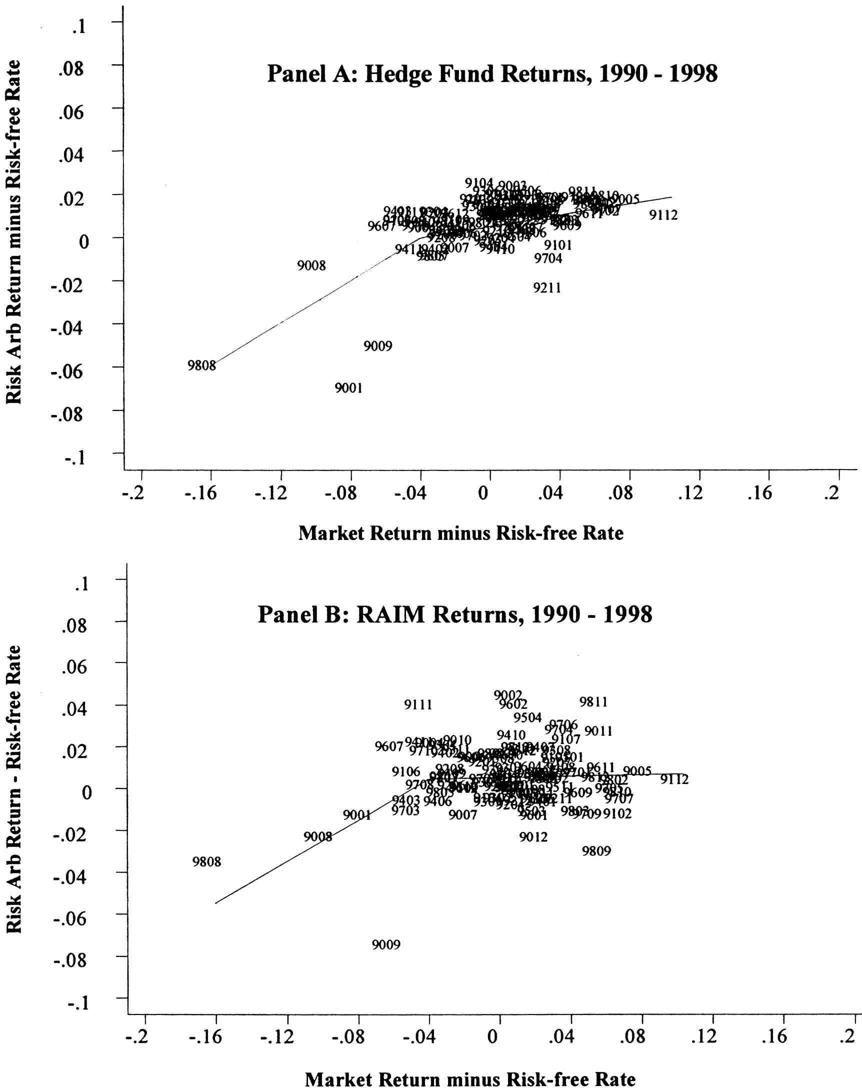

Figure 5. This figure compares RAIM returns and hedge fund returns during 1990–1998. Panel A presents hedge fund returns obtained from Hedge Fund Research's merger arbitrage index and Panel B presents RAIM returns. Data labels correspond to months (i.e., 9808 is August, 1998). Fitted lines from a piecewise linear regression are also shown.

those generated by active managers, we examine the correlation structure between RAIM returns, HFR returns, and individual hedge fund returns.[12] Individual fund returns are self-reported and were obtained from a large

[12] We are grateful to an anonymous referee for suggesting this analysis.

Table VIII

Piecewise Linear Regressions: Hedge Fund Returns versus Market Returns

This table presents results from the following piecewise linear regression relating risk arbitrage hedge fund returns to market returns:

$$R_{Hedge\,Fund} - R_f = (1-\delta)[\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(R_{Mkt} - R_f)] + \delta[\alpha_{Mkt\,High} + \beta_{Mkt\,High}(R_{Mkt} - R_f)],$$

where $R_{Hedge\,Fund}$ is the mean monthly return of actively managed merger arbitrage funds tracked by Hedge Fund Research, R_f is the risk-free rate, R_{Mkt} is the monthly return on the value-weighted CRSP index, and δ is a dummy variable equal to one if the market return is greater than a threshold and zero otherwise. Results for three thresholds (−3 percent, −4 percent, −5 percent) are presented. To insure continuity, the following restriction is imposed:

$$\alpha_{Mkt\,Low} + \beta_{Mkt\,Low}(Threshold) = \alpha_{Mkt\,High} + \beta_{Mkt\,High}(Threshold).$$

The sample consists of monthly returns over the 1990–1998 time period. Standard errors are in parentheses.

Dependent Variable	$\alpha_{Mkt\,High}$	$\beta_{Mkt\,Low}$	$\beta_{Mkt\,High}$	Adj. R^2	Sample Size
Panel A: Threshold = −3%					
Hedge fund returns	0.0067	0.5464	0.0862	0.457	108
	(0.0012)***	(0.0696)***	(0.0346)*		
Panel B: Threshold = −4%					
Hedge fund returns	0.0061	0.5985	0.1042	0.458	108
	(0.0011)***	(0.0787)***	(0.0324)**		
Panel C: Threshold = −5%					
Hedge fund returns	0.0055	0.6296	0.1223	0.443	108
	(0.0011)***	(0.0902)***	(0.0314)***		

*, **, *** indicate significance at the 0.05, 0.01, and 0.001 levels, respectively.

investor in merger arbitrage hedge funds.[13] Funds are included in our analysis if they have data for at least seven of the nine years between 1990 and 1998.

Table IX shows correlations between RAIM returns, HFR returns, and individual risk arbitrage fund returns. Panel A of Table IX shows that RAIM returns are positively correlated with both HFR returns and individual fund returns. However, the correlation between RAIM returns and a given fund's returns is generally lower than the correlation between two arbitrary funds' returns. To investigate this further, we examine the correlations after

[13] In addition to merger arbitrage, many large hedge funds pursue other relative value strategies (e.g., convertible bond arbitrage). To check whether alternative investments affect our results, we performed our analyses using average returns from a select group of hedge funds that, based on interviews, we are reasonably sure focus primarily on event arbitrage (mergers, spin-offs, carve-outs, self tender offers). Results obtained from this subgroup of managers are both quantitatively and qualitatively similar to those presented.

Table IX

Correlation Between RAIM Returns and Hedge Fund Returns, 1990–1998

This table presents correlations coefficients between RAIM returns, HFR returns, and individual hedge fund returns. RAIM returns are generated from our sample of cash and stock swap merger transactions; HFR returns represent an average of hedge fund returns assembled by Hedge Fund Research; individual fund returns are self-reported returns obtained from a large hedge fund investor. Panels A, B, and C present correlations using monthly returns. Panels D and E present correlations using quarterly returns. The monthly return threshold used to distinguish between depreciating and appreciating markets is −4 percent, whereas the quarterly return threshold is 0 percent. Using a 0 percent threshold for quarterly returns ensures that there is an adequate sample of returns in both appreciating and depreciating markets.

	RAIM	HFR	Fund A	Fund B	Fund C	Fund D	Fund E	Fund F	Fund G	Fund H	Fund I	Fund J
Panel A: Correlations using Monthly Returns, Complete Sample												
RAIM	1.00											
HFR	0.36	1.00										
Fund A	0.17	0.61	1.00									
Fund B	0.09	0.59	0.43	1.00								
Fund C	0.22	0.68	0.62	0.58	1.00							
Fund D	0.14	0.52	0.20	0.31	0.30	1.00						
Fund E	0.15	0.66	0.55	0.51	0.59	0.32	1.00					
Fund F	0.41	0.84	0.46	0.38	0.50	0.28	0.53	1.00				
Fund G	0.34	0.84	0.59	0.53	0.67	0.39	0.56	0.67	1.00			
Fund H	0.32	0.62	0.45	0.26	0.42	0.14	0.42	0.92	0.58	1.00		
Fund I	0.23	0.60	0.45	0.45	0.54	0.31	0.47	0.54	0.43	0.23	1.00	
Fund J	0.40	0.69	0.46	0.34	0.47	0.30	0.48	0.52	0.69	0.49	0.42	1.00
Panel B: Correlations using Monthly Returns, Depreciating Markets												
RAIM	1.00											
HFR	0.66	1.00										
Fund A	0.65	0.82	1.00									
Fund B	0.40	0.66	0.53	1.00								
Fund C	0.70	0.82	0.64	0.75	1.00							
Fund D	0.39	0.82	0.46	0.53	0.69	1.00						
Fund E	0.61	0.81	0.68	0.33	0.78	0.77	1.00					
Fund F	0.74	0.90	0.80	0.42	0.62	0.64	0.69	1.00				
Fund G	0.58	0.91	0.87	0.55	0.78	0.71	0.85	0.74	1.00			
Fund H	0.43	0.49	0.74	−0.02	0.12	0.20	0.51	0.95	0.66	1.00		
Fund I	0.62	0.78	0.50	0.49	0.71	0.60	0.49	0.91	0.55	0.09	1.00	
Fund J	0.76	0.90	0.83	0.41	0.69	0.62	0.84	0.91	0.88	0.72	0.70	1.00
Panel C: Correlations using Monthly Returns, Flat and Appreciating Markets												
RAIM	1.00											
HFR	−0.02	1.00										
Fund A	−0.14	0.43	1.00									
Fund B	−0.20	0.45	0.29	1.00								
Fund C	−0.12	0.47	0.53	0.44	1.00							
Fund D	−0.01	0.39	0.06	0.16	0.12	1.00						
Fund E	−0.19	0.48	0.42	0.49	0.40	0.13	1.00					
Fund F	0.09	0.71	0.19	0.32	0.35	0.10	0.30	1.00				
Fund G	0.04	0.62	0.35	0.38	0.46	0.20	0.18	0.44	1.00			
Fund H	0.11	0.68	0.22	0.32	0.46	0.04	0.26	0.86	0.41	1.00		
Fund I	0.00	0.47	0.35	0.36	0.38	0.19	0.35	0.30	0.22	0.16	1.00	
Fund J	0.10	0.40	0.20	0.16	0.18	0.11	0.18	0.09	0.41	0.20	0.21	1.00

Table IX—*Continued*

	RAIM	HFR	Fund A	Fund B	Fund C	Fund D	Fund E	Fund F	Fund G	Fund H	Fund I	Fund J
Panel D: Correlations using Quarterly Returns, Depreciating Markets												
RAIM	1.00											
HFR	0.69	1.00										
Fund A	0.37	0.87	1.00									
Fund B	0.18	0.42	0.43	1.00								
Fund C	0.64	0.87	0.83	0.73	1.00							
Fund D	0.55	0.55	0.16	0.15	0.31	1.00						
Fund E	0.59	0.88	0.86	0.26	0.75	0.46	1.00					
Fund F	0.67	0.89	0.72	−0.14	0.70	0.20	0.67	1.00				
Fund G	0.61	0.92	0.92	0.23	0.80	0.26	0.84	0.90	1.00			
Fund H	0.21	0.56	0.67	−0.30	0.30	0.02	0.60	0.91	0.75	1.00		
Fund I	0.65	0.73	0.61	0.81	0.91	0.31	0.50	0.64	0.61	−0.04	1.00	
Fund J	0.81	0.87	0.76	0.15	0.75	0.36	0.80	0.85	0.93	0.57	0.64	1.00
Panel E: Correlations using Quarterly Returns, Flat and Appreciating Markets												
RAIM	1.00											
HFR	0.38	1.00										
Fund A	0.09	0.34	1.00									
Fund B	0.36	0.26	0.23	1.00								
Fund C	0.03	0.32	0.53	0.20	1.00							
Fund D	0.20	0.59	0.08	0.19	0.07	1.00						
Fund E	−0.01	0.36	0.49	0.25	0.29	0.09	1.00					
Fund F	0.32	0.61	−0.03	0.24	0.07	0.08	0.38	1.00				
Fund G	0.35	0.61	0.20	0.23	0.39	0.46	0.10	0.44	1.00			
Fund H	0.51	0.60	0.06	0.43	0.18	0.04	0.06	0.89	0.65	1.00		
Fund I	−0.07	0.50	0.19	−0.22	0.19	0.49	0.44	0.28	0.02	−0.07	1.00	
Fund J	0.23	0.38	0.29	−0.04	0.26	0.22	0.15	−0.01	0.35	0.17	0.13	1.00

segmenting the data into two subgroups according to whether the market return minus the risk-free rate is greater than or less than −4 percent. Results, shown in Panel B for depreciating markets and Panel C for flat and appreciating markets, indicate that the correlation between RAIM returns and the HFR returns is high (0.66) in depreciating markets and close to zero (−0.02) in flat and appreciating markets. A similar effect is evident when comparing RAIM returns to individual fund returns. This pattern, however, does not hold when using quarterly, rather than monthly, returns. Panels D and E of Table IX show the results for depreciating markets and appreciating markets respectively using quarterly returns. Unlike the correlations calculated using monthly returns, the correlations using quarterly returns are much stronger, even in appreciating markets.[14] The correlation between RAIM and HFR is 0.38 and is statistically different from zero at the 5 percent level. This correlation is similar in magnitude to the correlations between

[14] To distinguish between depreciating and appreciating markets when using quarterly returns, we use a market return threshold of zero percent per quarter. This ensures that we have an adequate sample size in both depreciating and appreciating markets.

HFR returns and individual fund returns, which is surprising given that the HFR average is comprised of the individual funds' returns. Overall these results suggest that our RAIM portfolio provides a useful benchmark for evaluating hedge fund returns in depreciating markets, both for monthly and quarterly horizons. It also provides a useful benchmark in appreciating markets when a quarterly horizon is used. However, it does not reflect monthly variations of hedge fund returns in flat and appreciating markets.

There are a number of possible explanations for the lack of correlation between monthly RAIM returns and hedge fund returns in flat and appreciating markets. One possibility is that RAIM returns are generated from investments in simple cash and stock swap mergers whereas actively managed hedge fund returns reflect investments in other types of corporate transactions. In addition to investing in spin-offs and carve-outs, active hedge funds commonly invest in "collar" merger transactions. In a collar transaction, the amount paid to target shareholders depends on the acquirer's stock price during a period of time near the merger closing date. The typical collar results in a lower payment to target shareholders when the acquirer's stock price falls below a prespecified level and a higher payment if the acquirer's stock price rises above a prespecified level. Because of the concavity in the lower part of the collar and the convexity in the upper part of the collar, the return generated by an arbitrage investment in a collar deal decreases as the acquirer's stock price falls and increases as the acquirer's stock price rises. Since the acquirer's stock price is more likely to increase in appreciating markets, arbitrage returns generated by investments in collar transactions are likely to have a greater correlation with the market than simple stock transactions. The fact that hedge fund portfolios typically have positions in collar deals whereas our RAIM portfolio does not may explain why, in appreciating markets, individual fund returns are correlated with each other but not with the RAIM returns. This might also explain why the HFR returns have a beta that is more positive than the RAIM beta in appreciating markets and more negative in depreciating markets. To the degree that active managers use financial leverage, these inherent differences in betas will be amplified.

Results from our analysis suggest that three parameters, estimated with a piecewise linear regression, should be used in evaluating return series generated by risk arbitrage hedge funds. The three parameters are the down-market beta, the up-market beta, and the constant. RAIM regressions presented in Table IV provide parameter estimates that could be achieved using an index (i.e., no active information acquisition) approach. Superior hedge fund managers will have smaller down-market betas, larger up-market betas, and larger constants.

VII. Conclusion

Using a comprehensive sample of cash and stock-for-stock mergers, we examine returns generated from risk arbitrage. Our index portfolio starts with a fixed amount of cash and invests in every merger subject to three constraints. First, an investment in any merger cannot exceed 10 percent of total capital. Second, position sizes are limited by the liquidity of the underlying securities. A maximum price impact of 5 percent is allowed when investing in any position. Finally, the index fund must have an adequate amount of cash reserves to undertake the investment (the fund cannot use leverage). Returns obtained from the index portfolio are net of transaction costs including price impact and brokerage commissions. These costs are substantial. Whereas ignoring them would result in an annualized return to risk arbitrage of 16.05 percent per year, including them reduces the return to 10.64 percent per year.

In addition to the index portfolio, we calculate value-weighted average risk arbitrage returns. In this approach, we assume transactions are costless and that an unlimited amount of capital can be invested, earning the average risk arbitrage return. Although this approach is clearly unrealistic, it provides a benchmark useful for comparisons to previous studies that use a similar approach.

Our results indicate that in most market environments, risk arbitrage returns are uncorrelated with market returns. However, during market downturns, the correlation between market returns and risk arbitrage returns increases dramatically. This effect is asymmetric—similar increases are not observed in market rallies. We document similar patterns for out-of-sample tests, namely, the actual returns to professional risk arbitrage activity during the 1990s. Because of this similarity, our nonlinear analysis of risk arbitrage index manager returns can be used to generate a benchmark for evaluating risk arbitrage hedge fund managers.

These results suggest that risk arbitrage returns are similar to those obtained from writing uncovered index put options. In most states of the world, a small put premium is collected. However, in rare states, a large payment is made. This payoff profile suggests that risk arbitrage may be better evaluated using a contingent claims analysis rather than a linear asset pricing model such as CAPM. However, our analysis shows that when measuring excess returns, the error associated with using CAPM is significant only when the nonlinearity in returns is severe. This tends to be the case in time periods when cash, rather than stock, is the predominant form of merger consideration. Although linear asset pricing models mask the true risk in risk arbitrage, they do not result in large errors when measuring excess returns.

Results from our analysis indicate that risk arbitrage generates excess returns of roughly four percent annually. For individual investors that typically do not receive interest on their short proceeds, the excess return is only two percent. This compares to estimates from other studies that range between 11 percent and 100+ percent. Most of the difference between our estimates and those obtained in other studies can be attributed to transaction costs. Although our estimate is far less than estimates reported in other studies, it is still substantial. We postulate that this excess return reflects a premium paid to risk arbitrageurs for providing liquidity, especially during severe market downturns.

Appendix

A. Indirect Trading Costs

Breen et al. (1999) estimate the price impact of a trade of specified size based on liquidity characteristics of the underlying security. The price impact equation is given as

$$\frac{\Delta P}{P} = \beta(NTO) \tag{A1}$$

where $\Delta P/P$ is the price impact, equal to the percentage change in price resulting from a trade with net turnover equal to NTO. Net turnover is defined as one-tenth of the buyer-initiated volume minus seller-initiated volume divided by shares outstanding. Using the above equation, Breen et al. estimate β from price changes and net turnover over 5-minute and 30-minute intervals. The βs are then used in a cross-sectional regression to obtain the following price impact model (Breen et al. (1999, Table 5)).

$$\beta = 8.77 + 2.52X_1 - 1.84X_2 - 1.39X_3 - 1.92X_4 - 27.5X_5 - 8.29X_6 - 0.02X_7 - 0.38X_8 + 0.63X_9 - 0.08X_{10} - 0.39X_{11}, \tag{A2}$$

where

X_1 = log of market capitalization,
X_2 = log of previous quarter's trading volume,
X_3 = price at the end of the previous month divided by price 6 months prior,
X_4 = dummy variable equal to one if the equity is included in the S&P 500,
X_5 = dividend yield,
X_6 = R^2 of returns versus NYSE obtained from regressing monthly returns over the prior 36 months,
X_7 = NYSE inclusion dummy,
X_8 = NASDAQ inclusion dummy,
X_9 = dummy variable equal to one if last earnings release was more than 2 months ago,
X_{10} = percentage institutional ownership,
X_{11} = dummy variable equal to one if there are options traded on the security.

In this paper, we use equation (A2) to estimate β for both the acquirer and the target.[15] For any arbitrary price impact level (e.g., $\Delta P/P$ = 5 percent), we then use the estimate of β to calculate the maximum allowable number of

[15] Particularly for older transactions, we do not have all of the independent variables required for obtaining predicted values from equation (A2). Specifically, we are lacking X_4, X_9, X_{10}, and X_{11}. For these variables, the means from the Breen et al. (1999) sample are used.

Table AI

Pre-1975 Direct Trading Costs

Brokerage Commissions	
Size of Trade	Commission
\$100–\$2,499	1.3% + \$12.00
\$2,500–\$19,999	0.9% + \$22.00
\$20,000–\$29,999	0.6% + \$82.00
\$30,000–\$300,000	0.4% + \$142
Over \$300,000	Negotiable
Round-lot Surcharge	
Number of Round Lots	Charge per Round-lot
0–10	\$6.00
>10	\$6.00 for first 10, \$4 for each additional round-lot
Transfer Tax	
Stock Price	Transfer Tax (per share)
Less than \$5	\$0.0125
Between \$5 and \$10	\$0.025
Between \$10 and \$15	\$0.0375
More than \$15[a]	\$0.05

[a] According to Francis (1980), the transfer tax increases to \$0.05 when the stock price exceeds \$20. He does not indicate the magnitude of the tax for stock prices between \$15 and \$20. Therefore, we assume the \$0.05 tax applies to all stocks with a price above \$15.

shares that can be traded, assuming this maximum does not result in a position that exceeds 10 percent of the portfolio's total value. Equations (A1) and (A2) are also used to compute the indirect cost of trading. For every transaction in our index portfolio, we subtract transaction costs equal to the price impact implied by equations (A1) and (A2), divided by 10. The factor of 10 is used to account for the fact that traders attempt to limit the price impact of their trades by placing many small orders to accumulate a large position.

B. Direct Trading Costs

To calculate realistic returns using the risk arbitrage index portfolio, direct trading costs must be estimated. For the pre-1975 sample, this is a straightforward task. During that time period, per-share trading costs were regulated by the NYSE. The regulated direct trading costs consisted of three main components: (1) brokerage commission, (2) round-lot surcharge for orders of 200 shares or more, and (3) transfer taxes based on the price of the stock being bought or sold. Table AI, based on Francis (1980), outlines each of these costs.

Table AII
Post-1975 Direct Trading Costs

Date	Per Share Trading Cost
1975–1979	$0.10
1980–1989	$0.05
1990–1998	$0.04

After 1975, brokerage houses were free to compete on price. Because there is no set transaction cost after 1975, we assume the costs per share outlined in Table AII.

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