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Limited Arbitrage in Equity Markets

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ABSTRACT

We examine 82 situations where the market value of a company is less than its subsidiary. These situations imply arbitrage opportunities, providing an ideal setting to study the risks and market frictions that prevent arbitrageurs from immediately forcing prices to fundamental values. For 30 percent of the sample, the link between the parent and its subsidiary is severed before the relative value discrepancy is corrected. Furthermore, returns to a specialized arbitrageur would be 50 percent larger if the path to convergence was smooth rather than as observed. Uncertainty about the distribution of returns and characteristics of the risks limits arbitrage.

THIS PAPER EXAMINES IMPEDIMENTS to arbitrage in equity markets using a sample of 82 situations between 1985 and 2000, where the market value of a company is less than that of its ownership stake in a publicly traded subsidiary. These situations suggest clear arbitrage opportunities, yet, they often persist, and therefore provide an interesting setting in which to study the risks and market frictions that prevent arbitrageurs from quickly forcing prices to fundamental values.

Arbitrage is one of the central tenets of financial economics, enforcing the law of one price and keeping markets efficient. In its purest form, arbitrage requires no capital and is risk free (see Dybvig and Ross (1992)). By simultaneously selling and purchasing identical securities at favorably different prices, the arbitrageur captures an immediate payoff with no up-front capital. Of course, pure arbitrage exists only in perfect capital markets. In the real world, imperfect information and market frictions make what is referred to as "arbitrage" both capital intensive and risky.

Imperfect information and market frictions can impede arbitrage in two different ways. First, when there is uncertainty over the economic nature of an apparent mispricing and it is at least somewhat costly to learn about it, arbitrageurs may be reluctant to incur the potentially large fixed costs of entering the business of exploiting the arbitrage opportunity (Merton (1987)).

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Uncertainty over the distribution of arbitrage returns, especially over the mean, will deter arbitrage activity until would-be arbitrageurs learn enough about the distribution to determine that the expected payoff is large enough to cover the fixed costs of setting up shop. Even with active arbitrageurs, opportunities may persist while arbitrageurs learn how to best exploit them.

Second, once the fixed costs of implementing the arbitrage strategy are borne, imperfect information and market frictions often encourage specialization. Specialization limits the degree of diversification in the arbitrageur's portfolio and causes him to bear idiosyncratic risks for which he must be rewarded. For example, if there is a purely random chance that prices will not converge to fundamental value, a highly specialized arbitrageur who cannot diversify away this risk will invest less than one who can. Furthermore, even if prices eventually converge to fundamental values, the path of convergence may be long and bumpy. While waiting for the prices of the mispriced securities to converge, they may temporarily diverge. If the arbitrageur does not have access to additional capital when security prices diverge, he may be forced to prematurely unwind the position and incur a loss (DeLong et al. (1990), Shleifer and Summers (1990), and Shleifer and Vishny (1997)). The prospect of incurring this loss will further limit the amount that a specialized arbitrageur is willing to invest.

To empirically address the limits of arbitrage in equity markets, we construct a sample of situations where a firm's market value is less than the value of its ownership stake in a publicly traded subsidiary.[1] These situations are commonly referred to as "negative stub values" and can arise following equity carve outs of subsidiaries or from the partial acquisition of a publicly traded firm. We track each parent/subsidiary pair until an event occurs that eliminates the link between the two entities or until the mispricing disappears. Favorable outcomes include prices adjusting to eliminate the relative value discrepancy and distributions of the subsidiary shares to the parent firm's shareholders, while unfavorable terminations tend to be associated with acquisitions of the subsidiary and performance-related delistings of the parent. We attempt to control for the role that market frictions play in explaining the persistence of negative stub values by incorporating estimates of market frictions such as brokerage commissions, short rebates, and capital requirements into the analysis. The empirical results provide considerable support for the argument that there are costs that limit arbitrage in equity markets.[2]

[1] Throughout this paper, we refer to the company in which the parent holds an ownership stake as a subsidiary, even though the parent may not own more than 50 percent of the company's voting stock.

[2] Cornell and Liu (2000), Lamont and Thaler (2000), Schill and Zhou (2000), and Tezel and Schnusenberg (2000) examine 10 negative stub values during 1998 through 2000. They conclude that high demand for a limited number of subsidiary shares coupled with short sale constraints produce irrationally high prices. Relative mispricings in other markets have been studied by many authors, for example, Cornell and Shapiro (1989), Jarrow and O'Hara (1989), Rosenthal and Young (1990), Lee, Shleifer, and Thaler (1991), Longstaff (1992), Dammon, Dunn, and Spatt (1993), and Green and Rydqvist (1997).

We show that negative stub values are not risk-free arbitrage opportunities. The link between parent and subsidiary firms disappears without convergence of the arbitrage spread 30 percent of the time. This happens when there is a corporate event that permanently alters the relative mispricing in a manner that is detrimental to the arbitrageur's profits. For example, in some negative-stub-value situations in our sample, the parent firm goes bankrupt after using its subsidiary stake as collateral to issue debt. As a result, the link between the parent and subsidiary firms' market values is permanently severed without convergence of the arbitrage spread.

We also find that there is substantial variability in the time to termination, even for negative-stub-value investments that eventually converge. The average time between the initial mispricing and a terminating event is 236 days, the median is 92 days, the minimum is 1 day, and the maximum is 2,796 days. As a result of this uncertainty, even if convergence is eventually achieved, the negative-stub-value investment often underperforms the risk-free rate, thereby discouraging investments by arbitrageurs who are uncertain of the time to convergence and unable to close the arbitrage spread on their own.

The analysis indicates that annual returns to a specialized arbitrageur would be roughly 50 percent higher if the path to termination was smooth rather than the observed bumpy path. We estimate that when an investor posts sufficient collateral to insure against the bumpiness of the path to termination, returns are just barely larger than the risk-free rate. However, the effect of the volatile path can be substantially mitigated by combining negative-stub-value investments with the market portfolio or with other "special situations" such as merger arbitrage. This benefit of diversification, combined with the infrequent occurrence of negative-stub-value situations, suggests that it is unlikely that an arbitrageur would focus solely on negative stub values.

Finally, we document that the general uncertainty over the distribution of returns is a significant contributor to the persistence of negative stub values. We find (1) statistical reliability of abnormal returns is fairly low at the end of our 16-year sample period, and therefore unreliable near the beginning of the sample; (2) very unusual events cause extreme adverse valuation changes 13 years into the sample time series, such that even a seasoned arbitrageur would likely be caught off guard; and (3) statistically and economically large price movements occur on the day that uncertainty over the outcome is resolved. For example, when parent companies announce their intentions to distribute the subsidiaries' shares to parent company shareholders, or when they announce receipt of favorable IRS tax rulings regarding the distribution of shares, the value of the arbitrageur's position increases substantially over the three days surrounding the announcement. Even in the lowest risk cases, where the parent has previously announced its intention to distribute subsidiary shares, the value of the arbitrage position increases 8.7 percent when the parent announces receipt of a favorable IRS ruling or specifies a date for the distribution. Moreover, with no

change in the availability of shares for shorting, prices quickly adjust such that estimated stub values are no longer negative once this uncertainty is resolved.

This paper is organized as follows. Section I describes the data, Section II discusses the measurement of investment returns and performance, Section III reports results relating to the fundamental risk of negative-stub-value investments, Section IV reports results relating to the financing risk of negative-stub-value investments, Section V interprets the results and discusses arbitrage in imperfect capital markets, and Section VI concludes.

I. Data Description

A. Sample Selection Criteria

To be included in the sample, the parent's stub assets must, at some time, have an implied market value less than zero. Stub assets are defined as the market value of the parent's equity less any measurable net assets—net of the parent's unconsolidated liabilities.

$$V_{Stub} = MV_{Equity} - MV_{Stake} - [MV_{Other\,Assets} - MV_{Liabilities}]. \tag{1}$$

We use two different methods to determine whether the stub assets have a negative value. The first method, which we refer to as Rule 1, assumes that the market value of the parent's nonsubsidiary assets is equal to the market value of its liabilities. Therefore, the stub value is negative whenever the market value of the parent's equity stake in the subsidiary exceeds the parent's total market equity value:

$$\text{Rule 1:} \qquad V_{Stub} < 0 \quad \text{if} \quad \frac{MV_{Stake}}{MV_{Parent\,Equity}} > 1.0. \tag{2}$$

Our second approach to identifying negative stub values is to assume that the difference between the market value of the parent's nonsubsidiary assets (other assets) and the market value of the parent's unconsolidated liabilities equals the parent's unconsolidated book equity. This gives us Rule 2:

$$\text{Rule 2:} \qquad V_{Stub} < 0 \quad \text{if} \quad \frac{MV_{Stake} + BV_{Parent\,Equity}}{MV_{Parent\,Equity}} > 1.0. \tag{3}$$

Neither Rule 1 nor Rule 2 is problem free. First, the ratios do not account for off-balance-sheet liabilities, which could be substantial. For example, potential tobacco liabilities are not reported on Nabisco Brands' (sample firm) balance sheet, yet they might explain a significant portion of Nabisco Brand's negative stub value. As a practical matter, obtaining estimates of the market values of off-balance-sheet liabilities is difficult, and we do not

attempt to measure them in this paper.[3] Second, the book value of the nonsubsidiary assets may not accurately portray the market value of those assets. Nonetheless, the empirical results are robust to the choice of the rule used to identify mispricing.

B. Sample Construction

We construct the sample of negative-stub-value stocks using a two-step process. First, we search the Securities Data Corporation (SDC) database from 1985 through 2000 for all initial public offerings (IPO) where another publicly traded firm owned the IPO shares prior to the offering. For each of these parent–IPO pairs, we use stock price data from CRSP (pre-2000) and Datastream (during 2000) to calculate the ratios specified by Rule 1 and Rule 2 from the time of the IPO through December 2000. If, at any time, the estimate of the stub value using either Rule 1 or Rule 2 is negative, we include the parent–IPO pair in the sample.

Second, we search the financial press and trade publications for extreme relative value situations during the 1985 to 2000 period. As in the first step, we use CRSP and Datastream stock price data to ensure that the inclusion criteria are satisfied.

The resulting sample, covering the period from 1985 through December 2000, contains 70 parent/subsidiary pairs that satisfy the criterion specified by Rule 1 and 82 parent/subsidiary pairs that satisfy the criterion specified by Rule 2. Table I provides an annual summary of the negative-stub-value situations included in our sample by industry sector identified using Rule 1. Panel A shows that the sample covers a range of sectors, with a relatively high concentration in the technology sector during the latter part of the sample period. Panel B reports that many of the subsidiaries in the latter part of the sample period are firms with an Internet focus.

C. Shares Outstanding, Returns, and Short Rebates

To estimate the stub value in cross-holding situations, the number of parent shares outstanding and the number of subsidiary shares held by the parent are needed. We collect data on shares outstanding from quarterly company filings of financial reports.[4] Because estimates of arbitrage profits depend crucially on the numbers of shares outstanding at each point in time,

[3] Another potential liability is the tax arising from the distribution of the subsidiary shares to the existing parent firm shareholders. In general, to qualify for a tax-free distribution, the subsidiary business must have been in existence for at least five years and the parent firm must control at least 80 percent of the subsidiary voting shares. However, the 80 percent ownership rule can be circumvented. For example, the parent firm can create a new entity that buys the nonsubsidiary assets and then the subsidiary firm can acquire the remaining parent assets in a tax-free stock merger, effectively distributing the subsidiary shares to existing parent firm shareholders (see Andrade, Gilson, and Pulvino (2001)).

[4] Collecting shares outstanding data in this way ensures that errors in CRSP's daily shares outstanding do not affect our return calculations.

Table I

Sample Summary

This table presents a summary of the negative-stub-value situations included in the sample. Rule 1 is used as the criterion for inclusion:

$$\text{Rule 1:} \quad V_{Stub} < 0 \text{ if } \frac{MV_{Stake}}{MV_{Parent\,Equity}} > 1.0.$$

Panel A presents the frequency of situations by industry sector and year. Panel B presents negative-stub-value trades where either the parent or the subsidiary is an Internet firm. Internet firms are also included in the appropriate cells in Panel A. For situations that persist over many years, the year is determined by the date at which the stub value first goes negative. Numbers in each cell refer to subsidiaries/parents.

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Panel A: Frequency of Negative-stub-value Situations by Industry Sector and Year																
Basic materials			2/1	1/0	0/1		1/0	1/0		1/0		0/1				
Capital goods		2/1	1/0	0/1				0/1		0/1						
Consumer (cyclical)	1/0	2/2	1/0	1/0	3/2							0/1				
Consumer (non-cyc.)			3/2									2/1		1/1	2/3	
Energy																
Financial										1/0						
Health care										1/1					1/0	
Conglomerate	0/1	1/2	0/3	0/2		0/1	0/2			0/1						
Services				2/1	1/1		1/0		1/1	1/1	1/1	1/1		0/1	5/6	2/1
Technology		1/1	0/1			1/0		1/1			1/0	4/3	1/1	2/1	8/7	3/3
Transportation											0/1		1/1			
Utilities																0/1
Panel B: Frequency of "Internet" Negative-stub-value Situations by Year																
Internet												2/0		1/0	9/0	3/0

we identify exact dates at which shares outstanding change whenever the number of shares indicated in quarterly reports changes by at least 10 percent. Exact dates are determined by searching the financial press for relevant news.

In addition to share price and share ownership data, accurately assessing the risks and market frictions associated with negative-stub-value trades requires estimates of "short rebates." Short rebate refers to the rate paid to investors on the proceeds obtained from short selling a stock. We obtained short-rebate data from Ameritrade Holding Corporation, a large online retail broker. This short-rebate data covers the December 1998 through October 2000 time period. The data represent the interest rates that other institutions (typically large Wall Street investment banks) received from Ameritrade on the cash collateral that they posted to borrow Ameritrade's shares. Generally, the short rebate is 25 to 50 basis points less than the federal funds rate. However, the short rebate is occasionally lower and can even be negative. Because we observe short rebates only for securities borrowed from Ameritrade, it is likely that our short-rebate sample is biased toward stocks that are in high demand for shorting. Otherwise, the borrowing institutions would take them directly from their own inventory and would not need to borrow them from Ameritrade.

II. Measuring Investment Returns

To calculate returns and characterize risks associated with negative-stub-value investments, we begin by specifying an investment strategy. Implementing this strategy requires that the investor define the following four items: (1) the criterion by which the stub is judged to be mispriced, (2) the buy threshold, (3) the sell threshold, and (4) the amount of financial leverage used (the short position in the subsidiary's shares makes it impossible to invest in a negative-stub-value situation on an unlevered basis).

A. Investment Criteria and Thresholds

We consider two criteria by which to judge the mispricing of the stub assets. These two criteria mirror the selection criteria used to build the sample, as described in Section I. The first criterion, Rule 1, compares the market value of the stake of the subsidiary's equity held by the parent to the market value of the parent's equity:

$$\begin{aligned} \text{Rule 1:} \quad & \text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > \text{Buy Threshold} \\ & \text{Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} < \text{Sell Threshold.} \end{aligned} \tag{4}$$

For example, a buy threshold of 1.0 would imply that a trade is placed when the value of the parent's stake in the subsidiary is worth more than the entire equity value of the parent. To determine the sensitivity of our return calculations to the thresholds chosen, we present returns for buy/sell thresholds of 1.0/0.8, 1.25/1.0, and 1.5/1.0. Emphasis is on buy thresholds of 1.0 and larger because investors are likely to require some cushion over their estimates of mispricing. To determine robustness we also consider a strategy specified by Rule 2:

$$\text{Rule 2:} \quad \begin{aligned} &\text{Place trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} > \text{Buy Threshold} \\ &\text{Terminate trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} < \text{Sell Threshold.} \end{aligned} \tag{5}$$

B. Investment Capital and Financial Leverage

A final parameter that must be specified before returns can be calculated is the initial investment capital. Although straightforward for portfolios that contain only long positions, the appropriate denominator for calculating returns for a portfolio with both long and short positions is less obvious. In a frictionless capital market, the object of interest would simply be a short position in the subsidiary and a long position in the parent, which holds shares in the subsidiary. The long position would be fully financed by the proceeds from the short position. This does not work in real markets because the investor must post collateral for both long and short positions. Therefore, we calculate the return on the capital that is required to undertake the arbitrage trade. For example, an investor wishing to buy one share of a parent stock trading at \$26.25 and sell short 0.7154 shares of a subsidiary stock with a price of \$48.00 is required to contribute capital of at least \$30.29 (50 percent of both long and short position) to satisfy minimum initial capital requirements imposed by the Federal Reserve Board. To calculate returns, the total payoff from the long- and short-stock positions, as well as short rebate and the net interest payments from any excess cash minus margin borrowing is divided by the \$30.29 equity capital base. In addition to posting the required capital, investors may choose to allocate additional precautionary capital to lower the leverage of the position. Because choosing the denominator in the return calculation requires one to specify financial leverage, and since financial leverage has a direct effect on both the return and the risk, we present results using three leverage levels.

We refer to the first leverage level as "textbook" leverage. Results calculated using textbook leverage are based on two assumptions. The first assumption is based on Regulation T initial margin requirements and assumes that the initial invested capital is equal to 50 percent of the long market

value and 50 percent of the short market value.[5] The second assumption is that there are no maintenance margin requirements so that arbitrageurs never face margin calls.

The second leverage level we refer to as "Regulation T" leverage. As described above, Regulation T sets boundaries for the initial maximum amount of leverage that investors, both individual and institutional, can employ. In addition to Regulation T of the Federal Reserve Board, stock exchanges (e.g., NYSE) and self-regulatory organizations (e.g., NASD) have established maintenance margin rules to be followed after the initial transaction. For example, the NYSE and NASD require that investors maintain a minimum margin of 25 percent for long positions and 30 percent for short positions.[6] If security prices move such that the investor's position has less than the required maintenance margin, he will receive a margin call and will be required to, at a minimum, post additional collateral or reduce his position so as to satisfy the maintenance margin requirements.[7] To avoid biasing returns upward by allowing arbitrageurs to post additional collateral when a margin call is received, yet avoid counting the additional collateral in the initial investment if a margin call is not received, we assume that the arbitrageur responds to margin calls by partially liquidating his holdings.

We refer to the third leverage level as "conservative" leverage. Conservative leverage is defined to preclude all margin calls ex post, and therefore could not be determined by an investor ex ante. Nonetheless, this gives some insight into the effect on returns from setting aside additional capital to avoid forced liquidations. Specifically, for each investment strategy, we iterate over various initial leverage ratios to find the highest leverage ratio that can be used without triggering a margin call in any of the individual investments in our sample.

C. Assessing Investment Performance

We summarize the performance of negative-stub-value investments assuming that these investments are held individually as well as in a portfolio. Investment performance measures for negative stub values held in

[5] The Securities Exchange Act of 1934 granted the power to establish initial margin requirements to the Federal Reserve Board, which on October 1, 1934, instituted Regulation T. Since 1934, Regulation T has been amended numerous times, primarily to change the initial margin requirement. Regulation T was last amended in 1974 when the initial margin requirement was set at 50 percent.

[6] There are special margin requirements for shorting stocks that have a price less than $5.00. For stocks priced between and including $2.50 and $5.00, the maintenance margin requirement is 100 percent. For stocks priced below $2.50, the maintenance requirement is $2.50 per share shorted.

[7] Note that brokerage firms typically impose higher maintenance requirements for retail investors than the maintenance requirements stipulated by the NYSE and NASD. For example, Charles Schwab & Co. has a minimum maintenance requirement of 35 percent for long positions. In addition, brokerage firms often set higher initial and maintenance margin requirements for certain securities depending on volatility. In all cases, the higher requirement, whether imposed by the Federal Reserve Board, the exchange/self-regulatory organization, or the broker, prevails.

isolation include the mean annualized return in excess of the risk-free rate, the frequency of negative returns, and the frequency of margin calls. In calculating these returns, we assume that the investment horizon is one year. For investments that terminate less than one year from the initial investment date, we assume that the investment proceeds are invested in the risk-free security for the remainder of the one-year holding period. The reason for calculating returns in this way is that investments with modest daily returns, but very short durations, can have extremely high annualized returns, even though the returns are not obtainable for more than a few days. Including extreme annualized returns in a small sample skews the distribution dramatically, making it difficult to interpret the mean return as a measure of performance.

In principle, analyzing negative-stub-value investments from the perspective of someone who holds them in isolation is reasonable if the investments are truly arbitrage opportunities. However, there are many reasons to believe that few arbitrageurs would employ such a strategy. First, the negative-stub-value investments are not likely to be true risk-free arbitrage opportunities. Second, even if they are certain to converge, the path to convergence for individual investments may not be smooth. Diversification will have a potentially important effect on smoothing the arbitrageur's returns. Therefore, we also summarize the returns from a calendar-time portfolio investment strategy relative to the expected returns from the Fama and French (1993) three-factor model.

The portfolio analysis is based on monthly investment returns that satisfy Regulation T initial margin requirements and NYSE/NASD rules governing maintenance margin rules. Negative stub values are included in the portfolio from the close of market on the day that the buy threshold is reached until the close of market on the "resolution" day. The resolution day is the close of market on the day that either the sell threshold is reached or the negative stub value is terminated by some other event.

Monthly returns are obtained by compounding daily portfolio returns, which requires calculation of daily equity values for a portfolio of negative-stub-value investments. Equity is defined as the difference between assets and liabilities. Assets are the sum of the market values of long positions in the parent firms, cash proceeds from short sales of the subsidiaries, and cash. Liabilities are the sum of the market values of short positions and margin loans. Each day, these accounts are marked-to-market and net interest is paid. Cash balances receive the risk-free rate, margin loans pay 50 basis points more than the risk-free rate, and proceeds from short sales receive three percent per year.[8]

To ensure that the portfolio is at least partially diversified, we impose a "diversification constraint," which allows no more than 20 percent of the portfolio's equity to be initially invested in any one negative-stub-value trans-

[8] The short-rebate estimate of three percent reflects a discount from the more typical rate of 50 basis points below the federal funds rate. Section V discusses short rebates in more detail.

action. As a result, the portfolio is not always fully invested in negative stub values, but sometimes includes a large fraction of cash, which earns the risk-free rate. The portfolio is rebalanced only to (1) add and remove negative stub values that have crossed the buy or sell threshold, (2) close positions that have been terminated by an event, or (3) satisfy a maintenance margin call. Portfolio returns are calculated assuming direct transaction costs of \$0.05 per share in the 1980s and \$0.04 per share thereafter.

III. Fundamental Risk

In this paper, fundamental risk refers to the possibility that the negative-stub-value trade is terminated before prices converge to fundamental values (see DeLong et al. (1990) and Shleifer and Summers (1990)). The arbitrage trade involves holding a long position in the parent firm and a short position in the subsidiary firm. The long position in the parent firm gives the arbitrageur an indirect holding of the subsidiary firm, which can be shorted out, leaving a net position in only the stub assets. The key to the trade is the link between the parent and the subsidiary firm created by the parent's substantial ownership of the subsidiary. In our sample, fundamental risk relates to the unexpected severing of this link before the mispricing is eliminated.

The risk of a terminating event before prices converge is substantial. Panel A of Table II summarizes the frequency of convergence for negative-stub-value investments at the time of deal termination. The time of deal termination is determined either by the occurrence of an event that breaks the link between the parent's and subsidiary's stock prices or by the disappearance of the relative mispricing. Results are presented for samples defined by both Rule 1 and Rule 2, assuming a buy threshold of 1.0. For example, of the 70 negative-stub-value situations identified using Rule 1 and a buy threshold of 1.0, 66 had terminated and four still existed as of December 31, 2000. Of the 66 deals that terminated, the mispricing was not eliminated for 18 (27.3 percent) of the deals. With respect to the 82 negative-stub-value deals identified using Rule 2, 77 had terminated as of December 31, 2000. Of the 77 terminated deals, the mispricing was not eliminated for 27 (35.1 percent) of the deals. Changing the threshold ratio from 1.0 to 1.25 and to 1.50 for both Rules 1 and 2 does not substantially alter the frequency of deals that closed with/without elimination of mispricing.

Panel B of Table II describes the causes of negative-stub-value termination events associated with Rule 1. Fifteen of the 48 successful terminations were caused by favorable changes in the parent's and subsidiary's stock prices in the absence of an event. Twelve of the 48 successful terminations were caused by the distribution of the subsidiary's stock to the parent's shareholders. In all cases where there is a successful distribution, the parent and subsidiary stock prices converge and the negative-stub-value investment yields a positive return. However, it is important to note that even though, ex post, distributions are associated with positive returns, there is no guarantee, ex ante, that the distribution will occur. The following text published in PFSWeb's

Table II

Frequency of Deals for Which Mispricing Is Eliminated

This table presents a summary of the frequency with which mispricings associated with negative-stub-value investments are eliminated at the time of deal termination. Results are presented using the following two mispricing criteria:

$$\text{Rule 1:} \quad V_{Stub} < 0 \text{ if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > 1.0$$

$$\text{Rule 2:} \quad V_{Stub} < 0 \text{ if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} > 1.0$$

where V_{Stub} is the value of the parent's stub assets. Panel A describes the proportion of deals for which the mispricing is ultimately eliminated and Panel B describes the events that cause the mispricing to be eliminated.

Panel A: Frequency of Convergence for Negative-stub-value Investments

Mispricing Measurement	Total Sample Size	Number (Percentage) of Deals for Which Mispricing Is Eliminated	Number (Percentage) of Deals for Which Mispricing Is Not Eliminated
Rule 1	66	48 (72.7%)	18 (27.3%)
Rule 2	77	50 (64.9%)	27 (35.1%)

Panel B: Description of Negative-stub-value Termination Events (Rule 1)

Event	Number of Occurrences	Mispricing Eliminated	Mispricing Not Eliminated
Parent distributes subsidiary shares to parent shareholders	12	12	0
Third party acquires subsidiary	13	5	8
Parent acquires the subsidiary shares that it does not already own	5	3	2
Third party acquires both parent and subsidiary	7	4	3
Third party acquires parent	2	1	1
Subsidiary acquires parent	2	2	0
Parent stock is delisted	8	4	4
Both parent and subsidiary are delisted	2	2	0
Parent and subsidiary stock price changes eliminate mispricing	15	15	0
Mispricing not eliminated as of December 31, 2000	4	—	—
Total	70	48	18

IPO prospectus suggests that even with planned distributions, there is a chance that the distribution will be delayed or canceled:

> Daisytek [the parent of PFSWeb] recently announced that it had received an unsolicited offer to acquire all of Daisytek's outstanding shares.

> After considering a variety of factors, Daisytek's board determined that the offer was inadequate and inconsistent with Daisytek's previously disclosed plans to complete the spin-off. If, however, the bidder decides to begin a tender offer for the outstanding shares of Daisytek without the approval of Daisytek's board, such an offer, or stockholder litigation in connection with such an offer, could significantly divert our attention away from our operations and disrupt or delay our proposed spin-off from Daisytek. In addition, if the bidder is successful in acquiring control of Daisytek prior to the proposed spin-off, it would control a majority of our shares and the spin-off would likely not occur.[9]

The remaining causes of successful termination (21 of the 48) include acquisitions and delisting of the parent's and/or the subsidiary's stock.

As previously mentioned, the mispricing was not eliminated in 18 of the 66 (27.3 percent) negative-stub-value situations that were terminated prior to December 31, 2000. An acquisition of the parent and/or subsidiary is the single most common reason for adverse termination. Acquisitions account for 14 of the 18 adverse deal terminations. The negative-stub-value trade associated with Howmet International (the subsidiary) and Cordant Technologies (the parent) provides an example of the adverse effect that an acquisition can have on a negative-stub-value investment. On November 11, 1999, Cordant owned 84.6 million shares of Howmet. At a price of $14.06 per share, Cordant's investment was worth $1.2 billion. At the same time, Cordant's 36.7 million shares outstanding were trading at $29.94, implying a market capitalization of $1.1 billion. An arbitrageur that had previously placed a stub-value trade would have shorted 2.31 (2.31 = 84.6/36.7) Howmet shares for every one share of Cordant owned.

On November 12, 1999, Cordant announced an offer to buy Howmet's publicly traded shares for $17 per share. Howmet's shares closed that day at $17.75, up $3.69. Cordant's shares increased slightly, up $0.63. As a result of Cordant's bid to acquire Howmet's publicly traded shares, the arbitrageur experienced a −25 percent one-day return.[10] Since Cordant's acquisition of Howmet terminates the arbitrage opportunity, the arbitrageur would realize a loss.[11]

The remaining four adverse terminations documented in Panel B of Table II are caused by delisting of the parent company's stock. For example, some of the parent firms significantly increased their debt obligations by pledging subsidiary shares as collateral. When the underlying businesses failed to

[9] PFSWeb IPO prospectus, December 2, 1999, p. 10.

[10] This calculation assumes that 50 percent of the long position and 50 percent of the short position (per Regulation T) was posted as collateral.

[11] Ultimately, Howmet's board rejected Cordant's $17 offer and on March 13, 2000, Alcoa offered to buy Cordant Technologies for $57 per share in cash. It also announced its intention to buy Howmet's publicly traded shares. As of March 22, 2000, assuming the arbitrageur had the foresight, fortitude, and financial resources necessary to hold his position, his investment in Howmet and Cordant on November 11, 1999, would have returned 35 percent in four months.

generate sufficient cash flows to service the debt repayments, the debt holder laid claim to the collateralized asset, thereby terminating the arbitrage opportunity to the detriment of the arbitrageur.

With 27.3 percent (Rule 1) and 35.1 percent (Rule 2) of the stub-value investments terminating before the mispricing is eliminated, it is clear that fundamental risk exists and that these investments are far from risk-free arbitrage opportunities. Investments that are known to converge have shorter time horizons, larger mean returns, and far fewer negative returns than the full sample of negative stub values. Section IV reports that the median investment horizon for deals that eventually converge is roughly 75 percent as long as that for the full sample. Deals that are known to converge have mean annualized returns in excess of the risk-free rate that are roughly 50 percent to 100 percent larger than the returns for the full sample.

IV. Financing Risk

A significant risk faced by an arbitrageur attempting to profit from negative stub values is that the path to convergence can be long and bumpy. Shleifer and Vishny (1997) argue that arbitrageurs must deal with the possibility of interim liquidations even in the case when convergence is certain. In addition, the length of the interval over which convergence will occur is unknown. Increasing the length of the path reduces the arbitrageur's return, a risk we refer to as "horizon risk."

Increasing the volatility of the path increases the likelihood that the arbitrageur will be forced to terminate the negative-stub-value trade prematurely. There are two possible causes of forced liquidation related to the volatility of the path. First, if the arbitrageur faces a margin call, he will be forced to post additional collateral or partially liquidate. We refer to this risk as "margin risk." The second cause of forced liquidation stems from the fact that negative-stub-value trades require the arbitrageur to short the subsidiary's stock. If the arbitrageur is unable to maintain his short position, he will be forced to terminate the trade. We refer to the risk of forced termination because of an inability to maintain the short position as "buy-in risk." In this section, we describe the magnitudes of horizon risk and margin risk.[12] The discussion of buy-in risk is postponed until Section V.A.

A. *Horizon Risk*

Table III presents the distribution of the number of days between the initial investment in a negative-stub-value trade and the termination date. Unlike previous tables where the unit of observation is a negative-stub-

[12] Liu and Longstaff (2000) examine horizon risk and margin risk in bond arbitrage strategies. They show that it is often optimal for investors to refrain from taking the maximum position allowed by margin constraints, even when the arbitrage spread is guaranteed to converge in the future.

Table III

Investment Horizon

This table presents a summary of the number of days invested using two different trading strategies. Panels A and B show the number of days invested using Rule 1, for the full sample and for converged deals, respectively. Rule 1 is defined as:

$$\text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > \text{Buy Threshold}$$

and

$$\text{Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} < \text{Sell Threshold.}$$

Panels C and D show the number of days invested using Rule 2 for the full sample and for converged deals, where Rule 2 is defined as:

$$\text{Place trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} > \text{Buy Threshold}$$

$$\text{Terminate trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} < \text{Sell Threshold.}$$

Converged deals are identified as those where the mispricing ratio is smaller at termination than at the initial date. Results are presented for various buy and sell thresholds. Table entries, other than buy and sell thresholds, represent trading days.

Buy Threshold	Sell Threshold	Number of Investments	Percentile					
			Minimum	25th	50th	75th	Maximum	Mean
Panel A: Number of Days Invested Using Rule 1 for All Investments								
1.00	0.8	110	1.0	29.0	92.0	274.0	2,796.0	236.3
1.25	1.0	75	2.0	28.5	84.0	213.0	2,413.0	214.4
1.50	1.0	39	13.0	92.5	159.0	258.3	2,370.0	343.1
Panel B: Number of Days Invested Using Rule 1 for Converged Investments								
1.00	0.8	79	3.0	25.0	74.0	207.5	1,804.0	176.5
1.25	1.0	40	2.0	26.5	66.5	127.5	1,792.0	164.7
1.50	1.0	20	13.0	46.0	117.5	163.0	1,792.0	265.9
Panel C: Number of Days Invested Using Rule 2 for All Investments								
1.00	0.8	130	3.0	46.0	155.5	380.0	2,818.0	309.7
1.25	1.0	119	3.0	41.5	114.0	285.0	2,818.0	236.0
1.50	1.0	67	7.0	68.8	182.0	336.0	2,804.0	327.7
Panel D: Number of Days Invested Using Rule 2 for Converged Investments								
1.00	0.8	94	3.0	35.0	109.0	279.0	2,818.0	271.1
1.25	1.0	79	4.0	34.3	68.0	229.3	2,818.0	205.2
1.50	1.0	41	7.0	55.0	100.0	278.8	2,804.0	290.5

value situation, the unit of observation in Table III is an investment. Fluctuations in stub values can cause the buy and sell thresholds to be crossed numerous times, resulting in multiple investments per parent/subsidiary pair. Distributions shown in Table III are presented for investment criteria specified by both Rule 1 and Rule 2. For example, using Rule 1 combined with a buy threshold of 1.0 and a sell threshold of 0.8, the minimum number of days invested is 1, the maximum is 2,796, and the median is 92. Changing the buy threshold, the sell threshold, or the investment criterion has a relatively small effect on the distribution of the length of the arbitrage trade. In all cases, the variance of the number of days until deal termination is large. To get an idea of the effect of this variation on returns, consider an investment that is expected to generate a 15.0 percent return over the median of 92 trading days. This investment would generate an annualized return of 47 percent. A decrease in the number of days until termination from the median to the 25th percentile would increase the annualized return to 238 percent. Similarly, an increase in the number of days until termination from the median to the 75th percentile would decrease the annualized return to 14 percent.

Uncertainty over the time until convergence is large and has a significant effect on returns. Using Rule 1 to identify mispricings, the arbitrageur would have been better off investing in risk-free securities rather than in the arbitrage trade in roughly 10 percent of the situations that eventually converge in our sample, and in nearly 25 percent of the situations using Rule 2.

B. Margin Risk

B.1. Creative Computers / Ubid Example

To describe margin risk in negative-stub-value investments, we consider the example of Creative Computers (parent) and Ubid (subsidiary).[13] On December 4, 1998, Creative Computers carved out 20 percent of its online auction subsidiary Ubid in an IPO. At the time of the IPO, Creative Computers also announced its intention to distribute, after a minimum of six months, the remaining shares of Ubid that it owned in a tax-free spin-off to Creative Computers' shareholders. At the end of the first day of trading, Ubid's total equity value was $439 million. The implied value of Creative Computers' 80 percent Ubid stake was greater than Creative Computers' total market value by approximately $80 million, far in excess of the approximately $3 million of debt on Creative Computer's balance sheet. Because it is common for the typical IPO to be unavailable for shorting for a few days following the IPO, we assume that the arbitrageur's initial trade was placed on December 9, 1998, four days after the IPO. At the close of trading on December 9, 1998, the value of the stub assets had increased to negative $28 million. An arbitrageur attempting to profit by buying Creative Computers' negative $28

[13] See Pulvino and Das (1999) for a case study on Creative Computers' carve-out of Ubid.

million stub assets would have shorted 0.72 shares of Ubid for every share of Creative Computers purchased. In six months, if the remaining Ubid shares were distributed to Creative Computers' shareholders, the value of the stub assets would turn positive. Assuming that the arbitrageur used Regulation T leverage, the anticipated return from his investment would be approximately 45 percent at the end of six months.[14]

Figure 1 shows the paths of stock prices for both Creative Computers and Ubid. By December 18, 1998, the discrepancy between Creative Computers and Ubid stock prices had increased substantially—the value of the stub assets had decreased from negative $28 million to negative $94 million. Using margin maintenance requirements specified by NYSE and NASD, the arbitrageur would have faced a margin call and would have been forced to partially liquidate his position to satisfy maintenance margin requirements.[15] The arbitrageur would have lost 26 percent in seven trading days.

On December 21, 1998, the value of Creative Computers' stub assets decreased to negative $254 million. For a second trading day in a row, the arbitrageur would have faced a margin call and been forced to reduce his position even further, incurring an additional one-day loss of 84 percent. Bad luck continued when, on the following trading day, the value of Creative Computers' stub assets fell to negative $505 million, causing a one-day loss of 91 percent. On December 23, 1998, the value of Creative Computers' stub assets reached its minimum level of negative $766 million. The arbitrageur received his fourth and final margin call and an additional one-day loss of 63 percent.

Figure 1 shows that after December 23, 1998, the prices of Ubid and Creative Computers converged. As promised by Creative Computers' management, the remaining Ubid shares were distributed to Creative Computers' shareholders six months later. The portion of the arbitrageur's capital that was not liquidated returned 150 percent between the peak mispricing on December 23, 1998, and the spinoff on June 7, 1999. However, because the arbitrageur lost most of his capital prior to December 23, 1999, his overall return from the Creative Computers/Ubid investment was *negative* 99 percent. To avoid the costly margin calls, the arbitrageur would have had to post $4.53 of excess cash for every $1 of long position. Doing so would have generated a return of 8.7 percent between December 9, 1998, and June 7,

[14] Throughout this example, we assume that the arbitrageur does not earn interest on his posted collateral or short proceeds. In the full sample analyses that follow, we assume that cash balances earn the Treasury bill rate and short proceeds earn three percent.

[15] Alternatively, the arbitrageur could contribute additional capital. However, allowing the arbitrageur to do this would imply that a pool of capital had been allocated, ex ante, to meet margin calls. Thus, the denominator in the return calculation should include this pool of reserve capital. To avoid this, we assume that the arbitrageur partially liquidates his position in response to margin calls. This assumption has the effect of decreasing calculated returns if the subsequent arbitrage spread converges, and increasing calculated returns if subsequent arbitrage spreads widen.

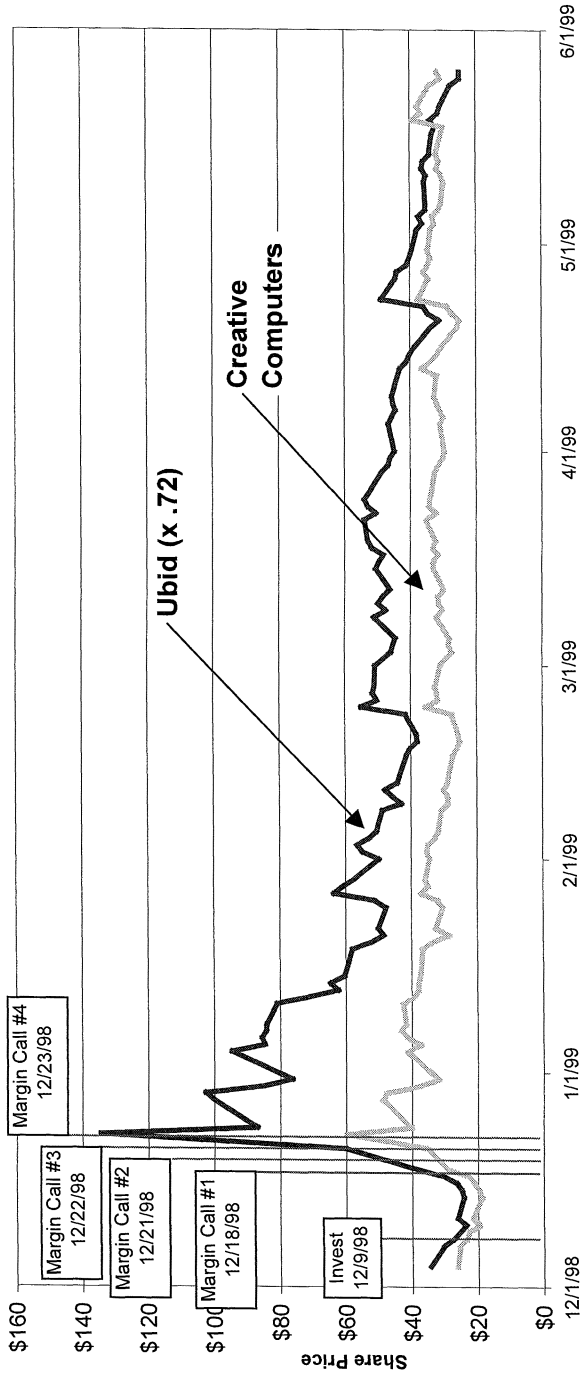

Figure 1. Paths of stock prices for Creative Computers and Ubid.

1999. This is significantly lower than the 45.9 percent that the arbitrageur could have obtained with the same initial investment had he not been required to liquidate to meet margin calls.

B.2. Full Sample Results for Individual Investments

The Creative Computers/Ubid example suggests that ignoring margin requirements results in overestimation of returns from negative-stub-value investments. To determine whether this is generally the case, we estimate returns for each of the negative-stub-value investments in our sample using the three leverage levels previously described—textbook leverage (Regulation T initial margin imposed, no maintenance requirements imposed), Regulation T leverage (both initial and maintenance margin requirements imposed), and conservative leverage (maximum asset/equity ratio for which no margin calls are received). Returns are estimated using investment strategies defined by Rule 1 using buy/sell thresholds of 1.0/0.8, 1.25/1.0, and 1.5/1.0.

Table IV presents annualized returns in excess of the risk-free rate obtained by following the investment strategy specified by Rule 1. Panel A presents results for buy/sell thresholds of 1.0/0.8. When all deals are included in the sample, the mean return obtained using textbook leverage is 18.5 percent, whereas the mean return using Regulation T leverage is 12.7 percent. The difference between these two returns is a result of the maintenance margin rules imposed by NYSE and NASD, suggesting that the effect of margin calls described by the Creative Computers/Ubid example is present in many of the individual investments. Of the 110 investments included in Panel A, 23.6 percent receive margin calls when maintenance margin requirements are imposed. Interestingly, margin calls are not always detrimental to the arbitrageur's profits. In cases where the arbitrage spread widens after a margin call is received, the margin call forces the arbitrageur to liquidate his position and saves him from further losses. It is this effect that causes the minimum return to occasionally be lower for textbook leverage than for the usually more stringent Regulation T leverage.

One way of preventing margin calls is to initially post additional collateral. Returns for conservative leverage in Table IV are obtained by choosing the assets/equity ratio that precludes a margin call across all deals in the sample for a given investment strategy. Insuring against a margin call has the benefit of reducing downside risk—the percentage of investments losing money relative to the risk-free investment is only 17.3 percent using conservative leverage compared to 22.7 percent using Regulation T leverage. However, the cost of insuring against margin calls for an individual investment is high. After insuring against margin calls by posting additional capital, the mean annualized excess return drops to 2.6 percent.

In addition to returns for the full sample, Table IV also presents returns after restricting the sample to those negative-stub-value situations that eventually converged. Even with these deals, where fundamental risk is ex post

Table IV

Individual Investment Returns Using Rule 1

This table summarizes annualized excess returns from investments in parent/subsidiary pairs using the following investment strategy:

$$\text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > \text{Buy Threshold}$$

and

$$\text{Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} < \text{Sell Threshold.}$$

Returns are presented for various buy and sell thresholds and also for various leverage levels. Textbook leverage returns are calculated assuming Regulation T initial margin requirements but no maintenance margin requirements. Regulation T leverage returns are calculated using Regulation T initial and maintenance margin requirements: when margin calls are received, positions are partially liquidated such that maintenance margin requirements are satisfied. Conservative leverage returns are calculated using an Assets/Equity ratio that precludes margin calls for all parent/subsidiary pairs in the sample. All returns are annualized holding period returns in excess of the risk-free holding period return and assume that the risk-free rate is paid on short proceeds.

	Minimum Return (%)	Mean Return (%)	Maximum Return (%)	Investments With Negative Returns (%)	Investments That Receive Margin Calls (%)	Sample Size
Panel A: Buy Threshold = 1.0; Sell Threshold = 0.8						
All deals						
Textbook leverage	−104.9	18.5	120.0	17.3	—	110
Regulation T leverage	−104.1	12.7	120.0	22.7	23.6	110
Conservative leverage	−13.7	2.6	16.7	17.3	0.0	110
Converged deals						
Textbook leverage	−20.6	28.6	120.0	5.1	—	79
Regulation T leverage	−99.3	23.1	120.0	11.4	16.5	79
Conservative leverage	−6.1	8.2	35.7	5.1	0.0	79
Panel B: Buy Threshold = 1.25; Sell Threshold = 1.0						
All deals						
Textbook leverage	−103.9	21.6	71.6	16.0	—	75
Regulation T leverage	−104.1	13.8	71.6	21.3	26.7	75
Conservative leverage	−9.1	2.8	8.0	16.0	0.0	75
Converged deals						
Textbook leverage	−7.8	33.2	71.6	2.5	—	40
Regulation T leverage	−99.4	25.0	71.6	10.0	22.5	40
Conservative leverage	−2.0	8.6	17.2	2.5	0.0	40
Panel C: Buy Threshold = 1.5; Sell Threshold = 1.0						
All deals						
Textbook leverage	−103.9	24.2	71.6	20.5	—	39
Regulation T leverage	−104.1	10.1	71.6	35.9	38.5	39
Conservative leverage	−10.4	4.0	10.3	20.5	0.0	39
Converged deals						
Textbook leverage	−7.8	41.6	71.6	5.0	—	20
Regulation T leverage	−57.8	27.9	71.6	20.0	30.0	20
Conservative leverage	−3.8	19.5	32.9	5.0	0.0	20

known not to have had a detrimental effect, returns are still frequently negative. Moreover, the difference between mean returns when maintenance margin requirements are satisfied and when they are avoided remains substantial for this subsample. In other words, the bumpiness of the path to convergence is costly to the arbitrageur. This suggests that both horizon risk and margin risk are important for individual investments even when fundamental risk is mitigated.

Panels B and C of Table IV present results for different buy/sell thresholds, again using Rule 1 as the investment strategy. Results are similar to those presented in Panel A, indicating that results are not strongly dependent on the levels of the thresholds. Overall, the results indicate that while annual excess returns from negative-stub-value investments are positive on average, they are not risk free.[16]

B.3. Portfolio Results

Table V displays calendar-time portfolio regression results for the negative-stub-value investments over the period January 1985 through December 2000. The portfolio returns are calculated as described earlier, satisfying Regulation T initial margin requirements as well as NYSE/NASD maintenance margin rules. In addition, we impose a diversification constraint that limits the initial investment in any one deal to 20 percent of total equity.[17] Portfolio returns are calculated assuming short rebates of three percent per year and direct transaction costs of \$0.05 per share in the 1980s and \$0.04 per share thereafter.

The investment strategy that uses Rule 1 to identify mispricing and a buy/sell threshold of 1.25/1.0 produces the largest and only statistically significant average abnormal returns: 1.241 percent per month, or 14.9 percent per year (1.241 percent $\times$ 12 months), with a t-statistic of 2.17. The estimated coefficient on the market excess return is slightly negative (-0.173 with a t-statistic of -1.18) and the coefficients are close to zero for the *SMB* and *HML* risk factors.

The other investment strategies produce similar overall results, although the monthly abnormal return estimates are not statistically reliable or as economically large, ranging from 0.514 percent to 0.825 percent for the other Rule 1 strategies (t-statistics of 0.78 and 1.60, respectively), and from 0.021 percent to 0.745 percent for the Rule 2 strategies (t-statistics of 0.06 and 1.54, respectively).

[16] We repeated the analysis presented in Table IV using Rule 2 to identify mispricing (results not reported). This change in the investment strategy has only a small effect on the results, suggesting that the risks and returns are not overly sensitive to the method used to quantify the mispricing.

[17] We originally chose the 20 percent diversification constraint as a reasonable level that an arbitrageur might choose. Subsequent analyses coincidentally showed that 20 percent is the level of diversification that maximizes portfolio returns over the sample period.

Table V

Calendar-time Portfolio Regression Results for the Negative-stub-value Investments (January 1985 through December 2000)

This table presents results from the following regression of monthly returns from a portfolio of negative-stub-value investments on common risk factors: $Rp_t - Rf_t = a + b(Rm_t - Rf_t) + sSMB_t + hHML_t + e_t$, where the dependent variable is the monthly return on a portfolio of negative-stub-value investments, Rp, in excess of the one-month Treasury Bill yield, Rf. The independent variables are the excess return of the market, $Rm - Rf$; the difference between a portfolio of "small" stocks and "big" stocks, SMB; and the difference between a portfolio of "high" book-to-market stocks and "low" book-to-market stocks, HML. See Fama and French (1993) for details on the construction of the factors. Results are presented for two investment strategies. Panel A shows the abnormal investment returns using Rule 1 defined as

$$\text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > \text{Buy Threshold}$$

$$\text{Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} < \text{Sell Threshold.}$$

Panel B shows the abnormal investment returns using Rule 2, defined as

$$\text{Place trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} > \text{Buy Threshold}$$

$$\text{Terminate trade if } \frac{MV_{Stake} + BV_{Parent\ Equity}}{MV_{Parent\ Equity}} < \text{Sell Threshold.}$$

Regression coefficients are presented for various buy and sell thresholds, with t-statistics in parentheses. The number of monthly portfolio returns are denoted by N.

Buy Threshold	Sell Threshold	No. of Investments	a	b	s	h	Adj. R^2 [N]	Annualized Abnormal Return
Panel A: Abnormal Investment Returns Using Rule 1								
1.00	0.8	110	0.825	−0.176	−0.269	0.088	0.050	9.9%
			(1.60)	(−1.34)	(−1.66)	(0.43)	[186]	
1.25	1.0	75	1.241	−0.173	−0.137	0.264	0.052	14.9%
			(2.17)	(−1.18)	(−0.78)	(1.19)	[172]	
1.50	1.0	39	0.514	−0.073	−0.270	0.284	0.047	6.2%
			(0.78)	(−0.43)	(−1.33)	(1.11)	[168]	
Panel B: Abnormal Investment Returns Using Rule 2								
1.00	0.8	130	0.021	0.120	−0.264	0.183	0.061	0.2%
			(0.06)	(1.26)	(−2.24)	(1.24)	[192]	
1.25	1.0	119	0.745	0.002	−0.076	0.130	0.009	8.9%
			(1.54)	(0.01)	(−0.49)	(0.68)	[192]	
1.50	1.0	67	0.391	−0.012	0.175	0.327	0.013	4.7%
			(0.61)	(−0.07)	(0.87)	(1.29)	[192]	

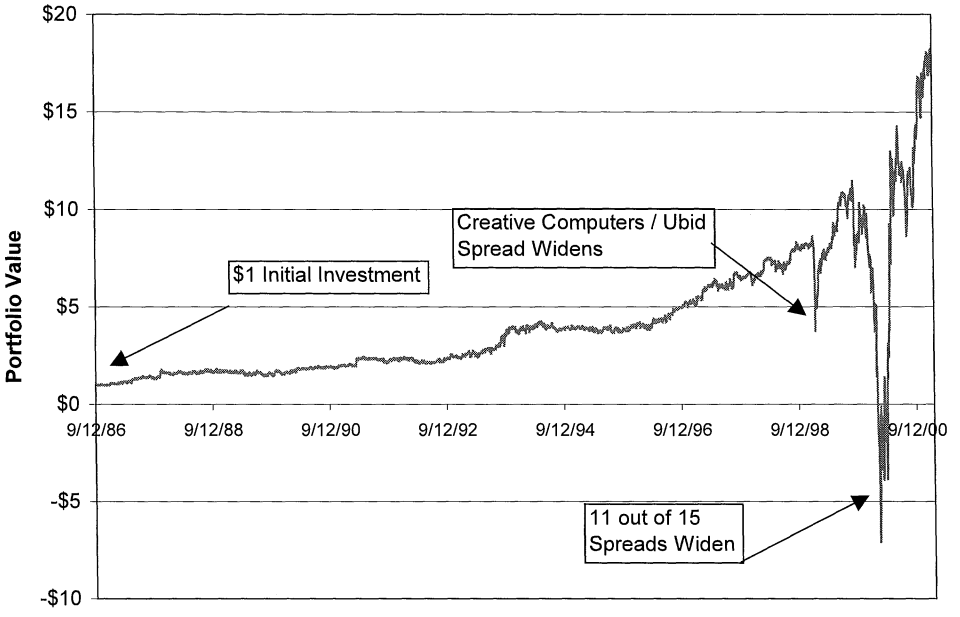

Figure 2. Daily portfolio values of negative-stub investments ignoring maintenance margin requirements. This figure shows the value of one dollar invested at the beginning of the period from 1986 to 2000 in negative-stub-value investments. Negative-stub-value portfolio values are obtained from an investment strategy based on Rule 1 (below) using a buy threshold of 1.25 and a sell threshold of 1.0:

$$\text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > 1.25 \text{ and Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} < 1.0.$$

The portfolio value calculation cumulates daily payoffs from the arbitrage positions and ignores maintenance capital requirements, allowing the value of invested capital to become negative.

Figure 2 shows that margin risk cannot be completely diversified away by holding a portfolio of negative stub values, as the effects of the Creative Computers/Ubid investment show up clearly in December 1998. At this time, the equity value drops below the maintenance margin requirement, and some of the portfolio holdings must be liquidated.[18] Nonetheless, an investor in a portfolio of negative stub values is considerably less sensitive to margin risk than one holding them individually. For example, when the Creative Computers/Ubid arbitrage spread widens in December 1998, an investor holding the portfolio of negative stub values receives one maintenance margin call, while the investor holding just Creative Computers/Ubid receives four margin calls.

[18] Positions are liquidated randomly to satisfy margin calls. Chance had this particular investment strategy liquidate a position other than Creative Computers/Ubid to cover the margin call. This proved fortunate for the arbitrageur as the Creative Computers/Ubid investment experienced a large return on the very next day, causing the equity value of the portfolio to increase 46.2 percent.

Another way to see that the bumpiness of the path is costly to a specialized arbitrageur holding a portfolio of negative-stub-value investments is to completely relax the maintenance margin requirements, going so far as to allow equity values to go negative without requiring liquidation. As with the individual investments, returns are considerably larger when maintenance margin requirements are not enforced. The ending equity value climbs to \$16.9 without margin requirements versus \$9.8 with maintenance margin requirements. Again, we see that margin risk will at least partially deter a specialized arbitrageur.

C. *Specialization of the Arbitrageur*

The calendar-time portfolio results are descriptive of the risks and returns that a highly specialized arbitrageur would face. By investing in just a few negative stub values at each point in time, and often holding sizeable cash balances, the arbitrageur is effectively able to diversify away fundamental risk, but still bears sizeable financial risk. The returns to such a strategy seem economically large, but for the most part, statistically unreliable.

There are few, if any arbitrage funds that exclusively engage in such an investment strategy. On the other hand, there are many arbitrage funds that engage in "special situations arbitrage," which includes negative-stub-value investments. Although these funds often specialize in one specific type of arbitrage trade, such as merger arbitrage, they only do so if there are sufficiently many transactions. This suggests that the specialized arbitrageur described so far is a bit of a straw man.

A more realistic assessment of the risks faced by the likely investor can be obtained by combining negative-stub-value returns with those from complimentary strategies. Table VI reports annual returns to our negative-stub-value investor following the investment strategy defined by Rule 1 and buy/sell thresholds 1.25/1.0, as well as for the market portfolio, a merger arbitrage index portfolio, and two hybrid funds, which combine the negative-stub-value investments with either the market or the merger arbitrage index.[19] The portfolio of negative-stub-value investments has the largest mean return of any of the portfolios over the sample period, but also the largest standard deviation, over 60 percent larger than that for the value-weighted market.

Returns from the negative-stub-value portfolio are negatively correlated with the market, such that a combination of the negative-stub-value portfolio with the market will achieve substantial diversification. The maximum in-sample Sharpe ratio of 0.99 is reached with 41 percent invested in the negative-stub-value portfolio and 59 percent in the market. This "fund-of-funds" approach actually understates the benefits of combining these investment strategies because it assumes that the capital invested in the market cannot be used as collateral to offset the financial risk faced by the portfolio

[19] Merger arbitrage index returns are obtained from the analysis described in Mitchell and Pulvino (2001).

Table VI

Negative-stub-value Portfolio Return Series

This table presents the annual return series for the portfolio of negative-stub-value investments. Returns are presented for the pure negative-stub-value portfolio, the negative-stub-value portfolio combined with the market portfolio (41% negative stub values, 59% market), and for the negative-stub-value portfolio combined with a merger arbitrage portfolio (15% negative stub values, 85% merger arbitrage). Negative-stub-value portfolio returns are obtained from an investment strategy based on Rule 1 (below) using a buy threshold of 1.25 and a sell threshold of 1.0:

$$\text{Place trade if } \frac{MV_{Stake}}{MV_{Parent\,Equity}} > 1.25$$

and

$$\text{Terminate trade if } \frac{MV_{Stake}}{MV_{Parent\,Equity}} < 1.0.$$

Value-weighted CRSP returns are presented for comparison purposes. Merger arbitrage index returns are from Mitchell and Pulvino (2001). For the combination portfolios, weights are chosen to maximize the in-sample Sharpe ratio. Sharpe ratios are calculated using annual returns and annualized standard deviations. All annual returns are obtained by compounding monthly returns. Annualized standard deviations (Std) are obtained by multiplying the standard deviation of monthly returns by $\sqrt{12}$.

Year	Pure Negative-stub-value Portfolio	Negative-stub-value Portfolio Combined with the Market Portfolio	Negative-stub-value Portfolio Combined with the Merger Arbitrage Portfolio	Value-weighted CRSP Returns	Merger Arbitrage Index Return
1986	9.5%	1.4%	1.9%	15.6%	20.6%
1987	44.4%	21.4%	9.9%	1.8%	3.8%
1988	17.5%	17.7%	26.1%	17.6%	27.6%
1989	−0.3%	16.9%	4.8%	28.5%	5.4%
1990	29.3%	7.8%	7.9%	−6.0%	4.4%
1991	17.6%	27.3%	13.2%	33.6%	12.1%
1992	6.4%	8.2%	4.8%	9.0%	4.5%
1993	55.6%	28.3%	18.2%	11.5%	12.3%
1994	2.5%	1.0%	11.1%	−0.6%	12.6%
1995	2.1%	21.1%	9.7%	35.7%	11.0%
1996	41.1%	29.5%	19.1%	21.3%	15.4%
1997	20.5%	27.1%	13.1%	30.4%	11.6%
1998	−14.2%	9.3%	2.1%	22.5%	4.1%
1999	15.7%	26.5%	19.0%	24.9%	16.7%
2000	77.4%	20.6%	25.3%	−10.9%	16.6%
Mean	22.0%	17.5%	12.3%	14.4%	10.5%
Std	24.8%	12.3%	6.0%	15.4%	5.8%
Sharpe ratio	0.676	0.992	1.163	0.592	0.914

of negative stub values. In other words, the path would have been much smoother so that there would have been fewer forced liquidations to satisfy margin calls. A similar analysis was performed using combinations of the negative stub values and the merger arbitrage index portfolio. The maximum in-sample Sharpe ratio from this strategy is 1.16 with 15 percent invested in the negative-stub-value portfolio and 85 percent in the merger arbitrage index portfolio.

This suggests that fundamental and margin risks, which are clearly important for someone investing in individual negative stub values, are less likely to create a serious impediment to the likely arbitrageur of these relative mispricings.

V. Arbitrage in Imperfect Capital Markets

A. Costs of Short Selling and Buy-in Risk

In addition to the risks discussed above, the persistence of the mispricing in negative-stub-value situations may be the result of short-selling frictions (see Lamont and Thaler (2001)). The arbitrage strategy requires selling short shares in the subsidiary firm, which generally have low public floats. In other words, the percentage of outstanding shares available to be publicly traded is small because the parent firms, and often the firms' managers, own the vast majority of the shares. As a result, the number of marginable shares that can be sold short may be low.

One indication that short selling may be costly is shown by the "short rebate." Short-rebate refers to the interest rate that investors are paid on the proceeds they obtain from borrowing and selling a stock. Generally, institutional investors are paid 25 to 50 basis points below the federal funds rate on short proceeds, but this discount can vary, and occasionally the short rebate is negative. That is, in addition to keeping the interest on the investor's short proceeds, the broker sometimes charges the investor to maintain the short position.

Of course, the short rebate is a market price, representing both supply and demand. To understand the market for selling short shares, we talked with several industry practitioners and obtained short-rebate data from Ameritrade Holding Corporation, a large retail on-line brokerage firm. All indications are that this is a very active and liquid market (see D'Avolio (2001) and Geczy, Musto, and Reed (2001)). The stock-loan department at Ameritrade lends shares out of its customers' margin accounts to large investment houses. If an investment house such as Goldman Sachs is unable to provide shares to loan to a client short seller out of its own customers' accounts or its proprietary account, it will try to borrow the shares from another institution such as State Street Bank or from a broker–dealer, such as Ameritrade.

Table VII displays summary statistics of the Ameritrade short-rebate data set. During the December 1998 through October 2000 period for which short-rebate data are available, there are 28 firms in our sample that qualify

Table VII

Short-rebate Data

This table summarizes short-rebate data provided by Ameritrade Holding Corporation over the period December 1998 through October 2000. Panel A displays the number of sample firms with negative stub values between December 1998 and October 2000, the number covered by the Ameritrade short-rebate database, the number (and fraction) with negative short rebates, and the number (and fraction) with buy-ins. Panel B reports the minimum short-rebate transaction price paid for each subsidiary firm in the short-rebate database.

Panel A: Summary Statistics on Short-rebate Data

	Rule 1			Rule 2		
	>1.0	>1.25	>1.5	>1.0	>1.25	>1.5
Number of firms with negative stub values between December 1998 and October 2000	28	21	17	32	31	23
Number of firms in short-rebate database	24	18	15	27	26	19
Number of firms in short-rebate database with negative short rebate	6 (25.0%)	6 (33.3%)	5 (33.3%)	7 (25.9%)	7 (26.9%)	7 (36.8%)
Number of firms in short-rebate database with buy-ins	3 (12.5%)	3 (16.7%)	2 (13.3%)	4 (14.8%)	4 (15.4%)	4 (21.1%)

Panel B: Minimum Short-Rebates Paid for Subsidiary Shares

Company Name	Transaction Date	Minimum Short Rebate
Stratos Lightwave	July 6, 2000	−40.0%
Palm	July 28, 2000	−30.0%
Net2Phone	October 1, 1999	−8.0%
Retek	June 26, 2000	−4.0%
Plug Power	September 18, 2000	−4.0%
PFSWeb	January 20, 2000	−3.0%
MIPS Technology	September 28, 2000	−2.0%
Williams Communications	September 19, 2000	0.0%
Xpedior	December 30, 1999	0.0%
Iturf	September 24, 1999	0.0%
Ubid	January 26, 1999	0.0%
Marketwatch.Com	May 25, 1999	0.5%
Intimate Brands	February 23, 1999	0.5%
IXNet	September 7, 1999	1.0%
Interspeed	October 6, 1999	2.0%
Digex	August 16, 1999	2.0%
NetSilicon	September 30, 1999	2.3%
XM Satellite Radio	January 24, 2000	3.0%
US Search	March 28, 2000	3.0%
Veritas Software	June 7, 1999	3.0%
Barnes & Noble	August 23, 1999	4.0%
Kaiser Aluminum	December 22, 1998	4.4%
Nabisco Brands	July 19, 1999	4.7%
Keebler Foods	August 8, 2000	5.0%
CareInSite	December 16, 1999	5.0%
Superior Telecom	September 27, 2000	5.0%
Deltathree.Com	July 31, 2000	6.0%
Mean		−1.5%
Median		1.0%

under Rule 1 with a buy threshold of 1.0. Of these 28 firms, 24 (85.7 percent) are in the Ameritrade database. Six (25 percent) of the firms in the Ameritrade database have negative rebates. As displayed in Table VII, similar patterns exist for the other buy thresholds and for Rule 2. We also note that out of roughly 10,000 NYSE, AMEX, and Nasdaq stocks during the December 1998 through October 2000 interval, there are a total of 48 firms in the Ameritrade database that have negative short rebates. Of these 48 firms, 7 (15 percent) are from our sample. Clearly, the price for selling short the subsidiary shares is high relative to the typical firm.

Panel B of Table VII reports the *minimum* short rebates paid for subsidiary shares reported for each subsidiary firm in the Ameritrade database. The data show that the minimum short-rebate transaction prices tend to be close to zero, suggesting that negative short rebates are unlikely to be the full story behind the persistence of negative stub values. Excluding the two most extreme observations, the minimum short rebates range from negative eight percent to six percent per year, with the median short rebate of one percent.

Consider the case of the most extreme negative short rebate in the sample, Stratos Lightwave. According to the data, an arbitrageur wishing to exploit the relative mispricing of Methode/Stratos Lightwave would have been charged a 40 percent annual interest rate on short proceeds from short selling Stratos Lightwave. Following the investment strategy described by Rule 1 and a buy/sell threshold of 1.25/1.0, the arbitrageur would have invested in the deal on July 11, 2000, and would have still been invested at the end of the year. Over this period, the equity value of the position increased 21.1 percent before including the effects of the negative short rebate.[20] However, after paying nearly six months of negative short rebate, the arbitrageur's return is reduced to −0.6 percent. This example highlights that the real impediment is not the short rebate, but instead the uncertainty over how long one will be paying it. In other words, an arbitrageur should be more than willing to receive a short rebate of −100 percent per year if he can correct a 25 percent mispricing in a week.

When shares available for shorting are most scarce, brokers cannot maintain their clients' short positions no matter what interest rate the investor is willing to pay. This situation, which arises when owners of the stock demand that their loaned-out shares be returned, is often referred to as being "bought-in." Of the 24 negative-stub-value trades in the Ameritrade short-rebate database, identified using Rule 1 and a buy threshold of 1.0, 3 were partially bought-in before the arbitrage spread converged. Similar results are found for Rule 2 and other buy thresholds. Moreover, casual empiricism suggests that the risk of being bought-in is greatest when the arbitrage spreads of several negative-stub-value investments have widened, suggesting that this risk may not be completely idiosyncratic. The possibility of being bought-in

[20] This calculation assumes the maximum initial leverage allowed by Regulation T and ignores net interest on cash and debit balances.

at an unattractive price provides a disincentive for arbitrageurs to take a large position and represents a substantial friction to executing the arbitrage trade.

B. Imperfect Information and the Persistence of Negative Stub Values

So why do negative stub values persist? To gain perspective on this question, it may be important to consider the details of this particular mispricing phenomenon. Merton (1987) argues that one must be careful when drawing inferences about market anomalies relative to a perfect capital market because imperfections, especially imperfect information, can induce serious distortions. We believe this to be the case for this sample.

First, there is enormous uncertainty over the economic nature of the apparent mispricing and it will take time to learn about it. Uncertainty over the distribution of returns makes it difficult to know whether the arbitrage trades will on average be worthwhile investments, and how they should best be exploited. In other words, at the onset, it is not known whether the estimated abnormal returns will be reliably positive, and how sensitive they are to the exact trading strategy employed.

Consider setting up a fund to exploit the type of mispricing analyzed in this paper. One would need to collect data and carefully analyze their characteristics, much as we have done. Are the 16 years of data used in this paper sufficient to infer details of the distribution of returns? In 16 years, we were able to find around 75 occurrences of negative stub values from which to estimate the distribution of returns.

For example, in our sample, we find that 30 percent of the time the arbitrage opportunity terminates without convergence. The events causing disadvantageous termination are fairly random, such that this "fundamental risk" seems to be idiosyncratic. Unless an arbitrageur must be very highly specialized to exploit these investment opportunities, it is unlikely that fundamental risk on its own will be much of an impediment to arbitrage activity since it can be diversified away. A potentially larger problem is that the distribution of "bad outcomes" is not known ex ante. Even now, the 30 percent estimate of adverse terminations is imprecise. Without more accurate information, it is difficult to know whether negative stub values represent a sample of opportunities caused by mispricings or simply a sample of fairly priced firms with major off-balance-sheet liabilities.

Second, uncertainty over the distribution of returns makes it difficult to know exactly how to best exploit these opportunities. Figure 2 shows that an investor with over 13 years of experience exploiting negative stub values learns a lot about how to manage her portfolio when the arbitrage spread of Creative Computers and Ubid widens dramatically. On the fourth day of consecutively losing roughly 50 percent of invested capital on the Creative Computers/Ubid deal, the specialized investor receives a margin call and must decide whether to partially liquidate that deal or another. With hindsight, it is clear that holding onto the Creative Computers/Ubid investment

is the right decision, but at the time, it would have been hard to know what to do. The spread could continue to widen, requiring still more capital, or the deal could simply terminate without ever converging. There had never been another arbitrage spread that had widened so much so quickly, and one would surely be questioning whether he had missed something important in his analysis. The opportunity to learn presents itself again one year later when 11 out of 15 arbitrage spreads widen over a three-week period. Again, there is little in the data that could have prepared the investor for this outcome, as this was the first time that so many negative stub values existed at one time. What at first may have seemed like an opportunity to diversify turns out to drive the equity value of the portfolio negative.

Another way to see that there is considerable uncertainty about the outcomes of negative stub values is to examine stock price reactions around announcements of news concerning distributions and the IRS tax treatments of these transactions. Specifically, we identify announcements of (1) the intent of the parent to eventually distribute subsidiary shares to shareholders, (2) a tentative or definitive date for distribution, and (3) IRS approval of distribution as a tax-free transaction.[21] Table VIII reports mean and median stock price reactions to the release of this information using three-day event windows. The dates of the information releases are collected from the *Wall Street Journal* and the Dow Jones News Retrieval Service. Sixteen of the sample firms had at least one news story discussing a distribution or the IRS. The average stock price reaction to the release of this information was 6.17 percent for the parent firm (t-statistic = 2.64) and −2.25 percent for the subsidiary (t-statistic = −0.95). The average three-day return for the net long-short position held by an arbitrageur is 8.29 percent (t-statistic = 3.25) and the median return is 9.39 percent (p-value = 0.0097). Importantly, stock price reactions tend to be just as large for firms that had previously indicated their intention to distribute the subsidiary shares to shareholders in their prospectus as for the firms that reveal this intention for the first time.

It is also interesting to note that the reaction is larger for the firms where the mispricing ratio initially indicates a negative stub value. Using Rule 1, many of the negative stub values have converged prior to these announcements, but for the firms that still have a negative stub, the average stock price reaction is 11.37 percent and the median is 10.85 percent. For this subsample, where Rule 1 indicates a mispricing prior to the announcement, the median mispricing ratio falls from 1.11 before the announcement to 1.01 immediately after the announcement.[22] In other words, with no change in the availability of shares for shorting, no modifications to the rules governing capital requirements, and no reduction in direct transaction costs, virtually all of the mispricing is immediately eliminated once the uncertainty over the outcome is resolved.

[21] Often these announcements are made simultaneously.

[22] The mean mispricing ratio falls from 1.12 before the announcement to 1.02 after the announcement.

Table VIII

Stock Price Reactions to the Release of News Concerning Distributions and Tax Status

This table presents the stock price reactions over the three days surrounding news announcements about spinoff distributions and IRS approval of these distributions as tax-free transactions. News announcements come from Dow Jones News Retrieval and the *Wall Street Journal*. Panel A describes the announcement period effects of all announcements by a single parent/subsidiary pair. Panel B describes the announcement period effects for firms where the prospectus indicates their intention to distribute the shares of the subsidiary to shareholders. Panel C describes the individual announcement period effects, treating multiple announcements by the same parent/subsidiary pair as distinct observations. Panel D describes the individual announcement period reactions to news, given that the mispricing ratio described by Rule 1 is greater than 1.0:

$$\text{Rule 1:} \quad V_{Stub} < 0 \text{ if } \frac{MV_{Stake}}{MV_{Parent\ Equity}} > 1.0.$$

The t-statistics are calculated using the standard error of the mean. The p-values are calculated using the Wilcoxon signed rank test.

	Parent	Subsidiary	Net Position
Panel A: Effect of All News Announcements for a Given Firm			
Mean	6.17%	−2.25%	8.29%
t-statistic	2.64	−0.95	3.25
Median	3.88%	−2.76%	9.39%
p-value	0.0097	0.2553	0.0097
N	16.0	16	16
Panel B: Effect of All News Announcements for Firms Where Prospectus Indicates Intention to Distribute Shares			
Mean	4.13%	−4.18%	8.71%
t-statistic	1.39	−1.34	2.03
Median	3.86%	−6.91%	12.70%
p-value	0.1641	0.2031	0.0742
N	9	9	9
Panel C: All Announcements Treated Separately			
Mean	3.95%	−1.50%	5.30%
t-statistic	2.83	−0.96	3.11
Median	3.75%	−0.71%	3.31%
p-value	0.0074	0.3914	0.0021
N	25	24	25
Panel D: All Announcements Where the Mispricing Ratio Using Rule 1 Is Greater Than 1.0			
Mean	6.57%	−4.01%	11.37%
t-statistic	1.84	−1.07	2.29
Median	4.52%	−2.38%	10.85%
p-value	0.0938	0.4375	0.0938
N	6	6	6

Finally, we note that our assessment of the risks associated with investing in negative-stub-value situations is based on the entire history of these trades, from 1985 through the end of 2000. An arbitrageur investing at any point during the sample period would not have had the benefit of seeing as much data. Stated differently, the arbitrageur's estimates of the risks associated with negative-stub-value investments almost surely would have been less precise than those presented in this paper. This added uncertainty provides another impediment to arbitrage and also helps to explain the persistence of seemingly obvious mispricings.

VI. Conclusion

This paper studies the impediments to arbitraging relative mispricings of corporate cross holdings, where the parent firm is worth less than its ownership stake in a publicly traded subsidiary. We find that there are costs that limit arbitrage in equity markets, which tests our faith in market forces keeping prices at fundamental values.[23]

The biggest friction impeding arbitrage appears to be the costs associated with imperfect information (Merton (1987) and Fama (1991)).[24] For arbitrage to keep prices at fundamental values, the arbitrageur must have a reasonable understanding of the economic situation. Becoming informed about negative-stub-value investing is difficult when there is little evidence to examine. Furthermore, the ex ante benefits from becoming informed are not known. Expected payoffs will be large only if there are numerous opportunities or the magnitude of the opportunities is large. Over a 16-year period, we are able to identify fewer than 100 negative-stub-value situations. The total amount of capital that can be employed in this investment strategy is low since the effective size (controlling for the public float) of the subsidiary tends to be very small.

In addition, imperfect information and transaction costs may encourage at least some specialization of arbitrageurs, which limits the effectiveness of diversification. Because poorly diversified investors will require compensation for idiosyncratic risks, fundamental risks associated with negative stub values can limit arbitrage activity. Even more serious are the financial risks borne by highly specialized arbitrageurs. As we show, the returns to a highly specialized arbitrageur investing in negative stub values would be 50 percent to 100 percent larger if capital requirements were relaxed. This drives a large wedge between the range of prices that will be arbitraged away in imperfect capital markets versus those in perfect capital markets.

Finally, to the extent that the initial mispricing is due to noise traders bidding up the subsidiary share prices, we can say something about their long-term prospects with respect to this event. Arbitrageurs' profits are made at the expense of the investors who are long the subsidiary's stock. The

[23] We thank Ken French for discussions on this issue.

[24] See also Brav and Heaton (2002).

abnormal returns to an equal-weight portfolio that is long parent firms are zero, while the abnormal returns to an equal-weight portfolio that is long subsidiary firms are reliably negative. This suggests that the subsidiary shares somehow become overpriced before arbitrageurs force them back down to fundamental values. Thus, the evidence is consistent with the arguments of Friedman (1953) and Fama (1965) that investors who make mistakes will experience losses and over time will be driven out of the market. Market forces are working hard to keep prices at fundamental values, but the effectiveness of these efforts is sometimes limited.

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