Return Performance Surrounding Reverse Stock Splits: Can Investors Profit?

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We examine the long-run return performance of over 1,600 firms with reverse stock splits. These stocks record statistically significant negative abnormal returns over the three-year period following the month of the reverse split. The sample firms experience poor operating performances over the four years that include and follow the year of the reverse split, which suggests informational inefficiencies. Because these stocks have unique financial characteristics, we also show that they would be very difficult to sell short. Thus, arbitrageurs would be restricted in their ability to earn abnormal profits, even if they correctly anticipated a price decline.

We begin our study by examining the long-term stock and financial performances for a sample of 1,612 firms following reverse stock splits. Our study period covers the 40 years between 1962 and 2001. When we compare our sample firms to firms with similar characteristics, we find a significant downward price drift and significantly lower earnings and operating cash flows (OCF) over the three years following the ex-split date.[1] These results suggest that the market underestimates the future poor performances of reverse stock splits and that investors should be able to exploit this market inefficiency by short-selling these stocks. However, institutional restrictions on short-selling and other transaction costs related to the unique characteristics of these stocks significantly curb investors' ability to earn abnormal profits from these stock movements. Thus, we conclude that while reverse splits are informationally inefficient, investors' opportunities to reap abnormal returns from this information are limited. Following Fama (1970) and Jensen (1978), we view this scenario as being consistent with market efficiency.

Our sample shows that reverse-split firms are nonrandom, in that they come primarily from the extreme left tails of the distributions for stock price and firm size. We demonstrate that these firms have liquidity and financial distress characteristics that prevent investors from reaping abnormal profits despite expectations of a poor market performance. During the month of the ex-split date and for three years following this month, our sample issues have significantly lower monthly short interest compared to firms without reverse splits. Further, the inability to short-sell is greater for sample stocks with an ex-split price less than $5.00. We also find that when we divide our

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[1]Earlier papers on reverse stock splits focus on the announcement-day effect and report significantly negative abnormal returns over the announcement period (e.g., Woolridge and Chambers, 1983; Peterson and Peterson, 1992).

sample into stocks above and below an ex-split price of $5.00 per share, only the smaller-priced subsample earns significantly negative abnormal returns. Taken together, the underperformance and short-selling findings suggest that investors are restricted in their abilities to earn economic profits after the ex-split date. Thus, despite the systematic underperformance after the ex-split date, we conclude that these results are consistent with an economically efficient market (Fama, 1970; Jensen, 1978).

We also find that the sharp decline in stock price on the day of the reverse split can be partly explained by a reduction in transaction costs on the ex-split date. We attribute this phenomenon to the nature of our sample, which is that most reverse splits are priced under $1.00 per share prior to the ex-split date. We find that the magnitude of the ex-split date stock decline is directly related to the size of the stock split, which in turn is directly related to the reduction in the stock's relative bid-ask spread. Accordingly, investors who sell prior to the ex-split date to avoid the negative return on that date will incur higher transaction costs to liquidate their positions. Once again, we conclude that despite the significant negative abnormal return recorded on the ex-split date, the market acts in an economically efficient manner.

Our findings and interpretations have implications for other long-run performance studies, since informational inefficiencies (e.g., systematic underperformance) may not always result in exploitable trading rules leading to arbitrage profits. Shleifer and Vishny (1997) and Pontiff (1996) describe conditions in which pricing anomalies in financial markets are likely to appear but are not eliminated due to limits on arbitrage. Pontiff, in particular, discusses the role that transaction costs have in creating barriers to arbitrage profits.

The paper is structured as follows. Section I describes the sample selection process. Section II describes the research methodology and the various benchmarks for computing abnormal returns. Sections III and IV present the empirical results for the returns and operating performance tests. Sections V and VI provide empirical evidence consistent with investors being unable to profit from the negative stock performances. Section VII concludes.

I. Sample Selection and Description

Our initial sample includes 1,644 common-stock reverse splits from January 1, 1962 through December 31, 2001, which we identify in the Center for Research in Security Prices (CRSP) database. We eliminate 32 observations with split factors less than 1:2 for two reasons. First, consistent with Byun and Rozeff (2003), extremely small reverse splits result in negligible stock market reactions. Second, to confirm that the CRSP's reverse stock split identifier is accurate, we randomly selected 100 reverse stock splits and used Moody's Dividend Record to confirm whether a reverse split took place in that particular year as well as the split factor. For this subsample, all 95 reverse splits greater than or equal to 1:2 were accurate. However, the five firms with split factors less than 1:2 did not check out. Eliminating these observations reduces our sample of reverse splits to 1,612.

Table I presents descriptive statistics for reverse splits. Panel A shows the distribution by year. Only 100 observations (6.2%) in our sample occur between 1962 and 1980. The heaviest activity is between 1990 and 2001, with 1,169 reverse splits (72.5%).

Panel B shows that when grouped by trading venue, 1,254 reverse splits (77.8%) take place on the Nasdaq, while the NYSE and Amex account for 178 (11%) and 180 (11.2%), respectively. These results are in marked contrast to forward splits, in which the Nasdaq and the NYSE/Amex comprise an almost equal number of forward splits (Byun and Rozeff, 2003). Since CRSP's coverage of Nasdaq firms begins in 1968, the percentages for the reverse splits are tilted toward the NYSE/Amex, although we note that our sample contains only 26 reverse splits before 1968.

Table I. Descriptive Statistics for Reverse Splits

This table presents descriptive statistics for our sample of 1,612 reverse stock splits. Year is the year of the split. Stock market is the stock market that the firm was trading on at the time of the split. Split size is the magnitude of the split. No. is the number of splits. Pre-split price is the mean pre-split price level, measured over –120 to –60 days prior to the ex-split day. Post-split price is the mean post-split price level, measured over 30 to 90 days following the ex-split day.

Panel A. Yearly Distribution Showing Number of Reverse Splits, Pre-Split Price, and Post-Split Price

Year	No.	Pre-Split Price	Post-Split Price	Year	No.	Pre-Split Price	Post-Split Price
1962	2	$2.27	$7.29	1982	23	$1.87	$6.23
1963	5	$2.44	$9.58	1983	28	$2.05	$5.24
1964	9	$1.59	$6.03	1984	28	$0.66	$3.48
1965	5	$2.70	$9.66	1985	38	$2.05	$6.94
1966	4	$3.00	$9.95	1986	27	$1.93	$5.32
1967	1	$17.00	$19.24	1987	62	$1.08	$4.29
1968	3	$6.25	$17.82	1988	55	$3.34	$6.55
1969	3	$5.10	$11.30	1989	67	$6.38	$9.26
1970	0	$0.00	$0.00	1990	92	$0.79	$3.09
1971	4	$4.10	$10.89	1991	84	$1.36	$5.54
1972	6	$5.02	$15.04	1992	140	$0.96	$3.87
1973	11	$4.65	$7.10	1993	103	$1.43	$6.02
1974	5	$8.80	$5.96	1994	87	$4.73	$6.31
1975	7	$1.70	$8.46	1995	87	$1.58	$6.32
1976	9	$2.16	$7.30	1996	82	$1.89	$5.52
1977	6	$1.59	$9.15	1997	86	$1.85	$5.05
1978	9	$1.22	$4.25	1998	156	$1.30	$3.54
1979	6	$1.95	$5.69	1999	103	$1.21	$3.43
1980	5	$2.22	$8.85	2000	51	$3.54	$6.58
1981	15	$4.75	$4.68	2001	98	$0.89	$3.66

Panel B. Distribution by Stock Market Showing Number of Reverse Splits, Pre-Split Price, and Post-Split Price

Stock Market	No.	% of Total	Pre-Split Price	Post-Split Price
NYSE	178	11.0%	$7.24	$12.73
Amex	180	11.2%	$2.31	$6.75
Nasdaq	1,254	77.8%	$1.21	$3.94
Total	1,612	100.0%		

Panel C. Distribution by Split Size Showing Number of Reverse Splits, Pre-Split Price, and Post-Split Price

Split Size	No.	% of Total	Pre-Split Price	Post-Split Price
1:2	136	8.4%	$6.72	$8.52
(1:2 to 1:10)	917	56.9%	$2.06	$5.19
(1:10 to 1:20)	385	23.9%	$0.97	$4.83
≥1:20	174	10.8%	$0.44	$4.02
Total	1,612	100.0%		

Panel B also presents the mean pre- and post-split prices for the sample stocks. We calculate the mean prices from 60 to 120 calendar days prior to, and 30 to 90 calendar days after, the ex-split date. As Panel B shows, the mean pre- and post-split prices differ by exchange. The mean pre-split price is $7.24 for NYSE firms, compared to $1.21 for Nasdaq stocks. The mean post-split

Table I. Descriptive Statistics for Reverse Splits (*Continued*)

Panel D. Distribution by Pre-Split Price Showing Number of Reverse Splits, Pre-Split Price, and Post-Split Price

Pre-Split Price Range	No.	% of Total	Pre-Split Price	Post-Split Price
0<P≤ $1	1,018	63.2%	$0.47	$2.71
$1<P≤ $2	257	15.9%	$1.40	$6.08
$2<P≤ $5	≤207	12.8%	$3.12	$10.02
$5<P = $10	57	3.5%	$6.45	$11.55
$10< P	42	2.6%	$31.56	$30.12
No pre-price data	31	1.9%	NA	$4.19
Total	1,612	99.9% (rounding error)		

Panel E. Distribution of Sample Firms Based on Market Capitalization of All Stocks Listed on the NYSE

Size Quintile	No.	% of Total
1 (lowest)	1,485	92.1%
2	127	7.9%
3-5	0	0%
Total	1,612	100.0%

price level for NYSE stocks is $12.73, compared to $3.94 for Nasdaq stocks. The differential in pre-split price between the NYSE/Amex and Nasdaq is consistent with that reported by Han (1995).

In Panels C through E, we separate our sample by split size, pre-split price, and market capitalization. The most frequent split factors are between 1:2 and 1:10 with 917 events (56.9%). Panel D shows that 63.2% of the sample firms have pre-split prices of $1.00 or less, and only 6.1% have pre-split prices greater than $5.00. Since one of the principal motivations for having a reverse split is to avoid exchange delisting due to a low stock price, the high percentage of under-$1.00 stocks is not surprising. In terms of market capitalization, Panel E shows that virtually all of the sample firms are in the smallest market equity size quintile of all stocks listed on the NYSE, with 92.1% falling into quintile 1 and the remaining 7.9% into quintile 2.

II. Long-Run Abnormal Returns: Methodology

As our main model of performance measurement, we use the Carhart (1997) four-factor model:

$$R_{it} - R_{ft} = a_i + b_i(R_{mt} - R_{ft}) + s_i SMB_t + h_i HML_t + m_i UMD_t + \varepsilon_{it}, \tag{1}$$

where SMB_t is the small-minus-big size portfolio return in month t, HML_t is the high-minus-low book-to-market portfolio return in month t, and UMD_t is the up-minus-down momentum portfolio return in month t. This model allows us to extract the excess returns beyond what could be attained by passive investments in these factors as dictated by the factor loadings. However, since reverse splits come mostly from the left tails of the distributions of firm size and trading price, these standard models may not adequately capture the unique liquidity and financial characteristics of our sample issues.

To address these concerns, we use a technique that matches each sample firm by industry, market price, and firm size. Using the Fama and French (1997) classification system for each sample firm, we find a control firm on Compustat that is in the same industry. We then select those firms whose pre-event price levels are within the same price range as the sample firm (see Table I, Panel D). From these potential control firms, we select a firm whose total assets at the beginning of the sample firm's fiscal year most closely match the sample firm's total assets.

We use a calendar-time (CTAR) approach to calculate long-run abnormal returns. We take the difference in four-factor alphas of value-weighted, calendar-time portfolios for the ex-split firms and their corresponding control firms. We construct post-event, calendar-time portfolios each month and include those stocks that have had a reverse split within either a one-, two-, or three-year window prior to the month in question. Pre-event portfolios include stocks that will have a reverse split within a one-year window subsequent to the month in question. The control firms serve as a benchmark for the unique, ex-split characteristics that may not be captured by the traditional four-factor model. We report White robust *t*-statistics to address potential heteroskedasticity that may arise from earlier months in which there are fewer firms in our sample.

There are two reasons we use a CTAR approach. First, there is considerable overlap in the pre- and post-event periods, which causes the individual alphas to be cross-sectionally dependent. Second, by using the CTAR approach, we can calculate the abnormal returns from an ex-split trading strategy that is long in the ex-split firms and short in the control firms.

We use value-weighted portfolios in order to mitigate microstructure issues due to the high proportional spreads of the small firms. For example, a stock with a bid-ask price of $0.50 and $0.75 will experience alternating returns of +50% and −33%, an additive return of +17%, as it bounces from bid price to ask price and vice versa. But we argue that this phenomenon could not be responsible for the sample's negative abnormal returns. First, the sample firms are matched against control firms with, presumably, similar bid-ask spreads and subject to the same percentage bid-ask bounce. Second, because trades are more likely to be seller initiated on/after the ex-split date (discussed in Section VI), the "bounce" is more likely to occur from the ask price to bid price, thereby creating a *positive* bias in the abnormal returns.

III. Long-Run Abnormal Returns: Empirical Results

We now present the empirical results and the robustness tests.

A. Pre- and Post-Split Performance Tests

Table II presents the abnormal returns for the pre- and post-split periods. The one-, two-, and three-year post-split alphas of the difference portfolios, which exclude the ex-split month, are −0.013 (*t*-statistic −2.34), −0.015 (*t*-statistic −2.71), and −0.015 (*t*-statistic −3.01), respectively. These alphas translate to cumulative abnormal returns (CARs) of −15.6%, −36%, and −54%, respectively, for the one-, two-, and three-year post-split periods.[2] Using equal-weighted portfolios (not tabulated) yields one-, two-, and three-year abnormal returns of −19.5% (*t*-statistic −2.93), −42.6% (*t*-statistic −3.71), and −52.3% (*t*-statistic −3.83), respectively. The difference alpha for the pre-12-month period is statistically insignificant (*t*-statistic −0.96), indicating that the

[2]These results are consistent with those reported by Desai and Jain (1997), who examine 76 reverse-split events over the period 1976-1991.

Table II. Pre- and Post-Split Abnormal Returns

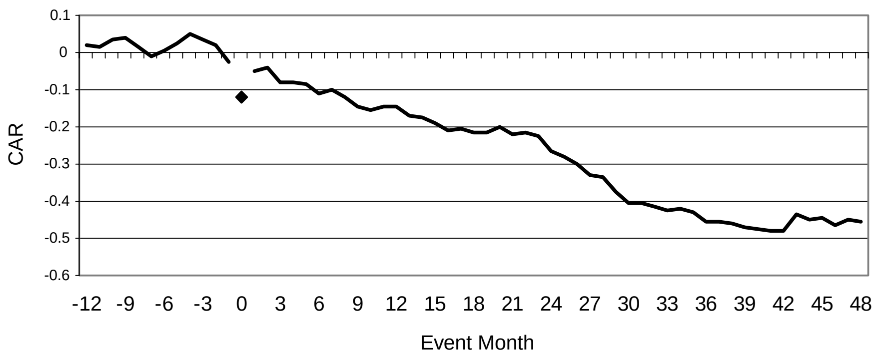
This table reports the one-year pre-split abnormal return as well as the one-, two-, and three-year post-split abnormal returns using monthly return data. The table also reports the daily abnormal returns surrounding the ex-split day. We calculate the one-year pre-split and the one-, two-, and three-year post-split abnormal returns by taking the difference in four-factor alphas of value-weighted, calendar-time portfolios for the ex-split firms and their corresponding control firms, which we match on industry, pre-split price, and total assets. We report the corresponding White robust t-statistics in parentheses below the parameter estimates. We calculate the daily abnormal returns by taking the average of differences in ex-split and control returns for each event day from −3 to +3. We report the corresponding t-statistics to the right of the average abnormal return for each event day. Levels of significance are shown only for the difference columns and daily abnormal returns.

	Pre-12 Month			Daily Abnormal Return (Split Minus Control)				1-Year		
	Split	Control	Difference					Split	Control	Difference
Alpha	−0.008	−0.001	−0.007				Alpha	−0.012	0.001	−0.013**
	(−1.377)	(−0.147)	(−0.963)	**evtdy**	**mean**	***t*-stat**		(−2.637)	(0.159)	(−2.340)
R_m - R_f	1.100	1.076	0.024	−3	−0.003	−0.622	R_m - R_f	1.134	1.130	0.004
	(7.971)	(6.984)	(0.162)	−2	0.003	0.631		(11.305)	(9.520)	(0.027)
SMB	1.210	1.552	−0.342*	−1	−0.009*	−1.850	*SMB*	0.938	1.169	−0.231
	(6.402)	(6.201)	(−1.759)	0	−0.066***	−10.017		(5.483)	(7.139)	(−1.323)
HML	−0.209	0.272	−0.481*	1	−0.002	−0.314	*HML*	0.450	0.757	−0.307
	(−0.888)	(0.694)	(−1.763)	2	−0.003	−0.429		(2.381)	(4.001)	(−1.547)
UMD	−0.423	−0.761	0.339	3	−0.014***	−2.793	*UMD*	−0.038	−0.050	0.012
	(−2.256)	(−2.628)	(1.592)					(−0.256)	(−0.368)	(0.088)
R^2	0.352	0.311					R^2	0.326	0.309	
	2-Year							**3-Year**		
Alpha	−0.013	0.002	−0.015***				Alpha	−0.013	0.002	−0.015***
	(−4.120)	(0.470)	(−2.714)					(−4.442)	(0.389)	(−3.008)
R_m - R_f	1.130	1.070	0.060				R_m - R_f	1.116	1.133	−0.017
	(15.549)	(7.531)	(0.390)					(16.533)	(9.257)	(−0.129)
SMB	1.250	1.275	−0.025				*SMB*	1.199	1.459	−0.260
	(11.093)	(5.393)	(−0.109)					(11.322)	(6.936)	(−1.205)
HML	0.563	0.733	−0.170				*HML*	0.438	0.793	−0.355*
	(4.388)	(3.864)	(−0.848)					(3.538)	(4.778)	(−1.897)
UMD	0.206	−0.090	0.296**				*UMD*	0.208	−0.072	0.280**
	(2.227)	(−0.710)	(2.251)					(2.524)	(−0.701)	(2.416)
R^2	0.496	0.277					R^2	0.528	0.388	

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Figure 1. Graph of Pre- and Post-Split Cumulative Abnormal Returns

This figure presents a graph of the cumulative abnormal returns (CARs) from event months −12 to +48. The graph displays a CAR line cumulating the abnormal returns, which we calculate each event month as the average of differences in the sample- and control-firm returns, from event months −12 to −1. There is a single point for the abnormal return on the ex-split month (event month 0), and the second CAR line cumulates the abnormal returns from event months +1 to +48.



post-split underperformance of the sample firms is not a continuation of poor returns or a negative momentum effect.

Figure 1 illustrates the post-split underperformance and pre-split "non"-underperformance. The graph shows a CAR line that cumulates the abnormal returns, which we calculate each event month as the average of differences in the sample- and control-firm returns, from event months −12 to −1. There is a single point for the abnormal return on the ex-split month (event month 0), and a second CAR line that cumulates the abnormal returns from event months +1 to +48. This graph is purely expositional, and we report no corresponding statistics. We note that the CAR line flattens out after month +36 and that there is no underperformance in the pre-split period.

Table II also shows that on the day of the reverse split, the mean abnormal return, calculated as the average of differences in the sample- and control-firm returns, is −6.6% (*t*-statistic −10.02). Since the ex-split date for most events is known in advance by the market, this negative return runs counter to what one would expect in an efficient market. In Section VI, we explore possible factors that could be driving this result and whether or not they are consistent with efficient market theory.

B. Robustness Tests

To ensure that the earlier period, when there are fewer firms in our sample, does not drive our results, we also use a weighted least squares approach, weighting each month by the square root of the number of firms in the portfolio during the month in question. Our results (not tabulated) are robust to this approach, yielding one-, two-, and three-year post-event CTARs of −18.4% (*t*-statistic −3.37), −30.5% (*t*-statistic −2.80), and −47.1% (*t*-statistic −3.35), respectively. Our results are also robust to different time periods, specifically 1976-1991 and 1992-2001 (not tabulated), and to other methods of calculating abnormal returns.

We also measure performance using a buy-and-hold abnormal return (*BHAR*) approach (see Appendix A for calculating *BHAR*s). Using benchmark portfolios based on size, book-to-market, and momentum, the one-, two-, and three-year *BHAR*s are −8.5% (*t*-statistic −3.77), −19% (*t*-statistic −7.48), and −29.8% (*t*-statistic −10.77), respectively. Corresponding bootstrapped *BHAR*s yield similar results. Our results are also robust to the use of delisting returns (see Shumway, 1997; Shumway and Warther, 1999).

IV. Operating Performances and Negative Post-Split Abnormal Stock Returns

We next examine the operating performances of the sample firms over a four-year interval including and following the year of the reverse split to determine if these performances are associated with the negative post-split, stock return performance. We focus on annual earnings per share (EPS) and annual operating cash flows deflated by total assets (OCFA) at the beginning of the ex-split month. All data are from the Compustat database. For OCF, we use the SFAS 95 definition for all firms from 1989 to 2001. Prior to 1988, when firms were not required to disclose their OCF, we define OCF as net income plus depreciation expense minus the increase in noncash current assets plus the increase in current liabilities (the current portion of long-term debt is excluded from current liabilities).

We compare the reverse-split group to the control group of firms matched, as before, by industry, pre-split price and total assets. We present both means and medians for the sample and control group portfolios, and then present t-statistics for differences between means and Wilcoxon statistics for differences between medians.

Table III presents our results. With the exception of the year 3 median OCFA, the sample firms' performance measures are significantly lower than are those of the control firms. In year 0, the sample group's mean EPS is −\$0.925 compared to −\$0.309 for the control group (with a difference in means t-statistic of −9.69). The sample's mean OCFA is −\$0.090 compared to −\$0.055 for the control firms (t-statistic −3.35). The medians produce similar results. Thus, regardless of whether we examine means or medians, firms with reverse stock splits are weaker performers than are comparable firms over the split year.

The poor operating performances of firms with reverse stock splits continue over the following three years. For year +1, the sample firms' mean EPS is −\$0.392 compared to −\$0.197 for the control firms (with a difference in means t-statistic of −4.55). The sample's mean OCFA is −\$0.076 compared to −\$0.046 for the control firms (t-statistic −2.89). The median EPSs are −\$0.18 and −\$0.05 for the sample and control firms, respectively; the corresponding median OCFAs are −\$0.014 and \$0.002. During the next two fiscal years, the reverse-split firms' performance remains significantly more negative compared to the control firms, except for the year 3 median OCFA results.

Overall, these results are consistent with the reverse-split samples' significantly negative post-reverse-split CTARs shown in Table II. When matched by industry, pre-split price, and total assets, reverse stock-split companies significantly underperform over the one-, two-, and three-year periods immediately following the ex-split date. Thus, the market does not adequately impound future firm operating performance into the sample issues' stock prices.

V. Is There an Arbitrage Profit to Be Had? Short-Selling Constraints and Market Efficiency

According to Jensen (1978):

> A market is efficient with respect to information set θ_t if it is impossible to make economic profits by trading on the basis of information set θ_t. By economic profits, we mean the risk adjusted returns net of all costs. (p. 96)[3]

[3] Alternatively, Rubinstein (2001) refers to this type of market as a "minimally rational market." According to Rubinstein, "Even if we decide markets are not rational, they may still fail to supply opportunities for abnormal profits. . .. If you tell me such-and-such stock is overpriced but there are significant obstacles to short selling or significant costs to trading the stock, again, I may not be able to do much about the opportunity."

Table III. Annual Earnings per Share and Annual Operating Cash Flows for Reverse Stock Split Firms and Control Firms for the Four Years Including and Following a Reverse Stock Split

This table presents mean and median annual earnings per share (EPS) and operating cash flows deflated by beginning-of-year total assets (OCFA) for our sample of reverse splits and our control sample. We match firms by industry, pre-split price, and total assets. We define industry according to the Fama and French (1997) classifications. Total assets are the total assets at the beginning of the ex-split month. Since 1988, firms have been required by SFAS 95 to disclose operating cash flows. We use this measure of operating cash flows for all firms from 1988 to 2001. Before 1988, we use the following formula to derive operating cash flows: net income plus depreciation expense minus the increase in noncash current assets plus the increase in current liabilities (the current portion of long-term debt is excluded from current liabilities). The *t*-statistic tests for differences in means between the sample and control group. The Wilcoxon (*z*) statistic tests for differences in medians between the sample and control group. Here *N* is the number of observations in each group.

Year		EPS($)			OCFA($)		
		Sample		Control	Sample		Control
0	Mean	−0.925		−0.309	−0.090		−0.055
	t-Stat.		−9.69***			−3.35***	
	Median	−0.290		−0.080	−0.024		−0.000
	Wilcoxon		−5.25***			−2.63***	
	N	1,140		1,138	1,150		1,138
1	Mean	−0.392		−0.197	−0.076		−0.046
	t-Stat.		−4.55***			−2.89***	
	Median	−0.180		−0.050	−0.014		0.002
	Wilcoxon		−3.35***			−2.91***	
	N	1,022		1,026	1,027		1,026
2	Mean	−0.243		−0.107	−0.070		−0.037
	t-Stat.		−3.55***			−3.04***	
	Median	−0.100		−0.030	−0.006		−0.036
	Wilcoxon		−2.89***			−2.48***	
	N	908		930	913		931
3	Mean	−0.155		−0.074	−0.063		−0.032
	t-Stat.		−2.06**			−2.24**	
	Median	−0.060		−0.020	0.004		0.008
	Wilcoxon		−2.28**			−1.16	
	N	772		781	777		782

*** Significant at the 0.01 level.
** Significant at the 0.05 level.

We test Jensen's (1978) definition of market efficiency for reverse stock splits by determining the extent to which investors can realize an arbitrage profit by immediately selling stocks short after the stocks have a reverse split. If investors are limited in their ability to short, they will be unable to take advantage of the underperformance that we document in Section III.

We posit that the transaction costs of short-selling firms undergoing reverse stock splits pose a barrier to investors from realizing arbitrage profits implicit in the subsequent underpricing. Our reasoning is analogous to Pontiff (1996), who discusses and shows how transaction costs affect arbitrage profits with respect to the mispricing of closed-end funds. We exploit the phenomenon that low-priced stocks are also directly related to short-selling transaction costs (D'Avolio, 2002).

Thus, we test and show that short-selling arbitrage profits are curbed by the transaction costs inherent in our sample firms.

A. Short-Selling Characteristics of Sample Firms

Our objective in this section is to demonstrate that investors cannot earn excess returns by shorting the stocks after the ex-split date. To short a stock, an investor must first be able to borrow the security from another lender. D'Avolio (2002) uses a sample from a "large institutional lending intermediary" that contains data on loan supply, loan fees, and loan recalls from April 2000 to September 2001 to assess the characteristics of firms that are sold short. He finds that 32.2% of the stocks in the lowest NYSE market equity decile and 33.5% of the stocks priced below \$5.00 per share are "unshortable." For our sample, 92.1% of the reverse stock-split firms are in the lowest size quintile, 91.9% of the stocks trade under \$5 per share prior to the split, and the average post-split price for the 1,254 Nasdaq reverse splits is under \$4 per share. Thus, reverse stock splits have similar financial characteristics to D'Avolio's sample of unshortable stocks.

Our arguments, thus far, focus on the supply factor while ignoring the demand side of the shorting equation. A study by Cohen, Diether, and Malloy (2006) investigates whether it is the demand or supply side that drives the relation between shorting indicators and subsequent stock returns. To do this, they decompose the rebate rate into its shorting demand- and supply-side components. For example, a lower rebate rate could be the result of either higher shorting demand or lower shorting supply, or both. While these issues are important for predicting future stock returns, they are not relevant for this study. Although the shorting quantity normally depends on both demand and supply, we show that a majority of our sample stocks (64.6%) have zero supply and, as such, are "unshortable."

B. Short Sales

We examine investors' monthly short interest to evaluate their ability to short-sell stocks on and following the reverse-split month. We define each firm's monthly short interest as the number of shares sold short divided by the firm's outstanding shares. We obtain our short-selling data from a Nasdaq database that contains monthly short sales for all stocks traded on the Nasdaq from June 1988 through December 2003. Thus, our sample is limited to reverse splits listed on the Nasdaq. We note that inferences from our analyses should be confined to these firms only.

We present short interest data over two time periods. First, we examine short-selling on the ex-split month. If investors can profit from the negative price drift on and following the split, then we expect to see relatively high levels of short-selling on that month. Second, we analyze the short interest over the three-year period following, but not including, the ex-split month. Again, we propose that if investors are able to take advantage of the three-year underperformance, we should see relatively large short interests over this time period.

In Table IV, Panel A, we compare the short interest on the month of the reverse split for a sample of 1,019 firms against control groups of all of the remaining Nasdaq firms on the Nasdaq database. We compare each sample firm to the average short interest of all other Nasdaq firms that did not have a reverse split on that month. Thus, each of the 1,019 firms with reverse splits has its unique control group.

Table IV. Monthly Short Interest for Sample Firms Compared to Control Firms

The sample consists of the reverse stock splits appearing in the Nasdaq short-selling database with trading months from June 1988 to December 2003. The control is the remaining Nasdaq firms that also appear in the Nasdaq database. For each sample firm, we calculate the number of shares sold short each month as a percentage of the firm's total shares outstanding. We do this each month over the 37 (maximum) month period including and following the month of the reverse split and compute an overall average for each firm. We use the same dates and calculate the same average monthly short interest for the control firms. Sample firms ≤\$5.00 are firms that have an ex-split price of \$5.00 or less immediately after the split. Sample firms >\$5.00 are firms that have an ex-split price greater than \$5.00 per share immediately after the split.

	Mean (%)	*t*-Stat.	Median (%)	*p*-Value
Short Interest on Ex-Split Month of the Reverse Split				
Panel A. Full Sample of Reverse Splits Compared to Control Firms (N = 1,019)				
Full sample	0.30	18.85***	0.00	<0.001
Control firms	1.13		0.97	
Panel B. Sample Firms with Ex-Split Price ≤\$5.00 (N = 747) Compared to Sample Firms with Ex-Split Price >\$5.00 (N = 272)				
Sample ≤\$5	0.25	3.53***	0.00	1.000
Sample >\$5	0.54		0.00	
Panel C. Sample Firms Compared to Control Firms Stratified by Whether Firm's Ex-Split Price is ≤\$5.00 (N = 747) or >\$5.00 (N = 272)				
Sample ≤\$5	0.25	10.67***	0.00	<0.001
Control firms ≤\$5	0.78		0.62	
Sample (>\$5)	0.54	8.92***	0.00	<0.001
Control firms (>\$5)	1.31		1.23	
Short Interest over 36-Month Period Following the Ex-Split Month				
Panel D. Full Sample Compared to Control Firms (N = 1,004)				
Full sample	0.51	28.04***	0.15	<0.001
Control firms	1.34		1.12	
Panel E. Sample Firms with Ex-Split Price ≤\$5.00 (N = 752) Compared to Sample Firms with Ex-Split Price >\$5.00 (N = 252)				
Sample (≤\$5)	0.36	5.82***	0.13	<0.01
Sample (>\$5)	0.67		0.36	
Panel F. Sample Compared to Control Firms Stratified by Whether Firm's Ex-Split Price is ≤\$5.00 (N = 752) or >\$5.00 (N = 252)				
Sample (≤\$5)		9.43***	0.13	<0.001
Control firms (≤\$5)			0.44	
Sample (>\$5)		10.88***	0.36	<0.001
Control firms (>\$5)			1.24	

*** Significant at the 0.01 level.

The mean (median) monthly short interest for the sample firms is 0.30% (0%) versus 1.13% (0.97%) for all other Nasdaq firms, a difference of 0.83% (0.97%) (t-statistic 18.85; p-value < 0.001). These results show that, overall, reverse-split firms have a lower short-selling interest than does the typical Nasdaq firm in the month of the reverse split. Examination of the distribution of short interest for the reverse-split sample shows that 64.6% of the firms have zero short interest on the ex-split month. Thus, it appears that investors are unable to short-sell a majority of these firms in the ex-split month.

In Panel B we present the results when we separate the sample firms into two groups, those with an immediate ex-post split price at or below $5.00 per share and those priced above $5.00. The rationale behind this categorization comes from D'Avolio (2002). We find that the 747 sample stocks priced at or under $5.00 have a mean (median) monthly short interest of 0.25% (0%), compared to 0.54% (0%) for the 272 stocks priced above $5.00. The t-statistic for the difference in means is 3.53, and is significant at the 0.01 level. The p-value for the difference in medians is one, reflecting the fact that the median short interest for each group is zero. However, we also find that 69.2% of the $5.00-or-under group has a monthly short interest of zero, while 53.7% of the over-$5.00 subsample has a zero monthly short interest. Thus, consistent with D'Avolio, it is more difficult for investors to short sample firms priced under $5.00.

In Panel C we compare the short interest between sample and control firms segmented by price. For firms trading at $5.00 or under, the sample firms record a mean (median) short interest of 0.25% (0%) versus 0.78% (0.62%) for the control firms. Test statistics for the differences in means (t-statistic 10.67) and medians are both significant at <0.001 levels. When we compare the short interest of the over-$5.00 sample firms with over-$5.00 control firms, we find a mean (median) monthly short interest of 0.54% (0%), compared to 1.31% (1.23%) (differences have a t-statistic of 8.92 and a p-value < 0.001). These findings show that in the ex-split month, the sample firms have special characteristics that make them more difficult to sell short, regardless of whether or not they were priced below or above $5.00.

In Panels D-F, we examine the average monthly short interest for the reverse-split firms over the 36-month period following the reverse-split month. (We note that due to missing data, the number of observations for the monthly and three-year periods are slightly different.) The inferences we draw from this time period are similar to those we draw from the event month; there were few opportunities to short-sell firms following reverse stock splits. In Panel D, the mean (median) monthly short interest for all sample firms is 0.51% (0.15%) compared to 1.34% (1.12%) for the remaining Nasdaq firms, a difference of 0.83% (0.97%) (t-statistic 28.04; p-value < 0.001). Thus, over the three-year period, there is significantly less short-selling for the sample of reverse stock splits than for other Nasdaq firms. In Panel E, we find that sample firms trading at or under $5.00 per share have significantly less short interest than sample firms trading over $5.00 per share. In Panel F, we find that when we also stratify by price, reverse stock-split firms still experience less short selling than do our control firms.

Although not shown in Table IV, we also perform the same tests on the Nasdaq firms without reverse splits over the 36-month period following the ex-split month. The mean monthly short interest for those firms priced at or below $5.00 is 0.65%. In contrast, firms trading above $5.00 have a mean monthly short interest of 1.41%. Testing for differences in means produces a t-statistic of 19.94, which is significant at the 0.001 level. Median short interest of 0.43% for stocks trading at or under $5.00, compared to 1.24% for those trading above $5.00, yields a p-value less than 0.001. Thus, differences in short interest between Nasdaq stocks priced under/over $5.00 remain statistically significant regardless of whether or not they experience a reverse stock split.

Overall, our findings are consistent with investors having limited opportunities to short-sell stocks that are undergoing reverse stock splits. The market implication of this restriction is that by and large, investors are unable to take advantage of the reverse-split firms' long-run underperformance.

C. Long-Run Performance for Reverse Splits Trading over and under \$5.00 per Share

To further clarify the market implications that low-priced stocks are difficult to short after reverse stock splits, we present and compare the one-, two-, and three-year post-split difference alphas for those firms with an immediate ex-split price less than or equal to \$5.00 per share against those firms with an immediate ex-split price over \$5.00 per share. Table V presents the results when we use the four-factor model and matched firm approach.

Panel A shows that the \$5.00-or-under firms have a significant, three-year difference alpha of −0.019 (*t*-statistic −2.78), which translates to an abnormal return of −67.4% for the three-year post-split period. Conversely, Panel B shows that the over-\$5.00 firms have an insignificant, three-year difference alpha of −0.003 (*t*-statistic −0.49), or an abnormal return of −11.4% for the three-year post-split period. Similarly, the one- and two-year difference alphas for the \$5.00-or-under group are significantly negative, but they are not significantly different from zero for the over-\$5.00 group. Thus, our long-run performance results are essentially being driven by the \$5.00-or-under stocks.

These results, together with our findings that few stocks priced at or under \$5.00 are sold short, support the view that the sample's negative, post-event performance is consistent with an efficient market. That is, trading frictions, in this case short-selling constraints, prevent investors from earning an arbitrage profit by immediately selling short firms that have reverse stock splits.

VI. Explaining the Ex-Split Date Negative Return: Transaction Costs

As we noted earlier, there is a significant negative abnormal return of −6.6% (*t*-statistic −10.02) on the day of the reverse split. The puzzle behind this finding is that the ex-split date is usually known in advance. So we ask if investors can develop a strategy, such as selling their stock before the reverse split, which enables them to benefit from the expected decline in share value.

We investigate whether a change in transaction costs can explain these ex-split day results. Han (1995) reports that firms with reverse splits experience a significant decline in transaction costs, measured by a reduction in bid-ask spreads, on and after the ex-split date. He conjectures, but does not document, that the drop in share price on the ex-split date might be attributed to this reduction in transaction costs. The premise is that low-priced stocks have wider relative bid-ask spreads than higher-priced stocks. Since reverse splits are designed to raise share prices, ceteris paribus, stocks will experience a decline in proportional bid-ask spreads on the ex-split date. For existing shareholders[4] to be indifferent between selling his/her shares on the ex-split date vis-à-vis the previous trading day, the stock price must drop on the ex-split day in proportion to the decline in the relative bid-ask spread on that date. That is, the negative abnormal return recorded on the ex-split day is mitigated by a commensurate reduction in the bid-ask spread.

[4]Would-be short traders could also benefit from this decline in proportional spreads since an increase in liquidity would facilitate more shorting activity (Kadiyala and Vetsuypens, 2002).

Table V. Abnormal Stock Returns for Under- and Over-\$5.00 Subsamples

This table reports the one-, two-, and three-year post-split abnormal returns for the under-\$5.00 and over-\$5.00 subsamples. We calculate the one-, two-, and three-year post-split abnormal returns by taking the difference in (four-factor) alphas of value-weighted, calendar-time portfolios for the ex-split firms and their corresponding control firms, which we match on industry, pre-split price, and total assets. We report the corresponding White robust t-statistics in parentheses below the parameter estimates. Panel A presents the abnormal returns for those sample firms with an ex-split price less than or equal to \$5.00 per share. Panel B presents the abnormal returns for those sample firms with an ex-split price greater than \$5.00 per share. Levels of significance are denoted only for the difference columns.

	1-Year			2-Year			3-Year		
	Split	Control	Difference	Split	Control	Difference	Split	Control	Difference
Panel A. Ex-Split Price ≤\$5.00									
Alpha	−0.018	0.004	−0.021***	−0.014	0.006	−0.020***	−0.011	0.007	−0.019***
	(−3.446)	(0.690)	(−3.181)	(−3.860)	(0.835)	(−2.599)	(−3.328)	(1.152)	(−2.775)
R_m - R_f	1.002	0.984	0.017	1.000	0.998	0.002	0.954	1.048	−0.094
	(6.142)	(7.016)	(0.084)	(9.106)	(5.842)	(0.010)	(9.514)	(6.742)	(−0.499)
SMB	1.297	1.411	−0.115	1.442	1.493	−0.051	1.510	1.707	−0.197
	(5.889)	(7.416)	(−0.414)	(10.400)	(4.928)	(−0.149)	(11.008)	(6.176)	(−0.639)
HML	0.571	0.671	−0.100	0.478	0.833	−0.356	0.330	0.777	−0.447
	(2.010)	(3.233)	(−0.299)	(2.589)	(3.718)	(−1.195)	(1.821)	(3.746)	(−1.565)
UMD	0.066	−0.034	0.100	0.259	−0.082	0.341	0.259	−0.053	0.312*
	(0.382)	(−0.227)	(0.550)	(2.350)	(−0.509)	(1.147)	(2.575)	(−0.379)	(1.903)
R^2	0.307	0.266		0.462	0.185		0.492	0.254	
Panel B. Ex-Split Price >\$5.00									
Alpha	−0.012	−0.000	−0.011	−0.011	−0.007	−0.004	−0.010	−0.007	−0.003
	(−1.760)	(−0.057)	(−1.261)	(−2.029)	(−1.156)	(−0.526)	(−2.026)	(−1.299)	(−0.490)
R_m - R_f	1.070	1.313	−0.243	1.122	1.351	−0.229	1.166	1.386	−0.220
	(6.550)	(7.674)	(−1.202)	(8.540)	(9.291)	(−1.212)	(9.979)	(10.747)	(−1.261)
SMB	0.570	0.696	−0.126	0.733	0.886	−0.153	0.757	0.951	−0.194
	(2.223)	(3.401)	(−0.510)	(3.224)	(4.640)	(−0.666)	(3.920)	(5.710)	(−0.942)
HML	0.530	0.559	−0.029	0.804	0.538	0.266	0.758	0.696	0.062
	(2.031)	(2.337)	(−0.112)	(3.891)	(2.777)	(1.118)	(4.088)	(3.722)	(0.272)
UMD	−0.197	−0.058	−0.139	−0.273	−0.072	−0.201	−0.201	−0.075	−0.125
	(−1.138)	(−0.331)	(−0.738)	(−1.962)	(−0.554)	(−1.194)	(−1.538)	(−0.633)	(−0.765)
R^2	0.176	0.218		0.248	0.279		0.289	0.326	

*** Significant at the 0.01 level.

We propose and demonstrate the following three relations. First, we document a negative relation between the levels of stock prices and proportional spreads. Second, we show that the drop in the relative bid-ask spread is directly related to the magnitude of the reverse split. This follows from the argument that the larger the reverse split, the larger the discrepancy in before-and-after split-date prices. Finally, we demonstrate that the negative abnormal return on the ex-split date is directly related to the size of the reverse split.

The relative bid-ask spread for time t (BAS_{it}) is:

$$BAS_{it} = \frac{AP_{it} - BP_{it}}{(1/2) \cdot (AP_{it} + BP_{it})}, \tag{2}$$

where AP_{it} is the ask price of stock i on day t, and BP_{it} is the bid price of stock i on day t. CRSP provides reliable data on the closing bid and ask prices only for Nasdaq stocks, so we conduct our analyses across the 1,254 Nasdaq firms that have sufficient bid-ask data. To minimize noise, we use mean *BAS*s computed over the 30 trading days before and 30 trading days after the ex-split date, respectively. We refer to these means as the pre- and post-split relative bid-ask spreads.

McInish and Wood (1992) find a negative relation between relative bid-ask spreads and stock prices for NYSE-traded firms during the first six months of 1989. To see if this relation holds for our sample of Nasdaq stocks, we divide our sample firms into three groups based on the pre-split price, and then compare the *BAS*s between groups. Using 30 trading days to calculate a mean pre-split price, we divide the sample into firms with mean prices under \$1.00, those with mean prices between \$1.00 and \$5.00, and those with mean prices above \$5.00. We find that the under-\$1.00 group ($n = 911$) has a mean relative *BAS* of 22.6% compared to 9.6% for stocks between \$1.00 and \$5.00 ($n = 252$), and 5% for stocks over \$5.00 ($n = 58$). The t-tests show that the differences between groups are statistically significant at the 0.01 level. Thus, there is an inverse relation between stock price and the bid-ask spread for our sample firms.

To show that these results are not restricted to reverse-split firms, we replicate these tests on a matched sample of 1,254 Nasdaq firms that do not have a reverse split, matching by industry (three-digit Standard Industrial Classification (SIC) code) and pre-split price. The mean relative *BAS*s for the three control groups are similar to those recorded by the reverse-split firms. For the under-\$1.00, between \$1.00 and \$5.00, and over-\$5 groups, the mean relative *BAS*s are 23.7%, 10.6%, and 4.1%, respectively. Again, the differences between the three groups are statistically significant at the 0.01 level.

We next examine the relation between the magnitude of the reverse split and the change in bid-ask spreads on the ex-split date. We divide our reverse-split sample into four groups based on relative split size: Group 1 consists of those firms with a 1:2 reverse split, Group 2 consists of firms with reverse splits over 1:2 but less than 1:10, Group 3 are firms with reverse splits of 1:10 but less than 1:20, and Group 4 are firms with reverse splits of 1:20 and higher. We propose a direct relation between the split-size group and the reduction in the relative bid-ask spread.

In Table VI, Panel A shows the mean (median) pre-split, post-split, and change in *BAS* for each of the four reverse-split groups. The mean and median changes in *BAS*s decrease monotonically over the four split groups. Group 1 yields a mean change in the *BAS* of 0.63%, compared to −1.90% for Group 2, −6.66% for Group 3, and −20.97% for Group 4. The medians produce a similar pattern of changes in *BAS*s. The t-statistics and Wilcoxon z-statistics, which test whether temporal changes are different from zero, are statistically significant for Groups 2 through 4, but not for Group 1 (1:2 splits). Further, Panel B shows that regardless of which two groups we compare, there is an increase in the negative change in the *BAS*, since the split size increases as

Table VI. Changes in the Relative Bid-Ask Spreads and Ex-Split Day Abnormal Returns for Reverse Splits Segmented by Magnitude of Split for Nasdaq Stocks

This table presents changes in the relative bid-ask spreads and the ex-split day abnormal return for 1,254 Nasdaq reverse splits. We divide the reverse splits into four categories based on the magnitude of the split. We define the relative bid-ask spread (*BAS*) as the closing ask price minus the closing bid price divided by the average of the two closing prices. We average the pre-split (post-split) *BAS* over the 30 calendar days prior to (following) the ex-split date. The abnormal return for the reverse-split firm is the raw return on the ex-split date minus the return on a matched firm, where we match by size, industry, and pre-split price. Panel A presents pre- and post-split *BAS* and the change in *BAS* from pre to post period. Panel B compares and tests for significant differences in changes in relative bid-ask spreads from the pre-event period to post-event period between groups. We calculate the difference in means (medians) between any two groups by subtracting the change in the mean (median) bid-ask spread for one group from the change in the mean (median) bid-ask spread from the other group. Panel C presents the mean and median ex-split day abnormal return when we use the matched control firm approach for the sample of Nasdaq firms that have both bid-ask data and returns data. Panel D tests for differences in abnormal returns between groups. The *t*-statistic tests for the difference in means. The Wilcoxon-*z* tests for the difference in medians.

Panel A. Relative Bid-Ask Spreads (BAS) for Pre-Split Period and Post-Split Period

Group	Split Size	Pre-Split Period *BAS* (%)			Post-Split Period *BAS* (%)		Change in *BAS* (%)		*t*-Stat.	Wilcoxon-*z*
		Obs.	Mean	Median	Mean	Median	Mean	Median		
1	1:2	66	9.56	6.34	10.19	6.93	0.63	0.59	0.36	0.07
2	(1:2,1:10)	535	13.66	10.33	11.75	8.20	−1.90	−2.13	−2.66[a]	−4.60***
3	(1:10,1:20)	182	17.41	13.91	10.75	7.70	−6.66	−9.71	−5.17[a]	−7.55***
4	≥1:20	66	35.37	33.31	14.40	10.82	−20.97	−22.49	−7.80[a]	−6.84***

Panel B. Testing for Differences in Changes in Relative Bid-Ask Spreads between Groups

Split Groups	Difference in Means between Groups (%)	Difference in Medians between Groups (%)	*t*-Stat.	Wilcoxon-*z*
1-2	2.53	2.72	2.66***	3.38***
2-3	5.76	7.58	6.35***	8.19***
3-4	14.31	12.78	6.70***	6.92***
1-4	21.60	23.08	9.75***	8.71***

Panel C. Event-Day Abnormal Return for Reverse Splits by Size of the Split

Split Groups	Split Size	Observations	Mean *AR* (%)	Median *AR* (%)
1	1:2	66	−2.0	−2.0
			(−1.47)	(0.16)
2	(1:2,1:10)	484	−5.8***	−4.8
			(−7.83)	(<0.001)
3	(1:10,1:20)	167	−11.3***	−9.8
			(−8.63)	(<0.001)
4	≥1:20	56	−12.9***	−14.7
			(−4.76)	(<0.001)

Panel D. Testing for Differences in Abnormal Returns between Groups

Split Groups	Difference in Means between Groups (%)	Difference in Median between Groups (%)	*t*-Stat.	Wilcoxon-*z*
1-2	3.8	2.8	2.44***	1.73*
2-3	5.5	5.0	3.66***	3.76***
3-4	1.6	4.9	0.53	0.54
1-4	10.9	12.7	3.59***	2.88***

*** Significant at the 0.01 level.

* Significant at the 0.10 level.

illustrated by the t- and z-statistics between groups. Thus, there is a direct relation between the split size and the reduction in the relative bid-ask spread.

Having established this link, we propose that the ex-split day negative abnormal return is directly related to the split size. This relation follows from Appendix B, where we show that the percentage decline in share price on the ex-split date should be determined by the changes in transaction costs (i.e., relative *BAS*s) that occur on this day. Formally,

$$\text{Expected Percentage } \Delta \text{ in } P_o \leq 1 - \left(\frac{1 - tc_b}{1 - tc_{\mathrm{o}}}\right), \tag{3}$$

where tc_b is the transaction costs before the ex-split date and tc_{o} is the transaction costs on the ex-split date. If there is no change in transaction costs (i.e., tc_b equals tc_o), the expected decline in share price on the ex-split date is zero. However, if tc_o is less than tc_b, that is, a drop in transaction costs on the ex-split day, then Equation (3) predicts a decline in share price on the ex-split day. Given the results reported in Panel A, we predict a significant drop in share price on the ex-split day for Groups 2 through 4, but an insignificant change in share price for Group 1.

Panel C shows that both the mean and median abnormal returns become increasingly negative as we move from Group 1 to Group 4. The mean abnormal return is −2%, for Group 1, −5.8% for Group 2, −11.3% for Group 3, and −12.9% for Group 4. The medians decrease steadily from −2% for Group 1 to −14.7% for Group 4. Consistent with our prediction that the magnitude and significance of the ex-split day abnormal returns mirrors the size and statistical significance of the change in *BAS*s, only Groups 2 through 4 have statistically significant means and medians. Panel D shows that the differences in abnormal returns between most groups are statistically significant at the 0.01 level. In particular, there are significant differences in both the mean and median abnormal returns between Groups 1 and 4.

Taken together, the results from Table VI strongly suggest that changes in transaction costs are at least partly responsible for the negative ex-split day abnormal returns, which, in turn, would be consistent with Jensen's (1978) definition of an efficient market.

VII. Conclusion

We examine 1,612 reverse splits from 1962 to 2001. We find a long-run return underperformance for firms beginning in the ex-split month and extending to three years after the split. These findings are robust to whether we use CTARs, *BHAR*s (matched firm or portfolio benchmarks), different time periods, bootstrapping, or delisting returns. To provide a justification for this underperformance, we compare operating performances for the sample firms relative to a control group for the four-year period including and after the year of the reverse split. Both the sample and control firms record negative EPSs and OCFAs in almost every year. However, with one exception, the sample firms' mean and median EPSs and OCFAs are significantly more negative than are those of the control firms. On balance, these results are consistent with the return underperformance results and suggest informational inefficiencies.

We also examine the issue of whether the market is economically efficient. We do so by determining whether investors can earn abnormal returns by short-selling these firms. Studies show that stocks without short interest are generally small, illiquid, and are priced under $5.00 per share. These characteristics match our sample of firms with reverse splits. More importantly, the mean monthly short interests for Nasdaq firms for the ex-split month and the 36-month period following the reverse split are significantly less than for the remaining Nasdaq firms. Further, when we compare sample firms priced at or below \$5.00 per share to the sample firms priced above \$5.00 per share, the former group's monthly short interest is significantly lower than the over-\$5.00 per share group. This result, coupled with the finding that stocks priced at or below \$5.00 per share are essentially driving the long-run, negative abnormal returns, suggests that arbitrageurs, hoping to profit from the expected decline in the share prices of the sample firms, apparently have a difficult time short-selling these stocks. We conclude that despite the systematic underperformance following the reverse split, markets are economically efficient.

Our final tests examine the ex-split day anomaly, when the sample firms experience a significantly negative abnormal return. Because the reverse-split date is typically known in advance, it is unclear why investors do not sell their holdings prior to this date. We offer a transaction costs explanation to account for this phenomenon. We find that the magnitude of the ex-split-day stock decline is directly related to the size of the stock split, which in turn is directly related to the reduction in the stock's relative bid-ask spread. Thus, investors who sell before the ex-split date to avoid the negative return on the stock's split date will pay higher transaction costs to liquidate their positions. Again, these findings are consistent with an economically efficient market. ■

Appendix A

We use the following formula to compute daily abnormal returns for each sample firm using the buy-hold method:

$$BHAR_{it} = \prod_{t=1}^{N}(1 + R_{it}) - \prod_{t=1}^{N}(1 + E(R_{it})), \tag{A1}$$

where:

$BHAR_{it}$ is the buy and hold abnormal return for firm i in month t,
R_{it} is the firm i's raw return in month t,
$E(R_{it})$ is the expected return for firm i in month t, and
N is the number of months.

Next, we calculate the average $BHAR$ for all firms in month t as follows:

$$\overline{BHAR_{it}} = \frac{\sum \prod_{t=1}^{N}(1 + R_{it}) - \prod_{t=1}^{N}(1 + E(R_{it}))}{n}, \tag{A2}$$

where:

$\overline{BHAR_{it}}$ is the average buy-hold abnormal return for all firms in month t, and
N is the number of firms.

We calculate t-statistics for the $\overline{BHAR}$ values as follows:

$$t_{BHAR} = \frac{\overline{BHAR_{i,t}}}{\sigma(BHAR_{i,t})/\sqrt{n}}, \tag{A3}$$

where:

$\sigma(BHAR_{i,t})$ is the cross-sectional sample standard deviation of abnormal returns for the sample of n firms.

Appendix B

Here, we show the determining level of pre- and post-event transaction costs when the investor is indifferent between selling shares either before or after the reverse split.

Sell stock before reverse-split date (rsd)

$$R_b = \frac{P_b(1 - tc_b) - P_P}{P_p}, \tag{B1}$$

where:

R_b is the percent return before rsd,
P_b is the stock price before rsd,
tc_b is the transaction costs before rsd, and
P_p is the purchase price.

Sell stock on reverse-split date (rsd)

$$R_o = \frac{P_o(1 - tc_o) - P_P}{P_p}, \tag{B2}$$

where:

R_o is the percent return on rsd,
P_o is the stock price on rsd,
tc_o is the transaction costs on rsd, and
P_p is the purchase price.

Indifferent if

$$R_b = R_o \text{ or } \frac{P_o(1 - tc_o) - P_P}{P_p} = \frac{P_b(1 - tc_b) - P_P}{P_p}. \tag{B3}$$

$$P_o(1-tc_o) = P_b(1-tc_b). \tag{B4}$$

$$\text{Therefore, if } P_o = P_b\left(\frac{1 - tc_b}{1 - tc_o}\right), \text{ I am indifferent.} \tag{B5}$$

$$\text{Accordingly, if } tc_o < tc_b, \text{ then } (1 - tc_b) < (1 - tc_o) \text{ and } P_o < P_b. \tag{B6}$$

Expected price decline on reverse-split date

$$\text{Expected percentage decline in } P_o \text{ should be } \leq 1 - \left(\frac{1 - tc_b}{1 - tc_o}\right). \tag{B7}$$

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