A TRADING RULE TEST USING STOCKHOLM AND U.S. CROSS-LISTED SECURITIES

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ABSTRACT

This paper examines the relative efficiency of the U.S. and Stockholm Stock Exchanges. Numerous stocks are cross-listed on United States Exchanges and the Stockholm Stock Exchange. We compare the prices of these firms at near-simultaneous trading times. This study is an extension of an earlier work by Jalbert, Moritz and Stewart (2005), who completed an efficiency test on stocks that are cross-listed on the Stockholm and a U.S. stock exchange, finding evidence of an inefficient market. This paper extends this line of work by conducting a trading rule test to provide additional evidence regarding the efficiency of these markets. The results provided here offer additional evidence of efficiency problems between these two markets.

INTRODUCTION

If pricing differences exist between two markets which trade identical goods, there may be an opportunity to earn an arbitrage profit by selling short in one market and buying to offset the short position in the second market. Previous research has provided evidence that pricing differences sometimes exist between identical securities which are cross-listed on the Stockholm Stock Exchange and a United States Stock Exchange. In this paper, this line of literature is extended by developing and testing trading rules designed to take advantage of these previously identified pricing differences. The evidence here suggests that profitable trading rules can be developed. These findings provide additional evidence to suggest efficiency problems exist between these two markets. The remainder of the paper is organized as follows. Previous literature is examined, followed by a discussion of the data used in the analysis. Next the results are presented and discussed, followed by some concluding comments.

PRIOR RESEARCH

Various studies have considered the relationships between cross-listed shares, with a specific focus on the efficiency of the prices of the two markets. Fisher (1996) first developed the technique of examining serial autocorrelation to test for market efficiency. In this framework, the existence of persistent serial correlation indicates the ability of historical returns to predict future returns. The presence of this type of price predictability is viewed as a violation of weak-form market efficiency. The approach developed by Fisher (1996) has subsequently been used in a plethora of studies, many of which have found significant autocorrelations and cross-autocorrelations. Boudoukh, Richardson, and Whitelaw (1994) provide a summary of some of this work. They attribute these correlations to either 1) market frictions, 2) time-varying economic risk premiums, or 3) market inefficiencies caused by under- and over-reactions to new information. They examine the autocorrelations of futures returns and returns on the underlying spot index of small-firm-weighted portfolios. They conclude that nonsynchronous trading and market frictions are the primary cause of the observed autocorrelations. They argue that frictions caused by nonsynchronous trading have not previously been given enough credit as a source of such autocorrelation.

Jensen (1978) utilized profits from trading rules as an alternative method for testing for market efficiency. This approach compares the returns associated with a specified trading rule to the returns on a buy and hold strategy. The trading rule is based upon historical, publicly available information so that the

information would be available to market traders. A few studies which report excess profits from various trading rules are Jegadeesh (1990), Lehmann (1990), Lo and MacKinlay (1990), and Jegadeesh and Titman (1995).

While most efficiency studies have not focused on cross-listed shares, many studies have examined how ADRs are priced. These studies are not entirely in agreement regarding the factors which have the greatest impact on ADR prices. Werner and Kleidon (1996) investigate the extent of intraday integration between U.K. shares and corresponding ADRs traded in New York. Interestingly, they find order-flow between the markets to be segmented. However, they do find some evidence that private information in New York is incorporated into prices in both markets during overlapping trading periods. Sundaram and Logue (1996) examine the pricing and segmentation of markets for cross-listed shares. Cross-listing in the U.S. is found to enhance valuations of cross-listed shares by reducing segmentation between international equity markets.

Jalbert, Moritz and Stewart (2005) examine the pricing of securities that are listed both on the Stockholm exchange and one of the U.S. exchanges. Using near simultaneous data, they identify significant pricing differences for identical stocks on the two exchanges. Specifically, they find statistically significant pricing differences for six of the nine firms examined in the study suggesting an inefficient market. They find that the pricing differences are reduced after 2003. They conduct a Granger Causality test to determine the existence and direction of causality in the series. They find that there is a feedback relationship between the U.S. price and the Stockholm price for eight of the nine series examined. In this paper we extend the work of Jalbert, Moritz and Stewart (2005) by developing a trading rule intended to provide further evidence of statistically different prices and to demonstrate how the previously identified pricing differences might be exploited by an individual trader. The data utilized in the study is discussed next.

DATA

The data used in this study includes stock and exchange rate prices from the period January 1998 through February 5, 2004. The data set is identical to that used by Jalbert, Moritz and Stewart (2005). During this time period, there were seventeen firms that were traded on both a U.S. stock exchange and the Stockholm Stock Exchange. Complete data was available for nine of these stocks so the other securities were eliminated from further analysis. Sweden stock price data comes from the Stockholm exchange website at: (www.stockholmsborsen.se). Corresponding data for U.S. exchange stock prices were obtained from Yahoo! Financial (http://chart.yahoo.com/d). In order to fairly compare prices, the data was adjusted for the effects of differences in share magnitude. For example, one ADR is equivalent to ten shares on the Stockholm exchange for the Ericsson and Swedish Match companies. In addition to stock prices, data on the exchange rate between the U.S. dollar and Swedish Krona was collected from the Pacific Exchange Rate Service (http://fx.sauder.ubc.ca/data.html).

To facilitate the analysis, the stock price data as well as the exchange rate data were synchronized in time. A two-step process was utilized to synchronize the data. The first step was to match the trading dates of the data. This step adjusted for differing holiday schedules between the two countries. In instances where either exchange was closed, all data for that day was eliminated from consideration. In addition, there were several dates where data were not available due to a lack of trading. In these instances, involving nine observations over the seven year period, the data was eliminated from consideration. The second step in the synchronization process was to synchronize the data by time-of-day. A six-hour time difference exists between New York and Stockholm. As such, collecting closing data from the two exchanges would result in non-synchronized data problems. Further complicating the data synchronization issue is the fact that the Stockholm and U.S. exchanges do not share common trading hours. The Stockholm stock exchange is open from 7:30 a.m to 5:30 p.m. local time each day while the

NYSE operates from 9:30 a.m. to 4:00 p.m. local time each day. Since there is an eight and one half hour difference between the close of trading on the two markets, we are not able to compare daily closing prices directly across the exchanges. In order to most closely match the data, U.S. opening price data (9:30 AM local time), is synchronized with closing data from the Stockholm Exchange. This matching procedure minimized the time differences between trading on the two exchanges. Specifically, by using this matching technique, the time difference between the data collection points is a maximum of two hours. In instances where the closing price collected on the Stockholm exchange was for a trade completed prior to the close, or instances where the opening price obtained from the NYSE was for a trade that occurred after the exchange opened, the time difference in the data collected on the two exchanges is less than two hours.

Clearly, intraday data could improve the accuracy of the synchronization and the precision of the test results reported here. However, such data was not available to the authors. Certainly, the extent to which the data is not synchronized limits the study. However this study is not the first to utilize data that is not perfectly synchronized. Other notable efficiency studies have been conducted using non-synchronous data including Rendleman and Carabini (1979). Second, the timing difference will not bias the results of this study as long as systematic intraday trends in stock price do not persist. It is expected that any pricing differences related to timing errors would be random and serve to offset each other. That is, price differences induced by timing differences are equally likely to be higher or lower, in a random fashion, on one exchange or the other and at any time frame. To the extent that the market is in a sustained period of price increases or decreases, timing differences could bias the results presented here. However, the time period examined in this study involves both times of increasing stock prices and decreasing stock prices, thus, any time induced bias would offset over time.

SUMMARY STATISTICS AND EARLIER FINDINGS

The analysis begins by presenting basic statistics and the relevant test results in Tables 1 and 2. These results are as reported in Jalbert, Moritz and Stewart (2005) and are reproduced here because they represent a description of the data common to both studies and the prime results that are to be expanded upon in the current paper. Table 1 provides general information about the nine firms that are included in the sample. Column 1 and 2 contain the firm name and ticker symbol. Columns 3 and 4 contain the beginning and ending dates of data availability. The number of data points available for each firm are reported in column 5. Column 6 and 7 contain the average daily trading volume on each exchange. Finally, column 8 indicates which U.S. exchange the firm is traded on. Average daily trading volume are reported for each firm as reported on June 1, 2004 at Yahoo.com for the U.S. exchanges, and as reported by the Stockholm exchange.

In Table 2, the extent and number of pricing differences between the two exchanges are reported. The column labeled > 0 indicates those instances where the price is higher in Stockholm that in the U.S. The column labeled < 0 indicates those instances where the price is higher in the U.S. than in Stockholm. For Autoliv, there were 903 observations where the price was higher in Stockholm than in the U.S. There were 544 observations where the price was higher in the U.S. than in Stockholm. We continue by examining the magnitude of the pricing errors. Columns 5 and 6 indicate those observations where the pricing difference exceeded $0.50 per share. There were 322 observations where the price in Stockholm was more than $0.50 per share higher than in the U.S. for the Autoliv company. There were 34 observations where the price was more than $0.50 per share higher in the U.S. than in Stockholm. Next we examine situations where the price difference is more than $1.00 per share. In 72 observations the price in Stockholm was more than $1.00 per share higher than the U.S. price. Four observations occurred where the price was more than $1.00 per share higher in the U.S. than in Stockholm. The differences in prices are found to be significant for six of the nine firms in the sample. Interestingly, three of the six differences are significantly positive, indicating that the average price in Sweden was significantly greater

than that witnessed in the U.S., while the other three differences were negative, indicating higher average prices in the U.S. than in Sweden.

Table 1: Sample Firms Summary Data

Company	Ticker	Data Start	Data End	Obs.	Avg. Daily Trade Volume in U.S.	Avg. Daily Trade Volume in Stockholm	U.S. Exchange
Astrazeneca	AZN	4-6-1999	2-6-2004	1,149	1,097,183	692,930	NYSE
Autoliv	ALV	1-2-1998	2-6-2004	1,447	372,772	597,055	NYSE
Biacore	BCOR	1-31-2000	2-6-2004	949	1,181	18,273	NASDAQ
Electrolux	ELUX	1-2-1998	2-6-2004	1,437	14,545	2,177,050	NASDAQ
Ericsson	ERICY	1-2-1998	2-6-2004	1,446	3,634,863	212,281,065	NASDAQ
Maxim	MAXM	1-2-1998	2-6-2004	1,446	492,123	276,221	NASDAQ
Oxigene	OXGN	1-2-1998	2-6-2004	1,440	260,136	62,693	NASDAQ
Tele2	TLTOA	1-2-2000	2-6-2004	967	49	709,232	NASDAQ
SW Match	SWMAY	1-2-2000	2-6-2004	963	1,000	2,134,424	NASDAQ

Table 2: Pricing Error Summary

Company	Obs.	>0	<0	>0.5	<-0.5	>1	<-1
Astrazeneca	1,149	557	592	166	210	26	53
Autoliv	1,447	903	544	322	34	72	4
Biacore	949	519	444	267	235	105	87
Electrolux	1,437	730	717	178	189	37	46
Ericsson	1,446	743	703	106	93	25	33
Maxim	1,446	519	444	267	235	105	87
Oxigene	1,440	732	708	50	58	11	11
Tele 2	967	544	423	251	201	114	96
SW Match	963	519	444	267	235	105	87

Jalbert Moritz and Stewart (2005) also examine the pricing errors before and after 2002. They find many fewer pricing errors after 2002 than before 2002. This finding suggests that the market may not have been efficient at one point but is moving toward increasing efficiency. A Granger Causality test is conducted to determine the extent of causality between the two series. A feedback relationship is found where prices in the U.S. Granger cause prices in Stockholm and prices in Stockholm Granger Cause prices in the U.S. Next, a trading rule is developed to determine if these differences can be exploited by traders.

TRADING RULES WITHOUT TRANSACTION COSTS

In this section we expand upon the work of Jalbert, Moritz and Stewart (2005) by applying a trading rule test that is designed to capitalize on the information discovered in that study. Specifically, we investigate the effectiveness of an arbitrage trading rule which compares the daily closing price in Stockholm with

the coinciding opening price in New York. In this section we develop a trading rule test that ignores the effects of transaction costs. A test that considers transaction costs is presented in the next section.

The trading rule is developed as follows. The stock price on the U.S. exchange and the Stockholm exchange are examined each day. If the difference between these prices is greater than a pre-specified filter level, a trade is made in each market. The size of the trade is fixed and specified prior to implementing the strategy. When a trade is indicated, the strategy purchases shares of the lower-priced security and short-sells shares of the higher-priced security. There is not a preset holding period for the shares. If the difference is positive, a long position is initiated in NYC and a short position is initiated in Stockholm. If the difference remains positive on subsequent trading days, additional shares are added to the long NYC position as well as the short Stockholm position. When the difference reverses, the process of unwinding the position is initiated. The profit or loss on the position is tracked daily. Table 3 illustrates the mechanics of the rule as applied to Astrazeneca.

Table 3: Trading Rule Example

Date	AZN Stockholm	AZN NYC	Diff	Action	Shares Stockholm	Shares NYC	Profit
4/7/99	$46.64	$45.19	$1.45	Sell STK; Buy NYC	(21.44)	22.13	$0.00
4/8/99	$45.53	$44.39	$1.14	Sell STK; Buy NYC	(43.40)	44.66	$6.10
4/9/99	$45.20	$43.53	$1.67	Sell STK; Buy NYC	(65.53)	67.63	($17.98)
4/12/99	$44.38	$43.78	$0.60	Sell STK; Buy NYC	(88.06)	90.47	$52.66
|	|	|	|	|	|	|	|
5/11/99	$38.34	$38.12	$0.22	No Trade	(429.55)	441.16	$348.01
5/12/99	$38.78	$38.61	$0.17	No Trade	(429.55)	441.16	$375.18
5/14/99	$39.01	$40.09	($1.08)	Buy STK; Sell NYC	(403.92)	416.22	$929.30

The example shows that on April 7, 1999, the difference between the Astrazeneca stock price in Stockholm and New York was $46.64 - $45.19 = $1.45. This positive difference is greater than the filter amount, indicating that $1,000 worth of Astrazeneca shares should be purchased in New York and simultaneously sold in Stockholm. This results in a short position of 21.44 shares in Stockholm and a long position of 22.13 shares in New York. Since the investment in each market is $1,000, the net profit from the positions is $0. On the following day, April 8, 1999, the stock price dropped in both markets. However, the difference between the stock prices was still positive and greater than the filter level at $45.53 - $44.39 = $1.14. This indicates that another $1,000 of shares should be short sold in Stockholm and simultaneously purchased in New York. These transactions roughly doubled the initial positions and subtracting the market value of the short position from that of the long position results in a $6.10 arbitrage profit. On April 9, notice that the positive difference persisted and the same action was taken. Again, the stock price declined in both markets, but the fact that the New York price declined more than the Stockholm price results in a $17.98 loss on the strategy at that point. On April 12, 1999, the price in Stockholm declined while the New York price increased. The price difference of $0.60 was still slightly greater than the filter level, so the process was repeated and the cumulative profit for the strategy was $52.66 as of that day. If at some point, the difference becomes negative and exceeds the size of the filter, as it did for Astrazeneca on May 14, 1999, then the rule indicates the purchase of $1,000 worth of shares in Stockholm and the sale of $1,000 worth of shares in New York.

The final three rows of Table 3 jump forward to May 11, 12, and 14 of 1999. On May 11 and 12, the difference between the stock prices in Stockholm and New York City was $0.22 and $0.17 respectively. In each case, the difference was less than the filter level of $0.50, so no action was taken and the number of shares remained constant. On May 14, the price in New York exceeded the price in Stockholm such that the price difference was -$1.08. This negative difference exceeded the filter amount and indicated

that $1,000 worth of shares should be purchased in Stockholm and a corresponding value should be sold in New York. In this case the number of shares short in Stockholm declined and the number of shares owned in New York also declined, resulting in a cumulative profit of $929.30 for the strategy to that point.

Table 4 reports the arbitrage profit from implementing this strategy using various filter levels. Each panel contains summary results for trading rules based upon price differences between identical securities traded on exchanges in both Stockholm and New York. The rows of each panel report the total arbitrage profit from the strategy, the maximum, minimum, and the standard deviation of profit for the strategy during this sample period. Also provided are the number of trading days where the strategy profit was negative and the total number of observations for that particular security. The size of the filter is listed at the top left-hand side of each panel. For example, the first panel reports the result from trades which were initiated when the price difference between exchanges was + or - $0.50. When the difference between the stock prices exceeds the filter level a trade is initiated. The columns provide summary data for each cross-listed company included in the sample. The arbitrage profit row represents the accumulated profit from implementing this rule. The maximum profit, minimum profit and standard deviation during the sample period are also reported. The observation < 0 row reports the number of days in the sample where the arbitrage profit for the strategy was negative. Total observations for each security are provided on the final row of each panel.

Table 4 represents the results from trading $1,000 worth of securities in each market when the difference between prices exceeds the specified filter. In Panel A, a $0.50 filter is used, in Panel B, a $1.00 filter is used, in Panel C, a $2.00 filter is used and in Panel D, a $3.00 filter is used. Various investment amounts were considered, however they did not have any impact on the results. The only effect of trade size is to increase or decrease the magnitude of the profit.

The filter strategy was profitable for each security in each panel regardless of the size of the filter used. In general we see the larger the filter size, the larger the average arbitrage profit across the nine securities. The same pattern is seen in the average maximum profit, average minimum profit, standard deviation of profit, and average number of observations where a negative cumulative profit was observed. These findings indicate that while smaller filters result in a larger total profit during this sample period, they are also more risky. In summary, the results indicate that an investor who could trade in the Stockholm and New York City markets at the observed prices, could successfully earn an arbitrage profit over time.

Another compelling facet of the success of these trading rules relates to results presented in a previous section of this paper. Earlier, we noted significant differences between the prices in the U.S. and Sweden for six of the nine stocks considered here. Interestingly, three of the six differences are significantly positive, indicating that the average price in Sweden was significantly greater than that witnessed in the U.S., while the other three differences were negative, indicating higher average prices in the U.S. than in Sweden. The trading rule produced a profit for all nine securities included in our sample. That is to say that it did not matter if the average daily prices for a particular security were significantly larger or smaller in one market. The rule was profitable even when investing in securities where the average daily price was not significantly different between the two markets.

Table 4: Trading Rule Results

Each panel contains summary results for trading rules based upon price differences between identical securities traded on exchanges in both Stockholm and New York. The size of the filter and are listed at the top left-hand side of each panel. For example, the first panel reports the result from trades which were initiated when the price difference between exchanges was + or - $0.50. The dollar amount per trade was $1,000 in each case. The columns provide summary data for each cross-listed company included in the sample. The arbitrage profit row represents the accumulated profit from implementing this rule. The maximum profit, minimum profit and standard deviation during the sample period are also reported. The observation < 0 row reports the number of days in the sample where the arbitrage profit for the strategy was negative. Total observations for each security are provided in the final row of each panel.

Panel A: Filter $0.50

Profit	**AZN**	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Total	$11,398	$9,313	$14,112	$16,417	$7,289	$5,827	$6,592	$23,527	$17,168	$12,405
Max	$12,175	$39,934	$14,236	$16,566	$11,909	$32,64	$9,162	$25,462	$17,717	$19,981
Min	($4,777)	($18,674)	$0	($283)	($3,786)	($2,253)	$0	$0	$0	($3,308)
Std Dev	$3,233	$3,982	$3,282	$3,629	$2,128	$6,603	$2,183	$5,974	$4,798	$3,979
Obs < 0	37	98	0	7	1	2	0	0	0	16
Obs	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253

Panel B: Filter $1.00

Profit	**AZN**	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Total	$5,456	$3,101	$7,158	$9,154	$2,099	$1,114	$1,405	$13,100	$7,690	$5,586
Max	$5,499	$10,202	$8,064	$9,300	$4,416	$6,285	$2,442	$13,834	$8,082	$7,569
Min	($1,658)	($4,111)	$0	($2,106)	$0	($1,305)	($30)	$0	$0	($1,023)
Std Dev	$1,536	$105	$1,702	$1,981	$787	$1,121	$519	$3,122	$2,176	$1,553
Obs < 0	13	18	0	8	0	15	2	0	0	6.22
Obs	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253

Panel C: Filter $2.00

Profit	**AZN**	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Total	$739	$733	$2,185	$6,108	$708	$512	$81	$4,333	$1,323	$1,858
Max	$744	$752	$2,600	$6,787	$2,482	$2,435	$248	$4,339	$1,361	$2,416.62
Min	($35)	$0	$0	($996)	$0	($509)	($8)	($55)	$0	($178.15)
Std Dev	$201	$168	$483	$1,386	$439	$403	$43	$973	$399	$499.49
Obs < 0	1	0	0	8	0	3	7	3	0	2.44
Obs	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253

Panel D: Filter $3.00

Profit	**AZN**	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Total	$5,456	$3,101	$7,158	$9,154	$2,099	$1,114	$1,405	$13,100	$7,690	$5,586.32
Max	$5,499	$10,202	$8,064	$9,300	$4,416	$6,285	$2,442	$13,834	$8,082	$7,569.43
Min	($1,658)	($4,111)	$0	($2,106)	$0	($1,305)	($30)	$0	$0	($1,023.28)
Std Dev	$1,536	$1,035	$1,702	$1,981	$787	$1,121	$519	$3,122	$2,176	$1,553.37
Obs < 0	0	0	0	6	0	7	0	1	3	1.89
Obs	1149	1447	953	1447	1447	1447	1447	970	970	1253

TRADING RULES WITH TRANSACTION COSTS

Next, we incorporate trading costs into the analysis. It is well known that the imposition of trading costs can negate profits available from many apparent arbitrage strategies. In this section we test to determine if the previously identified arbitrage opportunities persist in the presence of trading costs. Table 5 and Table 6 report the results of the trading rule under two different assumptions regarding transaction costs.

Table 5 assumes 1% transaction costs per trade. Each panel in the table summarizes the arbitrage profit, the number of transactions implemented, the dollar transaction costs for the strategy and the total number of observations for each security. Table 6 presents identical information under the assumption of 2% transaction costs per trade. Each panel contains summary results for trading rules based upon price differences between identical securities traded on exchanges in both Stockholm and New York. The size of the filter is listed at the top left-hand side of each panel. For example, the first panel reports the results from trades which were initiated when the price difference between exchanges was + or -$0.50. The dollar amount per trade is $1,000 for each panel. The columns provide summary data for each cross-listed company included in the sample. The arbitrage profit row represents the accumulated profit from implementing this rule. The number of transactions implemented within each combination of filter and trade amount is listed for each security. Each row reports the number of days in the sample where the arbitrage profit for the strategy was negative. Total observations for each security are provided on the final row of each panel.

The evidence presented in Table 5 indicates that when transaction costs equal 1%, the majority of the cross-listed stocks still produce an arbitrage profit. Using a $0.50 filter resulted in arbitrage profits for each of the nine stocks in our sample. Filters of $1.00 and $2.00 each produced arbitrage profits for eight of the nine stocks and the average profit per security was positive. In each of these panels we see a negative strategy profit for MAXM. A filter of $3.00 produced arbitrage profits for eight of nine securities and no negative profits. Interestingly, the average arbitrage profit declined as the filter window widened.

When transaction costs increase to 2%, we see that the persistence of arbitrage profits wanes somewhat. Table 6 indicates that a $0.50 filter produces profits in only three of nine cases with an average loss per security of ($1,181.70). A filter of $1.00 is more successful with profits in six of nine cases and an average profit per security of $1,075. The average profit is also positive when a filter of $2.00 or $3.00 is used. Each of these filters produced profits for seven of nine stocks.

Table 5: Trading Rule Results with 1 Percent Transaction Cost

Each panel contains summary results for trading rules based upon price differences between identical securities traded on exchanges in both Stockholm and New York. The size of the filter is listed at the top left-hand side of each panel. The dollar amount per trade was $1,000 in each market. The columns provide summary data for each cross-listed company included in the sample. The arbitrage profit row represents the accumulated profit from implementing this rule. The number of transactions implemented for each security. Total observations for each security are provided on the final row of each panel.

Panel A: Filter $0.50, 1% Transaction Cost										
	AZN	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Profit Total	$2,518	$2,253	$6,212	$9,137	$3,309	$767	$4,452	$14,567	$7,288	$5,612
Number of Transactions	444	353	395	364	199	253	107	448	494	340
Dollar Transaction Costs	$8,880	$7,060	$7,900	$7,280	$3,980	$5,060	$2,140	$8,960	$9,880	$6,793
Observations	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253
Panel B: Filter $1.00										
	AZN	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Profit Total	$2,696	$1,621	$4,178	$7,494	$939	-$846	$965	$9,000	$3,930	$3,331
Number of Transactions	138	74	149	83	58	98	22	205	188	113
Dollar Transaction Costs	$2,760	$1,480	$2,980	$1,660	$1,160	$1,960	$440	$4,100	$3,760	$2,256
Observations	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253
Panel C: Filter $2.00										
	AZN	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Profit Total	$539	$673	$1,685	$5,828	$288	-$128	$61	$3,173	$843	$1,440
Number of Transactions	10	3	25	14	21	32	1	58	24	21
Dollar Transaction Costs	$200	$60	$500	$280	$420	$640	$20	$1,160	$480	$418
Observations	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253
Panel D: Filter $3.00										
	AZN	**ALV**	**BCOR**	**ELUX**	**ERICY**	**MAXM**	**OXGN**	**TLTOA**	**SWMAY**	**Average**
Profit Total	$204	$673	$506	$5,618	$397	$112	-	$1,029	$237	$975
Number of Transactions	2	3	5	8	9	9	-	17	7	7
Dollar Transaction Costs	$40	$60	$100	$160	$180	$180	$-	$340	$140	$133
Observations	1,149	1,447	953	1,447	1,447	1,447	1,447	970	970	1,253

Table 6: Trading Rule Results with 2 Percent Transaction Cost

Each panel contains summary results for trading rules based upon price differences between identical securities traded on exchanges in both Stockholm and New York. The size of the filter is listed at the top left-hand side of each panel. The dollar amount per trade was $1,000 in each market. The columns provide summary data for each cross-listed company included in the sample. The arbitrage profit row represents the accumulated profit from implementing this rule. The number of transactions implemented for each security. Total observations for each security are provided on the final row of each panel.

Panel A: Filter $0.50, 2% Transaction Cost

	AZN	ALV	BCOR	ELUX	ERICY	MAXM	OXGN	TLTOA	SWMAY	Average
Profit Total	-$6,362	-$4,807	-$1,688	$1,857	-$671	-$4,293	$2,312	$5,607	-$2,592	-$1,182
Number of Transactions	444	353	395	364	199	253	107	448	494	340
Dollar Transaction Costs	$17,760	$14,120	$15,800	$14,560	$7,960	$10,120	$4,280	$17,920	$19,760	$13,587
Observations	1149	1447	953	1447	1447	1447	1447	970	970	1253

Panel B: Filter $1.00

	AZN	ALV	BCOR	ELUX	ERICY	MAXM	OXGN	TLTOA	SWMAY	Average
Profit Total	-$64	$141	$1,198	$5,834	-$221	-$2,806	$525	$4,900	$170	$1,075
Number of Transactions	138	74	149	83	58	98	22	205	188	113
Dollar Transaction Costs	$5,520	$2,960	$5,960	$3,320	$2,320	$3,920	$880	$8,200	$7,520	$4,511
Observations	1149	1447	953	1447	1447	1447	1447	970	970	1253

Panel C: Filter $2.00

	AZN	ALV	BCOR	ELUX	ERICY	MAXM	OXGN	TLTOA	SWMAY	Average
Profit Total	$339	$613	$1,185	$5,548	-$132	-$768	$41	$2,013	$363	$1,022
Number of Transactions	10	3	25	14	21	32	1	58	24	21
Dollar Transaction Costs	$400	$120	$1,000	$560	$840	$1,280	$40	$2,320	$960	$836
Observations	1149	1447	953	1447	1447	1447	1447	970	970	1253

Panel D: Filter $3.00

	AZN	ALV	BCOR	ELUX	ERICY	MAXM	OXGN	TLTOA	SWMAY	Average
Profit Total	$164	$613	$406	$5,458	$217	-$68	N/A	$689	$97	$842
Number of Transactions	2	3	5	8	9	9	N/A	17	7	7
Dollar Transaction Costs	$80	$120	$200	$320	$360	$360	N/A	$680	$280	$267
Observations	1149	1447	953	1447	1447	1447	1447	970	970	1253

CONCLUSIONS

In this paper we examine the relative efficiency of the U.S. and Swedish Stock Exchanges. Numerous stocks are cross-listed on United States Exchanges and the Swedish Stock Exchange. We compare the prices of these firms at near-simultaneous trading time. This study is an extension of an earlier work by Jalbert, Moritz and Stewart (2005), who completed an efficiency test on stocks that are cross-listed on the Stockholm and a U.S. stock exchange, finding evidence of an inefficient market. This paper extends this line of work by conducting a trading rule test to provide additional evidence on the efficiency of these markets. We develop a trading rule whereby arbitrage profits might be earned. We find the trading rule produces abnormal returns both without transaction costs and when incorporating transaction costs. Though as one would expect, higher transaction costs reduce the number and magnitude of arbitrage profits. The results hold regardless of the level of the filter. Thus the results here provide additional evidence of market efficiency issues between the Stockholm and U.S. exchanges.

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