Stock Exchange Mergers and Weak-Form Information Efficiency: Evidence from the OMX Nordic and Baltic Consolidation*

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Abstract

In this paper, we study whether the creation of a uniform Nordic and Baltic stock trading platform has affected weak-form information efficiency. A time-varying measure of return predictability for individual stocks is used in a panel-data setting to test for stock market merger effects. The results indicate that the stock market consolidations have had a positive effect on the information efficiency and turnover for an average firm. The merger effects are, however, asymmetrically distributed, indicating, among other, a flight to liquidity effect, i.e. relatively large (small) firms located on relatively large (small) markets experience an improved (reduced) information efficiency.

JEL Classification*: G12, G14, G15.*

Keywords:

Time-varying return predictability, turnover, market structure.

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1. Introduction

A major trend during the last decades has been the merger of international stock exchanges (see e.g. Kokkoris and Olivares-Caminal, 2008). A number of mergers have been made, e.g. the Euronext (2005), the OMX (2003-2006), the NYSE-Euronext (2006) and the NASDAQ-OMX (2007), and additional mergers can be expected in the future because of the competition between market exchanges and due to pressures to cut costs.[2] In light of this changing market structure for stock trading, an important question is how these changes potentially affect the quality of stock markets in terms of information efficiency; i.e. to what extent do current stock prices represent fair values given the available information? Stock price efficiency is important for a number of reasons. First, it is essential for an efficient allocation of savings within an economy, second, it is crucial for investor and firm-owner trust in stock markets, third, it is pivotal for an efficient construction of managerial compensation and incentives schemes, and fourth, it is of central interest through its connection to asset price predictability.

There are few theoretical models which predict how the trading behavior may be affected by a consolidation of stock exchanges. Arguments may nevertheless be put forth in favor of an expected overall increase in information efficiency. For example, a consolidation of markets may reduce the trading costs (Mendelson, 1987) thereby increasing the pool of potential investors available for each stock which, on average, makes deviations from a fair price less likely. That information efficiency increases following a merger is largely unexplored, although tentatively supported by the empirical findings of Khan and Vieito (2012). Apart from the expected positive effect on overall market efficiency, one can also argue that effects may be asymmetrically distributed over firms. For example, stocks which after a merger receive more attention from investors abroad due to increased visibility on foreign markets may become more information efficient compared with firms which after a merger receive unchanged or less investor attention. Nielsson (2009) finds that after the Euronext merger, liquidity increases for large, but not for small and medium sized, firms. Conditional on the changes in the level of investor attention (i.e. liquidity), it is also possible that the composition of informed versus uninformed investors following a stock may change, leading to additional asymmetric merger effects. For example, a change which leads to an increase in the proportion of informed investors that follow a given stock may make the given stock less likely to deviate from its fundamental value, whereas an opposite argument applies if it instead is the proportion of uninformed investors that goes up. Since knowledge of how stock exchange mergers influence stock price information efficiency to date largely is missing[3], in this paper we provide new empirical evidence by studying the effect of the OMX Nordic and Baltic stock exchange consolidation (henceforth the OMX merger).

During the period 2003-2006, the previously national stock markets in Denmark, Finland, Iceland, Sweden and the Baltic[4] countries merged into a single trading platform (the OMX merger).[5] To study the effect of these

[1] The harmonization of regulatory environment for capital markets in Europe combined with technological advances are likely to further fuel merger activities in the European capital markets.

[2] Nielsson (2009) studies stock venue merger effects from the Euronext merger upon liquidity, while Kokkoris and Olivares-Caminal (2008) focus up corporate access to financial capital. Khan and Vieito (2012), in an exploratory study, investigate the impact on weak-form market efficiency of the merger between the Portuguese stock exchange and Euronext in 2002.

[3] Estonia, Latvia and Lithuania.

[4] Since data for stocks on the Icelandic stock market partly are missing for the considered sample period, we exclude the Icelandic merger into the OMX in 2006 in our subsequent analysis.

mergers on information efficiency, time-varying measures of return predictability are estimated on stock returns for individual firms. These measures are then in a second stage related to variables measuring the mergers as well as to other covariates. This allows us to study possible asymmetric merger effects upon information efficiency based on firm location, size, and pre-merger visibility. A main advantage with our approach of identifying potential merger effects is that we can condition on other factors affecting information efficiency, both in the period before and in the period after the mergers. This is an extension compared with Khan and Vieito (2012) who compare the level of weak-form market efficiency for a pre-merger period with a post-merger period without conditioning on other covariates. The main contributions of the current paper are therefore that we (i) provide new empirical evidence concerning the effects of stock exchange mergers up information efficiency, (ii) analyze the issue using time-varying measures of efficiency, (iii) utilize panel data which makes it possible to use covariates and control variables for time- and firm-specific unobserved heterogeneity. Since much of the recent market efficiency literature (e.g. Gu and Finnerty (2002); Lagoarde-Segot (2009); Kim et al. (2011); Chuluun et al. (2011)), supports the notion that the relative level of weak-form market efficiency is time-varying and to a large extent depends on (for the researcher) unobservable factors, an approach allowing for covariates and controls of unobserved heterogeneity is of central importance.

To measure the time-varying level of return predictability, multiple versions of Wright's sign test (see Kim and Shamsuddin, 2008) are estimated on moving sub-samples over the considered time period.[6] Based on these measures, we obtain time-series of the test statistic for each individual stock. In the empirical analysis, these time-series are then analyzed directly as measures of the relative level of information efficiency. In the second stage of the analysis, merger event variables corresponding to each sub-sample window are used to measure the effect of the stock exchange mergers, conditioning on firm size, the prevailing market condition and on annual time- and firm-specific fixed effects. To examine possible asymmetric merger effects upon firms, we use interaction variables between the merger event variable and firm pre-merger listing locations, pre-merger firm size, and pre-merger foreign sales (to capture pre-merger foreign visibility). In addition to this analysis, we also provide evidence for merger effects on stock liquidity (measured by stock turnover) to gain further insights into the causes behind asymmetric changes in information efficiency.

The main findings of our study indicate (i) that the information efficiency and the turnover for an average firm are both improved by a consolidation of stock markets and (ii) that the effects are asymmetrically distributed over firms. In terms of asymmetric merger outcomes, we find tentative evidence supporting a flight to liquidity effect, i.e. improved information efficiency and turnover for relatively large firms located on relatively large markets, and reduced information efficiency for relatively small firms located on small markets. Our results also indicate that firms already visible to (i.e. traded by) foreign investors in the pre-merger period receive a relatively lower increase in information efficiency than firms less available to foreign investors in the pre-merger period. These results indicate that changes in the level of investor attention (turnover) may explain some, but not all of the changes in information efficiency. This lends support to the

[5] As a comparison, we also repeat our empirical analysis instead using the multiple variance ratio (VR) tests by Chow and Denning (1993) as a measure of time-varying return predictability. Results, who are qualitatively (in terms of signs and significance) similar, may be obtained on request. Evidence from Monte-Carlo studies in Kim and Shamsuddin (2008), do, however, favor the use of the multiple versions of Wright's sign test.

idea that merger effects may also stem from changes in the composition of informed versus uninformed investors following a stock.

The outline of the paper is as follows: Section 2 describes the OMX mergers and discusses different hypotheses about how stock market mergers may affect weak-form market efficiency. In Section 3 the data, the variable measurement and the empirical model are presented. Section 4 contains the results while the final section concludes.

2. The OMX merger and information efficiency

2.2 Background

The cooperation between the Nordic stock exchanges was formally initiated by the establishment of the NOREX alliance in 1998. It linked the stock exchanges in Stockholm and Copenhagen via a joint system for equity trading called SAXESS[7] and harmonized trading rules and membership requirements. The aim of this alliance was to facilitate interaction between exchanges without formally merging them. In 2000, both the Oslo and the Icelandic stock exchanges joined the alliance, followed by the stock exchanges in Helsinki, Riga and Tallinn in 2004. The stock exchange in Vilnius joined the alliance in 2005. In addition to this alliance, formal mergers of the Danish, Finnish, Icelandic, Swedish and the Baltic stock exchanges have taken place via the OMX mergers (today NASDAQ-OMX). In 2003, the Stockholm stock exchange (OMX) merged with the Helsinki (HEX), in 2004 the stock exchanges in Riga and Tallinn were included, and in 2005 the Vilnius exchange joined and in the same year OMX-HEX acquired the Copenhagen stock exchange. Finally, in 2006 the Icelandic stock exchange merged with OMX. After these mergers OMX offered access to about 80 percent of the Nordic and Baltic securities markets through a unified trading platform. Since the effects of a stock exchange merger are likely to be observed from the date when investors are given access to the common trading platform, these dates have been identified. Table 1 shows the dates when investors from each market were given access to the other trading venues for our considered markets (i.e. excluding the merger with the Icelandic stock market). For example, as of September 27, 2004, Swedish investors could access and trade stocks listed

[6] Securities-trading on the stock exchange takes place through the common SAXESS trading system. The SAXESS system was implemented at Stockholm stock exchange March 12, 1999, Copenhagen June 21 1999, Oslo May 27, 2002 and Helsinki, Riga, and Tallinn, 27 September 2004.

Table 1: Merger date for each market.

MARKET	2004-09-27	2005-01-03	2005-05-30
Stockholm (Sth)	Hel, Rig, Tal	Cop	Vil
Helsinki (Hel)	Sth, Rig, Tal	Cop	Vil
Copenhagen (Cop)	-	Sth, Hel, Rig, Tal	Vil
Riga (Rig)	Sth, Hel, Tal	Cop	Vil
Tallinn (Tal)	Sth, Hel, Rig	Cop	Vil
Vilnius (Vil)	-	-	Sth, Hel, Cop, Rig, Tal

on the Helsinki, Riga, and Tallinn stock exchanges via the SAXESS cash trading system. Later, Swedish investors could also trade Danish stocks when the trading platforms in Stockholm and Copenhagen were merged on January 3, 2005.

2.3. Information efficiency and stock exchange mergers

The prior literature emphasizes that the level of market efficiency may vary over time (e.g. Gu and Finnerty, 2002; Lo, 2004; Lagoarde-Segot, 2009; Kim et al., 2011; Chuluun et al., 2011). In this literature, it is acknowledged that different financial markets may be weak-form efficient to varying degrees instead of either being weak-form efficient or not, and that the level of weak-form efficiency may change over time. This is in contrast to much of the earlier empirical literature (see e.g. the survey by Lim and Brooks, 2011) which is based on the assumption of a constant level of information efficiency and which tries to reject or accept that markets are either weak-form efficient or not.

There is also a literature which looks at under what types of conditions markets are efficient. Lim and Brooks (2011) point out that factors that may lead to departures from market efficiency are characteristics of the market microstructure, limitations to arbitrage, psychological biases among investors, noise trading, and market imperfections. The degree of market efficiency is also likely to evolve over time due to changes in market conditions, macro institutions, market regulations, and information technologies. Today, there is a large literature which attempts to show a link between events to periods of low(er) market efficiency. Some studies[8] relate market conditions (mainly financial crises) to market efficiency whereas other studies[9] link financial reforms and changes in the regulatory framework to market efficiency. Yet other studies[10] test how technology improvements (the introduction of electronic trading systems) and the introduction of price limitation systems affect market efficiency.[11]

Is a stock exchange merger also a factor, or event, which may influence the information efficiency of stock prices? There are few theoretical models which provide guidance on what to expect after a consolidation of stock markets. A number of arguments in line with Nielsson (2009) may, however, be put forward leading to testable hypotheses. One is that a stock exchange merger brings buyers and sellers together on a common trading venue which reduces both the direct and the indirect (non-monetary) costs related to trading. Investors' direct costs may decrease if exchange operators pass on possible gains from the merger, e.g. due to scale effects from common trading and clearing systems, to investors in terms of lower fees. Indirect costs (e.g. in terms of saving time) are also likely to decrease when trading and clearing systems become more uniform.[12] This argument is in line with Mendelson (1987) who advances the network argument, i.e. that lower trading costs are linked to the concentration of buyers and seller to one consolidated market. Reduced direct and indirect trading costs are also likely to broaden a stock exchange in terms of the number of participants, both domestic and foreign, which implies that each

[7] See Hoque et al. (2007), Kim and Shamsuddin (2008), and Kim et al. (2011).
[8] Lagoarde-Segot (2009), Kim and Singal (2000a, b), Antoniou (1997), and Groenewold et al. (2004).
[9] Jain (2005), Naidu and Rozeff (1994), Freund et al. (1997), and Ryoo and Smith (2002).
[10] See e.g. Lim and Brooks, (2011), for a more comprehensive survey.
[11] Direct fee's could possibly increase on a consolidated market if the merger reduces venue competition in trading of stocks and exchanges exert monopoly power. In a cross-country merger of stock markets, most stocks are, however, usually only traded on one market in the pre-merger period. Thus, competition in trading of a given stock is not likely to change to any larger extent in this type of merger.

individual firm faces a potentially larger pool of investors after a merger. A large number of participating investors may lead to a deepening of the market, i.e. larger quantities available at prices marginally above and below the prevailing market prices, which makes individual trades less likely to drive price movements. These arguments imply that a consolidation of stock markets is likely to have a positive effect on the number of investors analyzing and trading in a given stock, and it may also imply that deviations from a fair price become less likely. Hence, information efficiency for an average firm is expected to increase on an overall basis.

Given the arguments in favor of an overall positive effect of exchange mergers upon market efficiency it is, however, possible that the effect is asymmetrically distributed, c.f. Nielsson (2009). One may expect that the effect of a merger on an individual stock depends on how much investor attention it receives after the merger compared to the attention received before the merger, as well as on the initial level of efficiency. If a stock, which before the merger displayed much deviation from a random walk (i.e. a low level of information efficiency), after the merger receives more investor attention then the information efficiency may increase. Whether a given stock receives more or less investor attention in the post-merger period is likely to depend on the firm´s previous (pre-merger) visibility on the foreign market. The latter is, in turn, likely to depend on the firm´s size and foreign sales. A large firm, or a firm with sizable foreign sales, may already be known to foreign investors. For a firm with a high pre-merger visibility, the merger may either increase trading in the stock if it attracts new foreign investors, or not affect trading if foreign investors are already trading in the stock. These arguments imply that previous visibility may work in either direction.

Another size related argument is that a firm which before the merger is large on a small stock market may end up being a medium sized (or small) firm on the consolidated market. Given that many investors form portfolios with firm size as a determining factor, a change in a firm´s relative position in the firm size distribution may lead to a corresponding change in investor attention after the merger. Since many institutional investors favor relatively large firms in their portfolios, this may imply that a reduction in a firms relative position in the firm size distribution will lead to less investor attention and reduced information efficiency.

One may also argue that asymmetric merger effects may originate from changes in the composition of traders following different stocks, i.e. in the proportion of informed versus uninformed investors (c.f. discussion in Grossman and Stiglitz, 1980). If the relative proportion of informed investors that trade in a given stock increases after a merger then this may, all else equal, decrease the likelihood of price deviations from a fair price.[13] An opposite argument applies if, instead, the proportion of uninformed traders goes up after a merger.

Empirical studies which look at how stock venue mergers affect market efficiency are to date scarce. One exception is Khan and Vieito (2012) who investigate the effects of the 2002 merger of the Portuguese stock exchange with Euronext. Although this study provides mixed results depending on the method used, it favours the finding of a positive effect upon weak-form market efficiency. Another relevant study is Nielsson (2009) who looks at the impact of stock exchange mergers (Euronext) upon liquidity. Since liquidity, in general, is found to be positively correlated with market efficiency (see e.g. Chordia et al. (2008) and Chung and Hrazdil (2010)), the results from Nielsson (2009) offer some guidance. A no-

[12] This line of reasoning is in line with the conjecture made by Grossman and Stieglitz (1980) that "the more individuals who are informed, the more informative is the price system".

Table 2: Sample summary statistics, 2000-2007.

	FULL SAMPLE	STOCKHOLM	HELSINKI	COPENHAGEN	BALTIC
Return characteristics:					
- Mean daily return (%)	0.013	-0.021	0.006	0.045	0.088
	(0.087)	(0.092)	(0.083)	(0.060)	(0.056)
- Mean volatility (s.d., %)	3.182	3.893	2.825	2.369	3.109
	(2.141)	(2.663)	(1.485)	(1.355)	(1.396)
- Mean kurtosis	36.861	20.937	23.310	55.881	82.988
	(87.321)	(44.498)	(69.192)	(109.806)	(149.996)
Market capitalization (MC):					
- Mean MC (thousands, Euro)	1,177,481	1,729,362	1,444,537	501,707	69,760
	(9,060,110)	(12,315,835)	(8,906,824)	(1,644,029)	(148,238)
- Mean MCLarge firms (thousands, Euro)	9,613,610	14,342,741	11,335,759	4,042,294	440,395
	(27,446,593)	(23,432,462)	(25,937,724)	(3,750,743)	(277,543)
- Mean MCSmall firms (thousands, Euro)	9,834	10,264	10,048	10,358	5,690
	(14,936)	(20,719)	(5,795)	(10,714)	(8,999)
GDP per capita (Euro)	7,358	8,040	7,322	9,456	4,615
	(1,859)	(511)	(501)	(337)	(898)
Nr. of firms	551	236	111	153	51
Nr. of firms missing foreign sales info.	186	79	20	43	44
Proportion of firms with foreign sales[a]	0.649	0.745	0.725	0.464	0.429

Returns and market capitalization are calculated as averages over all/large/small firms over the full sample period. GDP per capita is based on real, quarterly, seasonally adjusted data. aProportion based on fully observed sample, i.e. net of firms missing foreign sales information. Standard deviations in parenthesis.

table finding by Nielsson is the asymmetric effect on liquidity for different firms. For large firms, liquidity is positively affected by mergers while there are no effects for medium sized and small firms. Translating these findings to market efficiency indicate an asymmetric effect with a gain in market efficiency for large firms but no effect for medium and smaller firms.

3. Data, measures, and the empirical model

3.1 Data

To study to what extent the return predictability on the Nordic and Baltic stock markets have been affected by the OMX mergers, daily stock price data has been collected from the Thomson Reuters Datastream. The sample covers the period January 4, 2000 to December 31, 2007[14] and includes stock price data for 236 Swedish, 111 Finnish, 153 Danish, and 51 Baltic (13 Latvian, 10 Estonian and 28 Lithuanian) stocks. Descriptive statistics are presented in Table 2 along with measures of stock market capitalization, per capita GDP, and indicators of foreign sales.

To illustrate some key characteristics of the rates of return among the considered stocks, the average of the mean daily stock returns for individual firms, the average of the mean standard deviations (volatility), as well as the average of the mean kurtosis over all stocks and time periods, separated over each of the considered markets, are displayed in Table 2. During the sample period the average daily return for stocks located in Stockholm

[13] To avoid effects on time-varying return predictability from the financial crisis in 2008, and from the increased fragmentation in stock trading, due to the introduction of MTFs from 2008 and onwards, the sample is restricted until the end of 2007. The issue of market efficiency and fragmentation of trading is studied in Hellström, Liu, Sjögren (2013).

was negative, while it was positive for stocks on all the other markets. The highest average return, 0.088 percent, is found on the Baltic markets. The average volatility (s.d.) indicate that the highest mean variation in returns are found among Swedish firms followed by Baltic firms. In terms of kurtosis, the aggregated numbers indicate clear deviations from normality. The average kurtosis is highest on the Baltic markets.

We use a firm´s market capitalization as a measure of company size. Table 2 also displays the mean market capitalizations on each market both for the full sample as well as for large and small firms. Here, large and small correspond to the 10 percent of firms with the highest and lowest, respectively, market capitalization. The average market capitalizations show that the highest average values are found in Stockholm, Helsinki, Copenhagen and the Baltic markets, in descending order. Among the 10 percent largest firms on each separate market there are considerable differences. The average large firm listed in Stockholm is about 1.27 times larger than the average large firm in Helsinki, 3.55 times larger than the average large firm listed in Copenhagen, and about 32.57 times larger than the average large firm listed on the Baltic markets. This means that firms that in the pre-merger period were large on the Baltic market, are likely to be ranked as small or middle sized on the post-merger stock market.

Table 2 also shows that the average (over time) seasonally adjusted real per capita GDP is highest in Denmark, followed by Sweden, Finland and the Baltic states. Foreign sales data at the end of the pre-merger period have been collected from the Thomson Reuters Datastream Worldscope database. Unfortunately, data on foreign sales are missing for a number of firms. For the full sample, 34 percent of the firms lack information about whether they had foreign sales at the end of the pre-merger period. Here, 33 percent of the firms listed in Stockholm, 18 percent of the firms listed in Helsinki, 28 percent of the firms listed in Copenhagen and 86 percent of the firms listed on the Baltic markets lack this information. In Table 2, we also report the proportion of firms with foreign sales (for the firms on which we have full information). This proportion is highest for firms listed in Stockholm, 0.74, and lowest for firms listed on the Baltic markets, 0.43. This means that over 7 out of 10 firms on the Stockholm stock exchange had foreign sales at the end of the pre-merger period, while this figure in the Baltic states was roughly 4 out of 10 firms.

3.2 Measures of time-varying return predictability

To measure the relative level of stock return predictability over time, we use the multiple version of Wright's sign test (*JS*, see Kim and Shamsuddin, 2008) on moving sub-sample windows over the considered time span.[15] The test, performed on each sub-sample, has in Monte Carlo experiments (Kim, 2006; Kim and Shamsuddin, 2008) been found to perform well (better than conventional *VR* tests) in terms of size distortion and power, and the test is robust to more general forms of conditional heteroscedasticity such as GARCH and stochastic volatility errors. The test is, as the conventional *VR* tests, based on the fact that if asset return is purely random, then the variance of the *k*-period return is *k* times the variance of the one-period return. The multiple *VR* test considers whether the set of *VR* statistics for different holding periods *k* are jointly

[14] Apart from the multiple version of Wright's sign test we also test the robustness of the reported results by using the multiple variance ratio (VR) test by Chow and Denning (CD, 1993). We are grateful towards Professor Jae Kim for sharing the Gauss code concerning the multiple VR tests used in this paper. In the empirical analysis we also considered the wild bootstrap test of Kim (2006) on a sub-sample of firms rendering qualitatively similar results, i.e. with regard to sign and significance. This test was, however, time consuming to perform.

equal to one. For r_t, $t=1,\ldots,T$, asset returns the conventional *VR* statistic can be written as

$$VR(r;k) = \frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_t + r_{t-1} + \cdots + r_{t-k+1} - k\hat{\mu})^2}{\frac{1}{T}\sum_{t=1}^{T}(r_t - \hat{\mu})^2}$$

where $\mu = T^{-1}\sum_{t=1}^{T} r_t$. Under regularity assumptions for r_t, corresponding to r_t being serially uncorrelated with a general form of heteroscedasticity including the ARCH-type of conditional variance (see Lo and MacKinlay, 1988), it can be shown that under the null hypothesis the unknown population *VR* is equal to one, i.e. $V(k)=1$, and the test statistic is given by

$$M(r;k) = \frac{VR(r;k) - 1}{\left(\sum_{j=l}^{k-1}\left[\frac{2(k-j)}{k}\right]^2 \delta_j\right)^{1/2}}$$

where

$$\delta_j = \frac{\sum_{t=j+1}^{T}(r_t - \hat{\mu})^2(r_{t-j} - \hat{\mu})^2}{[\sum_{t=1}^{T}(r_t - \hat{\mu})^2]^2}$$

is asymptotically standard normal distributed (Lo and MacKinlay, 1988). The non-parametric sign based *VR* test of Wright (2000) is recommended in the case of non-normal time series and has been found to have a high power against a wide range of models displaying serial correlation. Let $s_t \in (0,1)$, be an indicator variable with $st=1$ if $rt > 0$, and zero otherwise. The sign based test of the individual hypothesis $V(k)=1$ against the alternative $V(k)\neq 1$ is then given by

$$S_1(k) = \left(\frac{Tk^{-1}\sum_{t=k}^{T}(s_t + s_{t-1} + \cdots + s_{t-k+1})^2}{T^{-1}\sum_{t=1}^{T} s_t^2} - 1\right)\left(\frac{2(2k-1)(k-1)}{3kT}\right)^{-1/2}$$

Kim and Shamsuddin (2008), in spirit of Chow and Denning (1993), propose a multiple joint test of $V(ki)=1$ for $i=1,\ldots,l$, against the alternative hypothesis that $V(ki)\neq 1$ for some i. The test is given by

$$JS = \max_{1\leq i\leq l}|S_1(k_i)|.$$

The exact sampling distribution of *JS* may be obtained through simulation, see Chow and Denning (1993) and Kim and Shamsuddin (2008).[16]

3.3 Testing for merger effects

To study to what extent weak-form market efficiency has been affected by the OMX mergers, we study the time-varying predictability in asset returns. The most straightforward measure of relative time-varying return predictability is to use the estimated series of the *VR* test statistics as a direct measure. The magnitude of the test statistic is then interpreted as a relative indicator of efficiency where a higher test statistic implies a lower probability of making a type-I error when rejecting the efficiency hypothesis, see e.g. Lagoarde-Segot (2009). In the second stage analysis, a panel data regression model is used to model the test statistics directly. To measure the effect of the OMX merger upon the time-varying return predictability of individual stocks, dummy variables are created with the value one, zero otherwise, from the date when the stock was possible to trade on the common OMX trading platform.[17] This means that for stocks on the Stockholm, the Helsinki, the Riga, and the Tallinn stock exchanges this dummy takes the value one from September 27, 2004 onwards, while for stocks on the Copenhagen stock exchange the dummy takes the value one from January 3, 2005 onwards. Since our dependent variable is constructed based on the *VR* tests for sub-samples, the dating of these in regard to the co-

[15] For example, the 5 and 10 percent critical values for with are 2.40 and 2.10, while 2.32 and 2.04 for , respectively.
[16] It is possible that the trading on, e.g. the Copenhagen stock exchange, was affected by the merger between the Stockholm, the Helsinki, the Riga, and the Tallinn stock exchanges, even though Copenhagen was not directly involved. For example, investors already trading on many of the Nordic and Baltic markets during the pre-merger period could have changed their trading patterns due to the merger, possibly also affecting trading on markets not directly involved in the merger. These effects are, however, likely to be of minor order and are therefore ignored.

variates and the merger dummies need some consideration. If we let indicate the date of the merger (i.e. the date from when investors could trade on a common trading platform), then we define a sub-sample window from t_0 to t_1 where $t_0 < t_M < t_1$. Based on the returns in the sub-sample window the *VR* statistic is calculated. Since the test indicates return predictability within the given sub-sample, and the time indexing for sub-samples do not correspond to the specific dates of the mergers, the merger event variable in the second stage analysis is the average of the merger event dummy during the sub-sample window. Thus, the merger event variable is a proportion between zero and one. For sub-samples with all return observations pertaining to the period before t_m the variable takes the value zero, for sub-samples containing return observations from both before and after t_m, a value between zero-one, and for sub-samples containing return observations only from the period after t_m, the value one.[18]

Apart from using fixed effects to control for unobserved time-constant stock specific characteristics, time-varying control variates unrelated to the merger event but possibly related to weak form information efficiency, are also included. Since large firms are usually better covered by analysts, and since investors typically are more familiar with big salient firms[19], the firms' market capitalization, as a measure of stock size, is included. Here we assume that price levels and the number of outstanding stocks are relatively unaffected by the merger event. In line with Nielsson (2009), GDP per capita is included as a control for the prevailing market condition. The market condition is unrelated to the merger and has been found to affect both trading volumes (Nielsson, 2009) and weak-form market efficiency (e.g. Hoque et al., 2007; Kim and Shamsuddin, 2008; and Kim et al., 2011). For the GDP and market capitalization, the average value during each sub-sample period is used in the second stage analysis.

4. Empirical analysis

4.1 Return predictability

Before turning to the main analysis of potential merger effects upon weak-form information efficiency, let us first discuss some results for the time-varying VR statistics. These are estimated on moving sub-sample windows of two years (500 trading days), moving the window forward one week at a time.[20] In Table 3, we summarize our results for the repeated *JS* test statistics over the considered time period aggregating the firm statistics over different categories based on location, size and foreign sales for the pre- and post-merger period, respectively.[21] In our sample, a number of stocks on the Helsinki and Baltic stock markets are characterized by infrequent (thin) trading leading to a relatively large number of zero return observations on the daily frequency. Many studies (Lo and MacKinlay, 1990; Stoll and Whaley, 1990; Miller et al., 1994) have found that thin trading can generate spurious serial correlation in stock returns, i.e. return predictability, and seriously bias the outcome of empirical tests of market efficiency. Summary statistics excluding thinly traded stocks are therefore also shown in Table 3.[22]

[17] Once the merger event variables take the value one, i.e. is only based on return observations after the merger date, they retain this value until the end of the sample period.

[18] Large and influential investors, e.g. pension funds, often focus on trading in the biggest companies.

[19] The choice of 500 trading days is motivated by the fact that the tests have been shown to perform reasonably well for this sample size (Kim and Shamsuddin 2008). In the robustness testing, similar results were also obtained with sub-sample windows of 400 and 600 trading days.

[20] Given that the non-parametric sign test (JS) is more appropriate for non-normal return distributions, we focus mainly on analysis of this statistic within the paper. Results pertaining to the analysis of the CD test statistic may be obtained from the authors upon request.

[21] To define thinly traded stocks we have chosen stocks with more than 10 percent out of the full sample consisting of zero volume trading days.

Table 3: Summary statistics for Wright's joint sign test.

	PRE-MERGER PERIOD					POST-MERGER PERIOD				
Joint sign test	Meanb	s.d.	Min.	Max.	Obs.	Meanb	s.d.	Min.	Max.	Obs.
Full sample										
- All	10.347*	22.008	0.143	111.961	78,027	6.279*	13.840	0.085	111.961	88,375
- Exclu. thin	1.808*	1.105	0.143	11.695	62,985	1.685*	0.908	0.894	12.706	70,499
Stockholm										
-All	1.627*	0.769	0.171	6.032	32,568	1.573*	0.706	0.111	6.622	38,704
Helsinki										
- All	26.064*	28.245	0.143	106.193	15,318	14.242*	20.510	0.085	104.973	18,204
- Exclu. thin	2.639*	2.162	0.143	11.695	5,106	1.777*	0.974	0.171	8.594	6,068
Copenhagen										
- All	1.859*	1.025	0.179	8.318	23,103	1.709*	0.850	0.089	5.724	23,103
Baltic										
- All	44.353*	36.672	0.268	111.961	7,038	23.353*	22.684	0.376	111.961	8,364
- Exclu. thin	2.035*	1.455	0.268	8.723	2,208	2.917*	2.125	0.376	12.706	2,624
Large firms										
- All	1.868*	2.249	0.143	22.460	7,884	1.724*	1.480	0.180	18.532	9,028
- Exclu. thin	1.602*	0.842	0.143	6.039	7,746	1.569*	0.607	0.180	3.578	8,864
Small firms										
- All	15.780*	30.687	0.182	111.961	7,962	10.855*	21.285	0.189	110.498	8,950
- Exclu. thin	1.570*	0.710	0.182	4.472	6,444	1.943*	0.977	0.189	6.708	7,146
Foreign sales										
- All	4.911*	10.345	0.171	83.913	33,369	2.695*	4.564	0.085	60.362	38,205
- Exclu. thin	1.733*	1.079	0.171	11.655	28,263	1.560*	0.771	0.098	8.594	32,137
Non-foreign sales										
- All	11.082*	23.155	0.143	107.275	18,431	7.050*	15.396	0.147	94.386	20,225
- Exclu. thin	1.895*	1.151	0.143	11.695	15,119	1.660*	0.811	0.147	4.919	16,289

aNote that the merger date differs between markets (Stockholm, Helsinki, Riga, and Tallinn: 2004-09-27; Copenhagen: 2005-01-03; Vilnius: 2005-05-30) and that no stocks are excluded due to thin trading on the Stockholm and Copenhagen stock markets. bMean of time-varying variance ratio test over time and firms for different locations/categories. *Indicates a significant difference in sample means of the JS test statistics between the pre- and post-merger periods based on two sample t-tests at significance level $p<0.05$.

A comparison of the pre- and post-merger periods for the full sample, as well as for the different categories, indicates that the mean of the *JS* test statistic distribution is, in general, significantly lower (based on two sample t-tests) in the post-merger period. This indicates an (unconditional) overall average improvement in relative information efficiency potentially due to the mergers. Exceptions to this general tendency of improved efficiency concern small and Baltic firms for the samples excluding thinly traded stocks. For Baltic firms the mean of the *JS* distribution increases from 2.035 in the pre- to 2.917 in the post-merger period, while for small firms the mean increases from 1.570 in the pre- to 1.943 in the post-merger period, both excluding thinly traded stocks. This is a tentative indication that the merger effects upon information efficiency may be asymmetrically distributed over firms with possible negative effects for Baltic and small firms. A comparison between the distributions for the *JS* test statistic including and excluding thinly traded stocks, respectively, reveal significant size differences. For the full sample the mean value including thinly traded stocks is about 5.7 times (and the maximum value 9.6 times) larger than for the sample excluding thinly traded stocks. Because of the potential bias in the test statistic for thinly traded stocks, we therefore focus on the sample where these are excluded. A comparison across firm location shows that the mean *JS* statistic is smallest for firms listed in Stockholm followed by Copenhagen, the Baltic countries, and Helsinki, respectively. Somewhat surprising the *JS* statistic is on average lower for smaller than for larger firms. This is most likely due to a proportionally larger exclusion of firms due to thin trading for the group of smaller firms. Comparing firms with foreign sales at the end of the pre-merger period with those without, shows that the *JS* statistic is on average smaller for those with foreign sales. Observe that if we interpret the mean *JS* statistic in terms of significant deviations from a random walk, i.e. we compare the mean *JS* to the 5 percent critical value 2.10, only the sample corresponding to firms listed in Helsinki indicate a significant deviation from a random walk in the pre-merger period. In the post-merger period, only the sample with firms listed in the Baltic countries shows a significant deviation from a random walk.

4.2 Return predictability and stock exchange mergers

To study the effects of the stock exchange mergers upon weak-form market efficiency in a conditional analysis accounting for other factors affecting market efficiency in the pre- and post-merger period, we relate the time-varying *JS* measure to covariates. Given that we also are interested in how the stock market mergers affect liquidity (to better understand the drivers for changes in information efficiency), the analyzed sample has been restricted to firms for which we observe stock turnover (to facilitate a comparison of merger effects between information efficiency and liquidity). In the main analysis our sample therefore excludes thinly traded stocks and stocks for which we lack data on turnover. In total, this sample consist of 411 firms (214 listed in Stockholm, 35 in Helsinki, 151 in Copenhagen, and 11 in the Baltic stock markets). In Table 4 we report estimation results for models based directly on the *JS* test statistic.[23]

In Model 1, the basic regressions are presented controlling for firm size (market capi-

[22] Apart from the included control variables, fixed effects (favored over pooled OLS based upon F-test and over random effects based on the Hausman test), controlling for time-invariant firm specific heterogeneity, and time-specific effects, to control for annual unobserved heterogeneity, are included in all regressions. Given that the analysis uses JS test statistics based on overlapping subsample windows, potentially inducing autocorrelation in error terms, Newey-West robust standard errors are throughout presented.

Table 4: Estimation results for panel regression with fixed firm specific effects – information efficiency.

JOINT SIGN TEST	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6		MODEL 7		MODEL 8	
	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.
dOMX	-0.32*	(0.07)	-	-	-0.36*	(0.07)	-	-	-0.33*	(0.07)	-0.78*	(0.08)	-0.76*	(0.08)	-0.77*	(0.08)
dOMXSth	-	-	-0.30*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXHel	-	-	-0.45*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXCop	-	-	-0.19*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXBaltic	-	-	-0.41*	(0.10)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXLarge	-	-	-	-	0.27*	(0.02)	-	-	-	-	-	-	-	-	-	-
dOMXSmall	-	-	-	-	0.57*	(0.02)	-	-	-	-	-	-	-	-	-	-
dOMXLarge – Sth	-	-	-	-	-	-	-0.18*	(0.04)	-	-	-	-	-	-	-	-
dOMXMiddle – Sth	-	-	-	-	-	-	-0.41*	(0.02)	-	-	-	-	-	-	-	-
dOMXSmall – Sth	-	-	-	-	-	-	-0.12*	(0.03)	-	-	-	-	-	-	-	-
dOMXLarge – Hel	-	-	-	-	-	-	0.58*	(0.05)	-	-	-	-	-	-	-	-
dOMXMiddle – Hel	-	-	-	-	-	-	-0.18*	(0.04)	-	-	-	-	-	-	-	-
dOMXSmall – Hel	-	-	-	-	-	-	-0.73*	(0.13)	-	-	-	-	-	-	-	-
dOMXLarge – Cop	-	-	-	-	-	-	-0.38*	(0.04)	-	-	-	-	-	-	-	-
dOMXMiddle – Cop	-	-	-	-	-	-	-0.24*	(0.03)	-	-	-	-	-	-	-	-
dOMXSmall – Cop	-	-	-	-	-	-	0.19*	(0.04)	-	-	-	-	-	-	-	-
dOMXLarge – Baltic	-	-	-	-	-	-	0.66*	(0.13)	-	-	-	-	-	-	-	-
dOMXMiddle – Baltic	-	-	-	-	-	-	-0.56*	(0.08)	-	-	-	-	-	-	-	-
dOMXSmall – Baltic	-	-	-	-	-	-	3.76*	(0.11)	-	-	-	-	-	-	-	-
dOMXPos. size dist	-	-	-	-	-	-	-	-	-0.39*	(0.02)	-	-	-	-	-	-
dOMXNeg. size dist	-	-	-	-	-	-	-	-	-0.31*	(0.01)	-	-	-	-	-	-
dOMXFor. sales	-	-	-	-	-	-	-	-	-	-	-0.01	(0.01)	-	-	-	-
dOMXF. sale - Large	-	-	-	-	-	-	-	-	-	-	-	-	0.28*	(0.02)	-	-
dOMXF. sale - Medium	-	-	-	-	-	-	-	-	-	-	-	-	-0.08*	(0.01)	-	-
dOMXF. sale - Small	-	-	-	-	-	-	-	-	-	-	-	-	-0.28*	(0.05)	-	-
dOMXF. sale - Sth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	(0.02)
dOMXF. sale - Hel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.02	(0.02)
dOMXF. sale - Cop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.03	(0.02)
dOMXF. sale - Baltic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)	-0.01*	(0.00)
GDPCapita	3.16*	(0.11)	3.99*	(0.22)	2.71*	(0.11)	0.35*	(0.12)	2.99*	(0.11)	1.72*	(0.25)	1.51*	(0.25)	1.39*	(0.31)
Constant	-26.32*	(1.02)	-33.87*	(2.02)	-22.42*	(1.02)	-1.15	(0.99)	-24.68*	(1.02)	-11.70*	(2.22)	-9.94*	(2.22)	-8.84*	(2.80)
F-test	481.23		381.37		516.20		450.73		468.13		282.43		271.02		239.31	
Nr. firms	411		411		411		411		411		286		286		286	

*Significance level: p<0.05. Newy-West robust standard errors in parenthesis. Fixed and time specific effects are included in all models.

talization, $MCit$), the prevailing market condition measured by $GDP\ Capita,t$ as well as firm- and time-specific fixed effects. The estimated effect from the mergers on the value of the *JS* statistic is negative (-0.32) and significant at the 5 percent level, i.e. the mergers have had a significantly negative effect on the *JS* statistic for an average firm. This indicates that information efficiency for an average firm on the consolidated market has increased due to the mergers. This result is consistent with the prior expectation that a merger on average increases the number of investors following a stock and that deviations from a fair price becomes less likely. The effect of firm size ($MCit$) indicates that a higher market capitalization, on average, is associated with a higher degree of information efficiency in terms of a lower *JS*. Also this result is in line with prior expectations since many institutional investors favor analyzing and following large firms. The estimated coefficient for $GDP\ Capita,t$ indicates that market efficiency is on average increasing for relatively lower values of GDP per capita. This result is broadly in line with the findings of e.g. Hoque et al. (2007), Kim and Shamsuddin (2008), and Kim et al. (2011). To examine possible asymmetric effects from the mergers, we in model 2-8, Table 4 analyze the effect on different groupings of firms based on location, size, and foreign sales.

4.2.1 Effects distributed over firm locations

We study the potential heterogeneous merger effects distributed over pre-merger stock exchange listings of firms. In Model 2, Table 4 the results for merger effects, estimated by firms pre-merger listing location, are reported. As can be seen, the results indicate that the information efficiency for an average firm listed in Helsinki and the Baltic stock markets has received the largest improvement (although not statistically different from each other), while this improvement (a lower *JS* statistic) is smaller for an average firm listed in Stockholm and Copenhagen (significantly lower improvement than the former). Given that Stockholm is the largest market measured in terms of equity market capitalization, followed by that in Helsinki, Copenhagen and the Baltic countries, these results (although indicating heterogeneous merger effects between listing locations) do not indicate any distinct pattern with respect to the firms' pre-merger listing location. Thus, the hypothesis that post-merger trading concentrates to the largest markets (Pagano, 1989; Chowdhry and Nanda, 1991; Portes and Rey, 2005), does not seem to be supported at this level of analysis.

To study these location based results in more detail, we in Model 4, Table 4 report a further division based on size. Here the results pertain to the 10 percent largest, the middle sized, and the 10 percent smallest firms in terms of market capitalization at the end of the pre-merger period. Overall, the results do not convey a clear picture. A comparison between locations among each size grouping (large, middle, and small firms) does, however, reveal that among the large firms, those listed on the smallest market (the Baltic) have experienced the most unfavorable merger effects (information efficiency has worsened the most), and a similar pattern is also found among the smaller firms, i.e. firms listed on the two smallest markets (the Baltic and the Copenhagen stock exchanges) have had the most unfavorable merger effects compared with firms listed on the relatively larger Stockholm and Helsinki markets (where information efficiency has increased due to the mergers). For middle sized firms these patterns are absent. Taken together these results suggest that the arguments put forward by Pagano (1989), Chowdhry and Nanda (1991) (who argue that if transaction costs are reduced, then trading will concentrate to a few markets), and Portes and Rey (2005) (who find that a key determinant of asset flows is market size) indicating a flight to liquidity effect, may potentially hold for smaller and

larger, but not middle sized firms, with respect to the firms' pre-merger listing locations.

An interesting effect not in line with the flight to liquidity argument is that the largest increase in information efficiency for middle sized firms takes place on the Baltic market. A possible explanation for this result is that if the mergers have led to an overall increase in the total investor base, it has increased proportionally more on the smallest market (the Baltic market). Thus, in this case an increased investor attention seems to have been directed towards middle sized Baltic firms.

4.2.2 Effects distributed over pre-merger firm size

To study the potential heterogeneous effects of stock exchange mergers distributed over firm size, the effects are separated for the 10 percent largest and 10 percent smallest firms (at the local markets) at the end of the pre-merger period.[24] The results, reported in Model 3, Table 4, indicate a non-significant effect on the information efficiency for an average large firm. The net marginal merger effect on the *JS* statistic for large firms is -0.09 (s.e. 0.07), a positive significant (at the 5 percent level) effect on the information efficiency for an average middle sized firm (-0.36), and a significantly negative effect on the information efficiency for an average small firm (here the net marginal merger effect on the *JS* statistic s 0.21 (s.e. 0.07)). These results indicate that smaller firms may have found it harder to compete for foreign investor attention in the post-merger period than middle sized firms. These results are in contrast to those in Nielsson (2009), who finds no effect on liquidity for small and middle sized firms but a positive and significant effect for large firms, due to the consolidation of stock exchanges.

Returning to Table 4 in Model 4, the results indicate that within location listings (Stockholm, Helsinki, Copenhagen and the Baltic markets), the information efficiency improves (worsens) the least (the most) for small firms compared with middle and large sized firms listed in Stockholm (Copenhagen and the Baltic markets). This supports a flight to liquidity effect from small to middle and large sized firms. The results are, however, contradicted by those for firms listed on the Helsinki stock market where the information efficiency is reduced for large firms but improves for small firms.

To further explore size-related merger effects, we also look at changes in firm's ranking in the pre- and post-merger size distribution. The cumulative proportion of the firm-size distribution corresponding to the firm ranking is estimated in the pre-merger period on the domestic market and compared with the corresponding ranking in the post-merger period on the fully merged market. The difference in ranking then indicates whether the firm has become relatively larger or smaller on the fully consolidated market. To test for differences in merger effects based on these changes, dummies indicating whether the relative size position of the firm has increased or decreased are created. In Model 5, Table 4 the estimation results for a specification which includes these dummies for the firms with the 10 percent largest and the 10 percent smallest changes in the firm size distribution are reported. The results (significant at the 5 percent level) show an increase in information efficiency both for firms that improve, as well as worsen, their ranking in the post-merger size distribution. The effect is, on average, relatively larger (significant at the 5 percent level) for firms receiving a higher rank in the firm-size distribution in the post-merger period, i.e. firms that become relatively larger on the fully merged market receive a relatively larger increase in infor-

[23] Note here that we control for direct effects of firms size through . This is included to control for improvements in information efficiency driven by growth in firm size (likely to be positively correlated with growth in investor attention), rather than being an outcome of the mergers.

mation efficiency (-0.72 versus -0.64). This indicates that changes in the relative firm size in the pre- and post-merger size distribution may be a potentially important factor in the competition for post-merger investor attention.

4.2.3 Effects distributed over pre-merger foreign visibility

To study the heterogeneous effects of the stock exchange mergers based on a firm's level of pre-merger foreign visibility, we follow Nielsson (2009) and use pre-merger foreign sales as a proxy for pre-merger foreign visibility. Here firms more active on foreign markets in the pre-merger period are assumed to be more known by foreign investors. In Model 6, Table 4, results pertaining to a separation of merger effects between those with and without pre-merger foreign sales are presented. The results indicate that information efficiency has increased significantly due to the mergers for both groups. This indicates that there does not seem to have been any proportional shift in investor attention post-merger between firms with or without previous foreign visibility.

To further investigate this issue, we in Model 7, Table 4 present results separating merger effects between those with and without pre-merger foreign sales, here separated with respect to firm size. The results indicate that information efficiency has increased significantly both for firms without pre-merger foreign visibility (-0.76), as well as for large (-0.48), middle (-0.84), and small (-1.04) firms with pre-merger foreign visibility. These result are interesting since they indicate that the firms which were best known on foreign markets pre-merger, i.e. large firms and firms with

Table 5: Estimation results for panel regression with fixed firm specific effects – turnover.

TURNOVER RATE	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6		MODEL 7		MODEL 8	
	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.
dOMX	0.52*	(0.09)	-	-	0.49*	(0.09)	-	-	0.56*	(0.09)	0.26*	(0.06)	0.27*	(0.06)	0.17*	(0.06)
dOMXSth	-	-	0.37*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXHel	-	-	0.34*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXCop	-	-	0.21*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXBaltic	-	-	-0.08	(0.13)	-	-	-	-	-	-	-	-	-	-	-	-
dOMXLarge	-	-	-	-	0.19*	(0.02)	-	-	-	-	-	-	-	-	-	-
dOMXSmall	-	-	-	-	0.37*	(0.02)	-	-	-	-	-	-	-	-	-	-
dOMXLarge – Sth	-	-	-	-	-	-	0.21*	(0.05)	-	-	-	-	-	-	-	-
dOMXMiddle – Sth	-	-	-	-	-	-	0.06*	(0.03)	-	-	-	-	-	-	-	-
dOMXSmall – Sth	-	-	-	-	-	-	0.32*	(0.04)	-	-	-	-	-	-	-	-
dOMXLarge – Hel	-	-	-	-	-	-	0.28*	(0.07)	-	-	-	-	-	-	-	-
dOMXMiddle – Hel	-	-	-	-	-	-	0.03	(0.06)	-	-	-	-	-	-	-	-
dOMXSmall – Hel	-	-	-	-	-	-	0.21	(0.17)	-	-	-	-	-	-	-	-
dOMXLarge – Cop	-	-	-	-	-	-	0.10*	(0.05)	-	-	-	-	-	-	-	-
dOMXMiddle – Cop	-	-	-	-	-	-	-0.12*	(0.04)	-	-	-	-	-	-	-	-
dOMXSmall – Cop	-	-	-	-	-	-	0.60*	(0.05)	-	-	-	-	-	-	-	-
dOMXLarge – Baltic	-	-	-	-	-	-	-0.28*	(0.16)	-	-	-	-	-	-	-	-
dOMXMiddle – Baltic	-	-	-	-	-	-	0.23*	(0.11)	-	-	-	-	-	-	-	-
dOMXSmall – Baltic	-	-	-	-	-	-	-0.26*	(0.14)	-	-	-	-	-	-	-	-
dOMXPos. size dist	-	-	-	-	-	-	-	-	-0.05*	(0.02)	-	-	-	-	-	-
dOMXNeg. size dist	-	-	-	-	-	-	-	-	0.12*	(0.02)	-	-	-	-	-	-
dOMXFor. sales	-	-	-	-	-	-	-	-	-	-	0.05*	(0.01)	-	-	-	-
dOMXF. sale - Large	-	-	-	-	-	-	-	-	-	-	-	-	0.14*	(0.01)	-	-
dOMXF. sale - Medium	-	-	-	-	-	-	-	-	-	-	-	-	0.01	(0.01)	-	-
dOMXF. sale - Small	-	-	-	-	-	-	-	-	-	-	-	-	0.48*	(0.03)	-	-
dOMXF. sale - Sth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.12*	(0.01)

foreign sales, seem to have lost investor attention primarily to middle sized and small firms with pre-merger foreign sales. Moreover, the results are interesting because they partly confirm the findings in Nielsson (2009), who finds liquidity gains (usually positively correlated with improved information efficiency) for firms with foreign sales. Splitting merger effects between those with and without pre-merger foreign sales over different locations (Model 8, Table 4) indicates no significant pattern.

4.2 Liquidity and stock exchange mergers

Given that a stock's liquidity may be seen as a proxy which captures changes in investor attention towards a stock, we complement our analysis with a study of how the stock exchange mergers affect liquidity (c.f. Nielsson, 2009) to better understand potential causes for changes in information efficiency. In Table 5 results for the corresponding model specifications (as for information efficiency) are reported with the stocks' turnover rate (the proportion of outstanding stocks traded) as the dependent variable.

In line with Nielsson (2009), the results in Model 1 indicate that turnover for an average firm increases significantly (at the 5 percent level) due to the mergers. This increased investor attention may explain the previous finding that the information efficiency for an average firm overall increases (see Model 1, Table 4). The results in Model 2 show that the average firm turnover increased significantly for firms listed on the Stockholm, the Helsinki, and the Copenhagen stock markets, while being unchanged for firms listed on the Baltic stock markets (the increase in turnover for an average firm listed in Stockholm is significantly larger than for firms listed in Copenhagen and the Baltic states, respectively, but not compared with an average firm listed in Helsinki). This indicates a potential flight to liquidity effect with respect to turnover. Relating these results to those for information efficiency (Model 2, Table 4) indicates that the size of investor attention (as measured by firm turnover) may explain parts, but possibly not all, of our efficiency results. Although the relatively large increases in turnover found for average firms listed in Stockholm and Helsinki may explain their relative improvement in information efficiency compared with an average firm listed in Copenhagen (where turnover have increased relatively less), it does not explain the increase in efficiency for an average firm listed on any of the Baltic stock markets. This indicates that changes in the composition of traders (informed versus uninformed investors), even for unchanged levels of investor attention (turnover), may potentially matter for the understanding of information efficiency effects from the mergers.

Looking at the merger effects on turnover over firms' sizes (results reported in Model 3, Table 5) indicates a significant increase for all sizes. In relation to the information efficiency results (Model 3, Table 4), these results favor the interpretation that changes in the composition of investor attention matters for merger effects. Notably, despite having the largest increase in turnover, information efficiency worsens for small firms but information efficiency improves the most for middle sized firms (even though they have the smallest increase in turnover).

In Model 4, Table 5, we report results separated with respect to size and location. A comparison of the location effect for each size group (large, middle, and small firms) indicates that among the group of large and small firms, those listed on the smallest market (the Baltic) have experienced a significant decrease in turnover, while large and small firms listed in Stockholm, Helsinki, and Copenhagen have experienced a significant increase in turnover. Comparing these turnover effects with those for information efficiency (Model 4, Table 4) explains the reduction of information efficiency

for an average firm listed on the Baltic markets, but does not explain the changes for an average firm on the other markets. For the middle sized firms, turnover has increased (significant at the 5 percent level) the most. Taken together these results indicate a flight to liquidity effect among the large firms (increased turnover for firms listed in Stockholm and Helsinki compared to those listed on the relatively smaller Copenhagen and Baltic stock markets), and to some degree for smaller firms, but not among middle sized firms. These results lend some support to the idea that trading will be concentrated to a few markets after a merger (Pagano, 1989; Chowdhry and Nanda, 1991; Portes and Rey, 2005).

When it comes to changes in the firm size distribution, a comparison between the firms' pre- and post-merger positions (Model 5, Table 5) shows that for firms with the 10 percent largest improvements, turnover has increased the least, while for the 10 percent firms with the largest worsening of their position, turnover has increased the most (all changes are significant from each other at the 5% level). These results are interesting if we relate them to the corresponding model specification for information efficiency (Model 5, Table 4). While information efficiency improves most for the 10 percent of firms improving their position in the firm size distribution, these firms experience the smallest relative increase in turnover. This is an additional indication on that merger effects may be driven by other factors than by changes in investor attention (turnover), e.g. by changes in the composition of informed versus uninformed investors.

As for potential asymmetric merger effects on turnover based on pre-merger foreign visibility, we in Model 6, Table 5 present results separating effects between firms with and without pre-merger foreign sales. The results indicate that turnover has increased significantly more among firms with pre-merger foreign visibility (0.31 versus 0.26, statistically different at the 5 percent level). This asymmetric effect is in line with results in Nielsson (2009) concerning turnover, but it is not in line with our results regarding information efficiency (Model 6, Table 4, where the information efficiency increases by the same size for both groups). Thus, despite the asymmetric merger effects on turnover, the impact on information efficiency does not seem to be asymmetrically affected.

In Model 7, Table 5 we display how the foreign visibility in the pre-merger period influences turnover. The results indicate that the average small firm with pre-merger foreign visibility has experienced the largest increase in turnover (0.75) after the mergers, followed by large firms with pre-merger foreign visibility (0.41). For medium sized firms with pre-merger foreign visibility and firms without pre-merger foreign visibility merger the effects are similar and smaller in size (0.28 and 0.27). In relation to the asymmetric merger effects on information efficiency (Model 7, Table 4), the change in turnover (investor attention) may explain most of the improvement in information efficiency for small firms with foreign pre-merger visibility, but not for middle and large size firms with pre-merger foreign visibility. These results indicate that small firms with pre-merger foreign visibility have gained the most, both in terms of efficiency and in terms of turnover. For the large firms, the results show that those with pre-merger foreign visibility have had the second largest increase in turnover but the smallest gain in information efficiency. This indicates that for large firms, it is both changes in the level of investor attention (turnover) as well as potential changes in the composition of investors which may explain the changes in information efficiency. Dividing the merger effects between those with and without pre-merger foreign sales over different locations (Model 8, Table 5), the results show that turnover increased most (significant at the 5 percent level) for firms with pre-merger foreign sales listed in the Copenhagen, followed by the Helsinki stock market while the merger effects on turnover for firms with pre-merger foreign

visibility listed in Stockholm and in the Baltic stock markets were unchanged.

Apart from the separate analysis of turnover, we have also re-estimated the models in Table 4 conditioning on firm turnover. Overall, the results from this analysis (unreported here, but available upon request) indicate that signs, sizes and significance levels of parameter estimates are similar to those reported in Table 4. These results provide further evidence that merger effects not only depend on changes in the level of investor attention (turnover), but also depend on other mechanisms, e.g. changes in the composition of informed versus uninformed investors following stocks.

4.2 Robustness of results

To test the sensitivity of our results, a number of robustness tests have been performed. First, the reported results within the paper pertain to *JS* statistics calculated on moving sub-sample windows of two years, i.e. 500 trading days. To test the sensitivity of our results to this choice the analysis has been repeated based on *JS* statistics calculated on moving sub-sample windows of 400 and 600 trading days. Results were similar in terms of signs and significance. Second, an analysis using the Chow and Denning (1993) multiple *VR* test (*CD*) confirm our reported results based upon the *JS* statistic.

Finally, we note that a possible drawback of interpreting the *JS* statistic as a direct measure of the relative level of information efficiency is that the impact of these test statistics on market efficiency is non-linear (Lagoarde-Segot, 2009) and that the statistic in itself is a random variable. The later comprises a problem, especially when using overlapping moving sub-period windows to generate a relatively smooth evolution of the *JS* series. In a comparison of successive values, one has to be careful in interpreting a slightly lower sub-period *JS* test statistic as an improvement in terms of information efficiency because it may comprise a comparison of two random variables that are not significantly different from each other. Because of this, we complement our analysis by studying the probability of observing a sub-period deviation from a random walk. To model the probability of a deviation from a random walk, an indicator variable is generated based on the *JS*-test statistic, where this variable indicates whether the null hypothesis of a random walk, for the given sub-sample *t*, for firm *i*, is rejected or not. The binary indicator variable, $Wit\in(0,1)$, takes the value one for periods with a significant (at the 5 percent level) deviation from a random walk, and zero otherwise. In the second stage analysis, a conditional logit model with fixed effects is utilized when modelling the probability of observing a sub-sample period deviating from a random walk.[25] The model is specified as

$$\Pr(W_{it} = 1|X_{it}) = \frac{\exp(\alpha_i + x_{it}\beta)}{1 + \exp(\alpha_i + x_{it}\beta)}, i = 1,2, \dots, N, t = 1,2, \dots, T,$$

where the vector x_{it} contains covariates while α_i are the stock specific unobserved fixed effects. Note here that this modelling approach excludes firms that are either informationally efficient, or inefficient throughout the whole sample period, i.e. that only have zeros or ones and thus lack within-firm variation in the dependent binary variable. This is in contrast to the models based directly on the *JS* test statistic where inference is also drawn from the relative variation, in terms of improved or worsened information efficiency, also for firms that are efficient or inefficient throughout the whole sample period. In all, 71 firms are excluded from the analysis when modelling the probability of observing a sig-

[24] Both random and fixed effects models were initially considered. Hausman tests did, however, favor the fixed effects specification since the unobserved stock specific effects were in general found to be correlated with the regressors.

Table 6: Estimation results for panel conditional logit with fixed firm specific effects.

PR(DEV. FROM RANDOM WALK)	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6	
	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.
dOMX	-1.113*	(0.265)	-	-	-1.132*	(0.266)	-	-	-2.770*	(0.343)	-2.696*	(0.341)
$dOMX_{Sth}$	-	-	-1.184*	(0.272)	-	-	-	-	-	-	-	-
$dOMX_{Hel}$	-	-	-1.527*	(0.277)	-	-	-	-	-	-	-	-
$dOMX_{Cop}$	-	-	-0.102	(0.277)	-	-	-	-	-	-	-	-
$dOMX_{Baltic}$	-	-	-3.305*	(0.350)	-	-	-	-	-	-	-	-
$dOMX_{Large}$	-	-	-	-	0.277*	(0.079)	-	-	-	-	-	-
$dOMX_{Small}$	-	-	-	-	1.151*	(0.066)	-	-	-	-	-	-
$dOMX_{Pos.\ size\ dist}$	-	-	-	-	-	-	-1.021*	(0.266)	-	-	-	-
$dOMX_{Neg.\ size\ dist}$	-	-	-	-	-	-	-0.818*	(0.272)	-	-	-	-
$dOMX_{For.\ sales}$	-	-	-	-	-	-	-	-	0.290*	(0.054)	-	-
$dOMX_{Large\ and\ f.\ sale}$	-	-	-	-	-	-	-	-	-	-	1.094*	(0.093)
$dOMX_{Small\ and\ f.\ sale}$	-	-	-	-	-	-	-	-	-	-	-1.322*	(0.393)
MC	-0.024*	(0.003)	-0.022*	(0.003)	-0.024*	(0.003)	-0.023*	(0.003)	-0.029*	(0.003)	-0.036*	(0.003)
GDP_{Capita}	7.758*	(0.311)	17.557*	(0.698)	7.325*	(0.315)	7.803*	(0.313)	-2.557*	(0.782)	-2.156*	(0.749)
LR χ^2	3625		4103		3926		3650		2494		2616	
Nr. firms	371		371		371		371		250		250	

* Significance level: p<0.05. Newy-West robust standard errors in parenthesis. Fixed and time specific effects are included in all models.

nificant deviation from a random walk due to firms being informational efficient for all sub-sample periods. In Table 6 we report estimation results for the conditional logit model.[26]

The results confirm the earlier analysis with an overall and on average significant (at the 5 percent level) improvement in information efficiency. Regarding asymmetrical merger effects over different groupings of firms, the results are mainly in line with the previous results. One exception is the distribution over different locations. Here the results indicate that information efficiency has increased significantly (at the 5 percent level) for all listed firms, except in the Copenhagen market.

5. Conclusions

In this paper, we contribute to the literature with new empirical evidence on the effects of stock exchange mergers upon weak-form market efficiency. Our first main result indicates that for an average firm, information efficiency has increased as a result of the mergers. The result is robust towards conditioning on confounding factors affecting information efficiency and is consistent with the hypothesis that a consolidation of markets, on average, increases the pool of investors available for each stock, thereby making deviations from fundamental values less likely. Initial analysis of turnover (liquidity as a proxy for investor attention) supports this conclusion, indicating a significant increase, on average, in turnover following the mergers. Conditioning the analysis of information efficiency on liquidity does not change our results. This lends support to the possibility that increased information efficiency may be driven by an increase in the proportion of informed investors following an average

[25] Since the estimation of the conditional logit model is based on a smaller sample similar model specifications as in model 7 and 8 in Table 4 were not possible to identify.

firm. Although we can not determine the precise underlying mechanism for the merger effects on information efficiency, our results strengthen previous findings reported in Khan and Vieto (2011), who study the Portuguese stock exchange and Euronext merger. Our aggregated result for the effect on liquidity is also consistent with the results reported in Nielsson (2009) that mergers tend to increase the turnover for an average stock.

Our second main result indicates that the merger effects are asymmetrically distributed over firms. Even if the patterns are somewhat blurred, we find a tendency for a flight to liquidity effect, both with respect to firm pre-merger listing location and pre-merger size. In relation to location, it is found that among the group of larger and smaller firms (10 percent largest and smallest at the end of the pre-merger period) there is a tendency that those listed on the smallest stock markets (the Baltic and the Copenhagen stock markets) have experienced an adverse effect on information efficiency, while those listed on the larger markets (Stockholm and Helsinki) have gained in information efficiency. As for firms´ pre-merger size, evidence also point towards a potential flight to liquidity effect, with an adverse merger effect on information efficiency for smaller firms but an improved effect for medium and large firms.

In terms of pre-merger foreign visibility, the results indicate that larger firms with pre-merger foreign sales seem (post-merger) to have lost investor attention towards small and middle sized firms with pre-merger foreign sales. A potential explanation may be that the firms which were most visible before the merger (large and with foreign sales) were already traded cross-border (before the merger). Thus, as the availability of foreign stocks increased as a result of the stock market mergers, the firms which were most visible before the merger stood out relatively less than firms which were less visible in the pre-merger period. Overall, the corresponding models for asymmetric turnover effects indicate that changes in turnover (investor attention) explain some, but not all of the changes in information efficiency, lending support to other explanations, e.g. that merger effects are also driven by changes in the composition of informed versus uninformed traders.

Given the scarcity of research concerning the effects on market quality from changes in stock trading market structures, and given that market structures for stock trading is in a state of change, as indicated by the Oslo stock exchange acquisition of the MTF Burgundy in 2012, the results in this paper are of importance both for the understanding of effects from future mergers, as well as an input in the implementation process of new mergers. Of particular interest is the understanding of the asymmetrical distribution of merger effects since this may affect the process about how to pursue mergers of multiple markets.

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