Essays on Stock Market Integration

- On Stock Market Efficiency, Price Jumps and Stock Market Correlations

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To my dear family

Abstract

This thesis consists of four self-contained papers related to the change of market structure and the quality of equity market.

In **Paper [I]** we found, by using of a Flexible Dynamic Component Correlations (FDCC) model, that the creation of a common cross-border stock trading platform has increased the long-run trends in conditional correlations between foreign and domestic stock market returns.

In **Paper [II]** we study whether the creation of a uniform Nordic and Baltic stock trading platform has affected weak-form information efficiency. 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 in the sense that relatively large (small) firms located on relatively large (small) markets experience an improved (reduced) information efficiency and turnover. Although the results indicate that changes in the level of investor attention (measured by turnover) may explain part of the changes in information efficiency, they also lend support to the hypothesis that merger effects may partially be driven by changes in the composition of informed versus uninformed investors following a stock.

Paper [III] analyzes whether the measured level of trust in different countries can explain bilateral stock market correlations. One finding is that generalized trust among nations is a robust predictor for stock market correlations. Another is that the trust effect is larger for countries which are close to each other. This indicates that distance mitigates the trust effect. Finally, we confirm the effect of trust upon stock market correlations, by using particular trust data (bilateral trust between country A and country B) as an alternative measurement of trust.

In **Paper [IV]** we present the impact of the stock market mergers that took place in the Nordic countries during 2000 – 2007 on the probabilities for stock price jumps, i.e. for relatively extreme price movements. The main finding is that stock market mergers, on average, reduce the likelihood of observing stock price jumps. The effects are asymmetric in the sense that the probability of sudden price jumps is reduced for large and medium size firms whereas the effect is ambiguous for small size firms. The results also indicate that the market risk has been reduced after the stock market consolidations took place.

Keywords: Time-varying return predictability, Tests for jumps, International financial markets, Market structure, Common trading platform, Integration, Time-varying correlation, C-GARCH, Trust, Portfolio Diversification, Stock Market Participation

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Yuna
Borås, March 2016

This thesis consists of a summary and the following self-contained papers:

[I] Hellström Jörgen, Liu Yuna, Sjögren Tomas, Stock exchange mergers and return co-movement: A flexible dynamic component correlations model, *Economics Letters 2014*, 121: 511-515

[II] Hellström Jörgen, Liu Yuna, Sjögren Tomas, Stock exchange mergers and weak-form market efficiency: Evidence from the OMX Nordic and Baltic consolidation, *Umeå Economic Studies,* No. 923.

[III] Liu Yuna, Trust and stock market correlation: A cross-country analysis, *Umeå Economic Studies,* No. 924.

[IV] Liu, Yuna, Stock exchange integration and price jump risks - The case of the OMX Nordic exchange mergers, *Umeå Economic Studies,* No. 925.

"An "efficient" market is defined as a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants ... on the average, competition will cause the full effects of new information on intrinsic values to be reflected "instantaneously" in actual prices." - (Fama, 1965b)

1. Introduction

This thesis consists of four self-contained papers on empirical finance which are related to different aspects of trading securities on multiple markets. The overall purpose is to study how changes in the market structure, such as stock market mergers (stock market integration), affect key stock market characteristics such as market efficiency, the interdependence of stock markets and the prevalence of sudden price jumps. This thesis is also concerned with how differences in trust levels between countries influence cross-country stock market correlations.

The fundamental task of a stock market is to serve as a place of exchange for capital and one basic requirement of a stock market is that it performs this task 'well'. The question is then what is meant when we say that the stock market 'functions well' and what factors determine whether a stock market fulfills this criterion? One criterion for a well-functioning stock market is that it is able to allocate resources where they can be put to the most effective use. A prerequisite for this is that asset prices fully reflect all available information so that agents can make balanced investment decisions. The question is then whether stock markets fulfill this requirement and here there are two competing schools: the Efficient Market Hypothesis (EMH) (Fama, 1965a, b; Malkiel and Fama, 1970) and Behavioral Finance (Shiller, 2003; Barberis and Thaler, 2003; Ritter, 2003).

The Efficient Market Hypothesis was proposed by Eugene Fama in the 1960s in which he defined an efficient market to be a market where the actual prices at each point in time represent good estimates of the assets' intrinsic values given the information available (Fama, 1965a). If this assumption is satisfied, it is not possible (except by pure luck or by taking on more risk) to 'beat the market' because the observed prices already reflect all the relevant information. Malkiel and Fama (1970) proposed three different levels of market efficiency: weak form, semi-strong and strong. In its weak form, the EMH asserts that securities prices reflect all past, publically-available information whereas a market is semi-strongly efficient if the set of information consists both of the previous prices plus all publically-available information. Finally, a market is strongly efficient if the set of information consists of the previous prices plus all publically-available information plus private (or insider) information.

The EMH was the dominant theory in finance until Behavioral Finance emerged in the 1990s. The key assumption in the latter field is that people, under certain circumstances, take decisions which are not fully rational. These decisions are caused either by certain types of preference or because of cognitive limitations such as overconfidence, loss aversion, overreaction, mental accounting and herd behaviour (see e.g. Shiller, 2003; Barberis and Thaler, 2003; Ritter, 2003). One implication of these arguments is that financial markets do not always function well and price changes do not always accurately reflect the arrival of new information (Shiller, 2003). This conclusion differs from the conclusion of the EMH, where it is assumed that prices are unpredictable. The field of behavioural finance received much interests during the financial crisis in 2008 – 2009 because it made it possible to understand price movements that were not consistent with EMH (Barberis, 2011; Shefrin and Statman, 2011).

In an attempt to reconcile the classical EMH with behavioural finance, Lo (2004; 2005) proposes the adaptive market hypothesis by applying evolutionary

principles to financial interactions (incorporating features such as competition, adaption and natural selection). The adaptive market hypothesis implies that the degree of market efficiency is extremely dynamic since it is capable of adapting to an ever-changing environment with respect to factors characterizing market ecology, such as the number of competitors in the market, the magnitude of profit opportunities available and the adaptability of the market participants. In addition, several empirical studies point out that the degree of weak-form market efficiency may vary over time (see, for example, Gu and Finnerty, 2002; Lagoarde-Segot, 2009; Kim et al., 2011; Chuluun et al., 2011). These findings suggest that it is important to understand the type of factors that may cause a market to become efficient. In a review study, Lim and Brooks (2011) conclude that some key determinants are financial liberalization, the occurrence of market crashes or financial crises, changes in regulatory policy and advances in information technology.

In recent years, there has been a trend towards consolidating stock markets via mergers and acquisitions. Examples are the Euronext merger in 2005, the New York Stock Exchange (NYSE) acquisition of Euronext in 2006, the OMX mergers of the Nordic and Baltic exchanges 2003 – 2006, the NASDAQ acquisition of the OMX Nordic stock exchange in 2007, the London Stock Exchange merger with Borsa Italia in 2007 and the acquisition by Intercontinental Exchange (ICE) of NYSE Euronext in 2013. Since the studies referred to in the preceding paragraph emphasize that the degree of market efficiency is time-variable, it is also interesting and important to understand whether a changing market structure (via stock exchange mergers) is a process which may affect market efficiency. This question is addressed in Paper II in this thesis which focuses on the effect of the OMX Nordic and Baltic exchange mergers in 2003-2006 on weak-form market efficiency. To provide a comparison between the pre and the post-merger periods, data covers the period 2000-2007.

As Shiller (1992) has pointed out, excess volatility is evidence of a failure of the efficient markets model. In an efficient market, the observed prices represent good estimates of intrinsic values, given all publicly-available information. As a consequence, price data would be expected to contain less extreme volatility since publically-available information does not normally change extensively over time. This argument indicates that there may be a negative relationship between market efficiency and extreme price volatility.

A main finding in Paper II is that stock market mergers on average increase weak-form market efficiency. Combined with the previous discussion, the findings in Paper II indicate that stock market mergers may also reduce extreme volatility in prices. Paper IV therefore studies whether stock market mergers affect price jumps. A price jump is defined as a deviation from the current normal variation in the stock price (Hellström et al., 2012; Huang and Tauchen, 2005; Jorion, 1988; Kim and Mei, 2001; Lahaye et al., 2011; Lee, 2012). In other words, jumps are changes in returns that do not belong to the normal price variations. In this framework, the 'current normal' price variation is assumed to follow a specific structure which may change over time. For example, normal price variations are commonly assumed to follow a GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) process because this specification makes it possible to capture volatility clustering. A price jump is not a rate of return above a certain level. Instead, it is a relative concept which depends on the 'normal' valuation. This means that a given level of return may be viewed as normal when the stock market is volatile but it may be viewed as a price jump when the stock market is calm. Paper IV in this thesis tests whether the mergers of the Nordic stock exchanges, which took place in the period 2003-2006, reduce the probability of observing price jumps for stocks listed on the Danish, Finnish and Swedish stock markets, using data that ranges from 2000-2007.

The findings in Papers II and IV imply that stock market mergers increase market efficiency and reduce the probability of observing price jumps. To further investigate the effects of stock market mergers on key market characteristics, Paper I tests whether the creation of a common, cross-border stock trading platform also changes return correlations between stock markets. By studying the effects of the Nordic and Baltic stock exchange mergers that took place in the period 2003-2006, the primary conclusion is that market consolidation does lead to increased stock market interdependence. This result indicates that international risks may be more important after a stock market merger has taken place because the more correlated stock market returns are, the more difficult it will be to alleviate risk by diversification. It may also imply that the more correlated stock market returns are, the more difficult it will be to avoid financial contagion between countries.

Another objective of this thesis is to empirically study the impact of trust on stock market correlations. This is carried out in Paper III. This is important because understanding under what circumstances stock market correlations are high or low may provide key insights as to when and where to invest in order to achieve a well-diversified portfolio of financial assets. The results gained from Paper III indicate that stock market returns, on average, move together more between trusting countries than between mistrusting countries.

The following part of this introduction is organized as follows. Section 2 gives a short overview of the stock market mergers that have taken place in the Nordic markets. Moreover, Section 2 relates this thesis to the existing literature on stock market mergers, price jumps, stock market correlations and trust. Section 3 summarizes the papers.

2. Background and Previous Studies

In subsection 2.1, I will briefly describe the process of stock market mergers that took place in the Nordic and Baltic countries in the period 2003-2006. I will

thereafter review the most important previous studies related to stock market mergers, price jumps, stock market correlations and trust, respectively, in subsections 2.2-2.5.

2.1 Background

Let us begin by briefly describing the process of stock market consolidations that has taken place in the Nordic and Baltic countries over the last decade. The first step towards consolidation took place in 1998 when the Stockholm and the Copenhagen stock exchanges constructed a strategic partnership called the NOREX Alliance. This alliance implemented a joint equity trading system called SAXESS and harmonized trading rules and membership requirements. As such, this alliance aimed to facilitate interaction between the two exchanges without formally merging them. In 2000, both the Iceland Stock Exchange and the Oslo stock exchange joined the NOREX Alliance, and the Helsinki, Riga and Tallinn stock exchanges joined in 2004. In 2005, the Vilnius stock exchange also joined the alliance.

Subsequently, the stock exchanges in Stockholm, Copenhagen, Helsinki and Iceland, as well as the Baltic stock exchanges, have formally merged into what is today called the NASDAQ-OMX exchange. This process was initiated in 2003 when the Stockholm stock exchange (OMX) merged with the Helsinki (HEX) stock exchange to form a common trading platform called OMHEX. OMHEX changed its name to OMX in 2004. In 2004 the Riga and the Tallinn stock exchanges also merged with OMX, and the Vilnius exchange followed in 2005. In the same year, OMX acquired the Copenhagen stock exchange. In 2006, the OMX Nordic Exchange brand (Stockholm, Helsinki and Copenhagen) was launched together with common listings of all Nordic companies. Finally in 2006, the Iceland stock exchange merged with OMX. In February 2008, OMX was acquired by NASDAQ. After merging the trading platforms, the exchanges are still separate legal entities in their respective jurisdictions, but the rules for

issuers are basically harmonized, especially regarding the listing requirement and disclosure rules.

2.2 Stock market mergers

The rapid advances in information technology that have taken place in the last decade have made it easier than ever to invest globally. Consequently, competition for global capital has increased and there is now a trend towards consolidating stock markets so as to create larger and more attractive trading platforms.

Stock market mergers bring more buyers and sellers together on a common trading platform and this may reduce both the direct and the indirect (non-monetary) costs associated with stock trading. Direct costs may decrease if exchange operators pass on possible gains (e.g. due to scale effects from common trading and clearing systems) from the merger to investors in terms of lower transaction fees. Indirect costs may decrease if a uniform trading and clearing system makes trading easier.

Reduced trading costs are likely to make individual stocks available to a broader market in terms of the number of participants, both domestic and foreign. Larger quantities of stocks are therefore likely to be available at prices marginally above and below the prevailing market prices which, in turn, may imply that price movements are less likely to be driven by individual trades. It is also possible that the number of informed investors will increase which implies that the stock prices may be more likely to reflect intrinsic values than before. One important question in this context is therefore whether mergers have increased price efficiency?

Today, there are only a few earlier studies which have looked at the effects of stock exchange mergers on market efficiency and the results are mixed. In a study of the 2002 merger of the Portuguese stock exchange with Euronext, Khan and Vieito (2012) find mixed results depending on what estimation

method is used, although the findings tend to favour a positive effect of market consolidation on weak-form market efficiency. Charles et al. (2016), in turn, find that mergers of stock exchanges that are large and well developed tend to increase weak form market efficiency. Another relevant study is Pagano and Padilla (2005), who find that the integration process of the Euronext merger made it possible to rationalize operations, reduce direct and indirect costs for investors and increase liquidity in terms of volume and bid-ask spreads.

2.3 Price jumps

A growing body of literature has documented that including jump components in the modelling of volatility do improve volatility forecasting (Andersen et al., 2002; Bates, 2000; Chan and Maheu, 2002). For example, Andersen et al. (2007b) find that the volatility jump component is extremely important in empirical analyses and they suggest that separating jump movements from the smooth continuous movements can significantly improve the forecasting of volatility in exchange rates, equity index returns and bond yields.

What causes price jumps? Empirical studies have found that the prevailing market structure change, macroeconomic news, political news and firm-specific news are key drivers of price jumps (Andersen et al., 2007a; Hellström et al., 2012; Kim and Mei, 2001; Lahaye et al., 2011). Hellström et al. (2012) test how the integration of the Nordic electricity markets has affected electricity price jumps. They find that this market integration has reduced the frequency of price jumps in the electricity market. Kim and Mei (2001) find that political developments in Hong Kong have exerted a significant impact both on the volatility and on the return of the Hong Kong stock exchange. Lee (2012) finds that jumps in the U.S. stock markets are likely to occur shortly after the release of new macroeconomic information, such as Fed announcements, non-farm payroll reports and jobless claims, as well as overall market jumps detected in

the S&P 500 market index. In addition to macroeconomic information, Lee finds that price jumps are related to firm-specific news such as earnings releases, analyst recommendations, past price jumps and dividend dates. Andersen et al. (2007b) find that macroeconomic news announcements influence jumps on the foreign exchange market and on the bond market, except for the stock index market. Lahaye et al. (2011) find similar results.

In a study of the London Stock Exchange, Farmer et al. (2004) find that large price fluctuations are driven by fluctuations in liquidity, i.e. the market's ability to absorb new orders. Even for the most liquid stocks, there may be substantial gaps in the order book. A new order can therefore trigger a significant price change.

2.4 Stock market correlations

For any observer of the global financial market, it is clear that stock markets in different countries tend to move in the same direction. However, there is some variation in the sense that some stock markets seem to be more correlated with each other than others. Understanding why such differences occur is vital both for portfolio managers who want to obtain a well-diversified portfolio of financial assets, and for policy-makers who want to have a better 'tool box' to insulate against global financial risks.

As a consequence, a substantial body of empirical studies has emerged which tries to pin down the key determinants of stock market correlations. (Beine and Candelon, 2011; Bekaert, 1995; Coeurdacier and Guibaud, 2011; Flavin et al., 2002; José, 2009; Karolyi and Stulz, 1996; Lucey and Zhang, 2010; Morck et al., 2000; Pretorius, 2002). In these studies, stock market correlations are related to macroeconomic variables, geographical variables, cultural distance, economic integration and differences in the legal system. Dumas et al. (2003) present statistical evidence to support a positive relationship between output growth rates and correlations in stock market returns. Morck et al. (2000) find

that stock prices are more correlated between poor countries (measured by low per capital GDP) than between rich countries. They conjecture that poor countries lack strong property rights for outsider investors and one implication of this is that stock markets in poor countries incorporate less firm-specific information. On the other hand, prices in poor countries incorporate more market level information, which leads to a higher level of co-movement. In a study of economic integration, Bekaert and Harvey (1997) find that trade is essential for explaining equity correlations, especially between emerging markets. Similarly, Pretorius (2002) confirms that the extent of bilateral trade, and industrial production growth differentials, have been important determinants of stock market correlations between emerging markets during the period 1995 to 2000.

Other studies find that removing frictions related to the trading of financial assets increases financial integration. For example, Flavin et al. (2002) find that the number of over-lapping opening hours and whether countries share a common border (these variables are both used as proxy variables for informational asymmetries across the investment community) tend to increase stock market correlations. Flavin et al. (2002) also conclude that financial variables such as market size and risk (i.e. telecom stocks) influence cross-country return correlation. In particular, markets which are large and liquid tend to be more correlated with each other. Lucey and Zhang (2009) find that cultural distance (where cultural distance may refer to differences in individualism, masculinity, power distance[1] and uncertainty avoidance) reduces international stock market co-movements.

There are also a number of financial variables which have been documented as key determinants of stock market correlations. For example, Forbes and

[1] Power distance in Lucey and Zhang (2009) measures the extent to which the less powerful members of organizations and institutions accept and expect that power is distributed unequally. For example, in cultures with high power distance, people take inequality as given, tolerate the concentration of power, and are more reluctant to give up independence.

Rigobon (2002) find that increased volatility may cause a significant increase in stock market correlations. Dellas and Hess (2005) conclude that liquid stock markets are linked to higher stock market correlations since such markets will react more quickly to a greater range of information than a thin market. Awokuse et al. (2009) find that the correlation between Asian emerging markets and three major stock markets (Japan, UK and US) increased with the financial liberalization policies in the early 1990s. They conclude that both financial liberalization and financial integration influence stock market correlations.

2.5 Trust

Arrow (1972) emphasized that "virtually every commercial transaction has within itself an element of trust". Trust influences how a person decides whether to invest in risky and/or risk-free financial assets (Georgarakos and Pasini, 2011; Guiso et al., 2008). For example, trust has been shown to be important when investors make decisions on whether or not to invest in real estate and/or financial assets (El-Attar and Poschke, 2011). Moreover, trust is an important incentive underlying venture capital investments between countries (Bottazzi et al., 2011). However, the trust that underlies an individual agent's investment willingness has not been shown to be closely related to risk attitudes (Houser et al., 2010).

Trust has also been shown to be important in other contexts, such as for economic growth (Zak and Knack, 2001), for per capita GDP (Dearmon and Grier, 2009), for central-bank independence (Berggren et al., 2014), for trade (Guiso et al., 2009), for financial integration within the EU (Ekinci et al., 2007) and for portfolio and direct investments between countries (Guiso et al., 2009).

In the literature two types of trust are defined. The first is generalized trust and the other is particular trust. The literature mentioned above all utilized generalized trust in their analysis, while Spring and Grossmann (2013) use bilateral trust in their analysis. Generalized trust is measured as the proportion

of people who think that most people can be trusted, which is intended to capture how much trust people in a country have vis-a-vis other people in the same country. The level of generalized trust varies between countries. A high level indicates that there are a relatively larger proportion of people who think that most people can be trusted. The other type of trust (particular trust) is measured as the proportion of agents in Country A that trust the agents in Country B. No studies, to the author's knowledge, consider the effects of generalized and particular trust on stock market correlations. This study hence contributes to the current literature by providing a key determinant on relationships between financial markets.

3. Summary of papers

3.1 Summary of Paper I:

In this study, we provide empirical evidence on whether the integration of the Nordic stock exchanges (the OMX Nordic merger) affects the return co-movements between stock markets. We conjecture that stocks on the merged market are possibly valued conditional on similar expectations by both domestic and foreign investors about, for example, the future global macroeconomic situation. An increased conformity in these expectations would possibly lead to a higher return co-movement after the mergers. This study makes a contribution to the literature by focusing on the understanding of determinants of stock market correlations between countries. It also contributes to an evaluation of future stock market mergers. In addition, this study provides an extension of the flexible dynamic correlation model (Baur, 2006; Tsay, 2005), in the spirit of Lee and Engle (1993). This extension is facilitated by introducing transitory components, which are deviations from the long-run trends of conditional correlations, with the aim of separately analysing the merger effects on both the long-run trends and also the transitory components in the conditional correlations.

The findings in this paper indicate that (i) the creation of a common, cross-border stock trading platform has increased long-run trends in return co-movements for all of the markets considered. In other words, market mergers is one of the determinants of cross-country return correlations; (ii) the dynamics of time-varying correlations are mixed, for example some pairs of correlations' short-run deviations approach the long-run trend in an oscillating manner while it is non-oscillating for others; (iii) The merger decreases the persistency of short-run deviations from the long-run trend, i.e. return correlations adjust faster towards their long-run trend after markets are merged.

3.2 Summary of Paper II

In this paper, the overall purpose is to examine whether the degree of market efficiency may change over time due to changes in market structures. To do this, we study whether the creation of a uniform Nordic and Baltic stock trading platform (via the OMX mergers) have influenced market information efficiency. The aim is also to study possible asymmetric merger effects on information efficiency based on firm location and pre-merger visibility. From this perspective, this paper addresses a central issue in recent research which is concerned with the conditions under which markets become efficient. The paper also provides new empirical evidence on how stock market mergers affect market efficiency. Since we use panel data analysis which allows for covariates and control variables associated with time and firm-specific unobserved heterogeneity, the analysis in this paper is an extension of Khan and Vieito (2012) who study the influence of stock exchange mergers on weak-form market efficiency without conditioning on other covariates. This is important because the recent literature on market efficiency (see. e.g. Gu and Finnerty, 2002; Lagoarde-Segot, 2009; Kim et al., 2011; Chuluun et al., 2011), supports the hypothesis that the relative level of weak-form market efficiency is time-

varying and to a large extent depends on (for the researcher) unobservable factors.

The empirical results of Paper II indicate that information efficiency and turnover, overall, are improved by a consolidation of stock markets but that the effects are asymmetrically distributed in terms of the groupings of firm size, location, foreign trading and firm ranking in the pre-merger periods (on the domestic market) and post- merger periods (on the fully-merged market). For example, we find that information efficiency has increased relatively more for larger firms located on larger markets but that it has been reduced for smaller firms on smaller markets. These results indicate that investors tend to trade in larger firms with which they are already familiar. We also find that firms already visible to (i.e. traded by) foreign investors in the pre-merger period receive a relatively lower increase in information efficiency compared with firms that were less visible in the per-merger period. In addition, we find that firms with a higher rank in the post-merger period (compared with the pre-merger period) gain a relatively larger improvement in information efficiency.

3.3 Summary of Paper III

The objective of this paper is to enhance the understanding of the role of trust on stock market correlations. Earlier studies have shown that trust is an important determinant of the financial decisions of individual investors. Therefore it is of interest to test whether trust is also an important determinant of stock market correlations. This is important for a number of reasons. First, previous studies generally use a generalized trust measure to study the effect of trust. In Paper III, two types of trust measures are tested; generalized and particular trust. These measures are defined in Section 2.5. Second, little evidence exists concerning the influence of trust on financial market interdependence. Third, there are (to the authors' knowledge) no previous

studies that are concerned with how geographical distance between countries influences the trust effect on economic investment decisions.

One finding is that generalized trust among nations is a robust predictor of stock market correlation. A possible explanation is that high trust levels may lead to more bilateral capital flows which, in turn, increase stock market correlations. Another finding is that the effects of trust are asymmetrically distributed in the sense that they are greater for countries which are closer to each other. The reason for this may be that distance hinders information transmission, which in turn, decreases trust effects. Finally, the effect of trust is confirmed after using particular trust (bilateral trust between Country A and Country B) as an alternative measurement.

3.4 Summary of Paper IV

In this paper we provide novel evidence on how the creation of common trading platforms affects the probability of price jumps. In particular, this paper empirically studies how jump-probabilities of Nordic stock prices were affected by the OMX mergers that took place in the period 2003-2006. We argue that stock market merger effects are broadly characterized along two potentially important dimensions. Firstly, a larger market attracts more buy/sell orders which affects the order books. One possible effect of this may be that the order books become more evenly distributed than before while another possible effect may be that more stocks are available at prices marginally above/below the prevailing market prices. Secondly, stock market mergers may also change the composition of informed investors. Furthermore, there are (to the author's knowledge) no previous studies which jointly consider price jumps and stock market mergers; Paper IV therefore contributes to the existing literature by testing the relationship between stock market mergers and larger-scale price movements. As such, Paper IV provides a better understanding of the effects of stock market integration on financial stability.

One main finding of the paper is that stock market mergers, on average, reduce the likelihood of observing price jumps. Another finding is that the effects are asymmetrically distributed in terms of that we only observe reduced probability of price jumps for large and medium size firms. Furthermore, the likelihood of observing negative price jumps decreases for an average firm after the mergers have taken place whereas the likelihood of observing positive jumps increases. Finally, the market risk is reduced after stock market consolidations.

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Stock exchange mergers and return co-movement: A flexible dynamic component correlations model

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HIGHLIGHTS

- Stock exchange mergers increase the long-run trends in return correlations.
- Short-run deviations approach the long-run trend in an oscillating manner.
- Persistency in short-run deviations decreases due to stock exchange mergers.
- The FDCC model captures successfully long- and short-run correlation components.

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ABSTRACT

The creation of a common cross-border stock trading platform is found, by use of a Flexible Dynamic Component Correlations (FDCC) model, to have increased long-run trends in conditional correlations between foreign and domestic stock market returns.

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1. Introduction

During the last decade the market structure for stock trading in Europe has experienced some major changes. A number of mergers and acquisitions have been made, for example, the Euronext merger (2005), the NYSE acquisition of Euronext (2006), the OMX merger (2003–2006), the NASDAQ acquisition of the OMX Nordic stock exchange (2007), and the merger between the London Stock Exchange and Borsa Italian (2007). In light of these mergers, an important question concerns to what extent changes in stock trading market structures affect interdependencies between stock market returns. The question is crucial for both policy makers governing stock market trading and systemic financial risk, as well as for investors seeking diversification. This is in particular important since further mergers are to be expected in the future.[1] A number of studies exist focusing on the effects of stock exchange mergers, e.g. Arnold et al. (1999), Santos and Scheinkman (2001), Padilla and Pagano (2005), Nielsson (2009) and Khan and Vieito (2012), but none of these consider the effect upon return co-movement. To provide evidence upon the issue, we study in this paper empirically to what extent the integration of the Nordic stock exchanges (the OMX Nordic merger) have affected the underlying interdependency structure between returns on these markets.

From a theoretical point of view one could argue that international stock market mergers on average should increase

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[1] During the last decade the pressure to increase the competitiveness among existing stock exchanges have increased, among other, due to the introduction of multilateral trading facilities (MTF:s), e.g. Chi-X, Turquoise, BATS and NEURO.

cross-country return correlations. In the post-merger period, ignoring possible home bias, each stock potentially faces the same group of investors (both domestic and foreign) regardless of where the stocks are listed. This means that on the merged market both domestic and foreign firms are valued conditional on similar expectations about, for example, the future global macroeconomic situation. This is in contrast to the pre-merger period were domestic firms mainly are valued conditional on domestic investors' expectations (that possibly could differ between countries). Given this increased conformity in the formation of expectations about foreign and domestic listed firms, one would then expect an on average higher co-movement between cross-country market returns. One can, however, also formulate counter arguments. One is that the lowering of transaction costs following the merger enable easier and quicker international reallocation of portfolios on the merged markets. A local negative shock, lowering the returns for domestic listed stocks, may then lead to a reallocation to foreign listed stocks, inducing a positive price reaction on the foreign market, rendering an on average lower correlation between stocks on the domestic and foreign markets. This argument is, however, conditioned upon that investors reallocate into the stocks and do not leave the stock market as a whole for safer assets. A local shock discouraging allocations both on the domestic and foreign stock market may then lead to falling returns on both markets and an increase in return correlations. Since arguments may be found both in favor of increased, as well as decreased cross-country return correlations after a stock exchange merger we consider the issue empirically.[2]

To study the effect of stock market mergers upon market return interdependency a Flexible Dynamic Component Correlations (FDCC) model is outlined. The model builds on the FDC model of Tsay (2002) and Baur (2005) and is extended in the spirit of the C-GARCH model by Engle and Lee (1993, 1999). The model facilitates an analysis of the long-run trend, as well as the transitory component, in the time-varying conditional correlations. In contrast to other multivariate GARCH models, e.g. the newly proposed DCC-MIDAS class of models (Colacito et al., 2011), the current framework does not require similar specifications of the conditional variance and correlation functions. This allows for flexible modeling of the conditional correlation function, e.g. including asymmetries or explanatory variables, without including these in the specification of the conditional variance (Baur, 2005). To test for possible effects of the stock market mergers we introduce dummy variables, with the value one from the date of the merger and onwards (zero otherwise), in the specification of the long-run trend and transitory components of the time-varying return correlations.

The main findings of the paper indicate that the long-run trends in conditional market return correlations between the Nordic stock exchanges have increased due to the creation of a common trading platform. The results are robust over different model specifications and conditioned upon controls for global stock return volatility, the collapse of the dot-com bubble and the financial crises in 2008. Evidence is further found that short-run deviations approach the long-run trend in an oscillating manner and that the persistency in this process has decreased due to the stock market mergers.

In Section 2 the FDCC model is outlined. The data and the empirical results are presented in Section 3, while the final section concludes.

2. The FDCC model

To study whether the Nordic stock exchange mergers have affected the return co-movement between the aggregated Nordic stock markets the second order moments of the Nordic stock index returns are analyzed. The returns are calculated as $r_{it} = \ln(I_{it}/I_{it-1})$, where I_{it} is the value of stock market index, $i = Sweden, Finland, Denmark$, and $Iceland$, at time t. To allow for time varying return co-movement between return series the Flexible Dynamic Correlations (FDC) model (Tsay, 2002; Baur, 2005) is utilized. The model is specified as

$$\mathbf{R}_t = \boldsymbol{\mu}_t + \boldsymbol{\epsilon}_t, \tag{1}$$

where $\mathbf{R}_t$, $\boldsymbol{\mu}_t$, and $\boldsymbol{\epsilon}_t$, are $N \times 1$ vectors denoting the returns, the conditional mean functions and the random disturbances, respectively. The conditional mean functions are parameterized as $\mu_{it} = \theta_{0i} + \sum_{l=1}^{L} \theta_{li} r_{it-l}$, while the disturbances in $\boldsymbol{\epsilon}_t$ are assumed to be normal i.i.d. mean-zero innovations specified as $\varepsilon_{it} = \sigma_{it} z_t$, where $z_t \sim N(0, 1)$. To gain direct modeling access to the correlation coefficients the covariance matrix, $\mathbf{H}_t$, conditional on the information set Φ_{t-1}, is expressed as

$$\mathrm{Var}(\boldsymbol{\varepsilon}_t|\Phi_{t-1}) = \mathbf{H}_t = \mathbf{D}_t \boldsymbol{\rho}_t \mathbf{D}_t, \tag{2}$$

where $\mathbf{D}_t$ is a diagonal matrix with standard deviations on the main diagonal and $\boldsymbol{\rho}_t$ is a correlation matrix. The conditional covariance matrix for a bivariate model ($N = 2$) is then given by

$$\begin{aligned}\mathbf{H}_t &= \begin{bmatrix} \sigma_{1t}^2 & \sigma_{12t} \\ \sigma_{12t} & \sigma_{2t}^2 \end{bmatrix} = \mathbf{D}_t \boldsymbol{\rho}_t \mathbf{D}_t \\ &= \begin{bmatrix} \sqrt{\sigma_{1t}^2} & 0 \\ 0 & \sqrt{\sigma_{2t}^2} \end{bmatrix} \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix} \begin{bmatrix} \sqrt{\sigma_{1t}^2} & 0 \\ 0 & \sqrt{\sigma_{2t}^2} \end{bmatrix}. \end{aligned} \tag{3}$$

In this specification the covariance term is reparameterized as $\sigma_{12t} = \rho_t \sqrt{\sigma_{1t}^2}\sqrt{\sigma_{2t}^2}$, i.e. the covariance term is replaced by a parameter, ρ_t, for the time-varying correlation, times the standard deviation for each return series. Under conventional assumptions regarding σ^2, $\mathbf{H}_t$, is positive definite as long as $|\rho_t| < 1$.

To enable a study of changes both in the long-run return co-movement as well as in the short-run, we extend the FDC model and specify a model with time-varying return correlation decomposed into a permanent (long-run) and a transitory (short-run) component in spirit of the C-GARCH model of Engle and Lee (1993, 1999). The bivariate Flexible Dynamic Component Correlations (FDCC) model is specified as

$$\begin{aligned}\rho_t &= q_t + \varphi_1(z_{1t-1}z_{2t-1} - q_{t-1}) + \varphi_2(\rho_{t-1} - q_{t-1}) \\ q_t &= \omega + \gamma_1(q_{t-1} - \omega) + \gamma_2(z_{1t-1}z_{2t-1} - \rho_{t-1}),\end{aligned} \tag{4}$$

where q_t is the long-run time-varying correlation trend component. The transitory component, $(\rho_t - q_t)$, describing the short-run deviations from the underlying long-run conditional correlation, converges to zero with powers φ_1 and φ_2. Thus, the persistence of the short run component is given by $\varphi_1 + \varphi_2$. The shocks in the conditional correlation function is modeled in terms of standardized residuals, $z_{it} = \varepsilon_{it}/\sigma_{it}$. To restrict the correlation to the $(-1, 1)$ interval we use the $\hat{\rho}_t = \rho_t/\sqrt{1+\rho_t^2}$ transformation.[3] To keep the model as simple as possible and to focus upon decomposing the conditional correlation, the process for the conditional

[2] For the more general issue of international (real and monetary) economic integration and its consequence for the between country correlation of stock returns, a larger literature exists; see e.g. Tavares (2009) and Bekaert et al. (2011). The empirical evidence from this literature is, however, not unequivocally conclusive.

[3] Tsay (2002) use the Fischer transformation $\hat{z} = (\exp(z) - 1)/(\exp(z) + 1)$ to restrict $|\rho_t| < 1$. Baur (2005) do, however, find that this restriction is more restrictive than $\hat{z} = z/\sqrt{1+z^2}$. In the empirical study both of these transformations were used yielding similar results concerning variables of interest.

Table 1
Summary statistics—returns.

	Pre-merger period[a]						Post-merger period					
	Mean	s.d.	Corr[b]	Q(r)[c]	Q(r^2)	Obs.	Mean	s.d.	Corr[b]	Q(r)[c]	Q(r^2)	Obs.
Stockholm	0.003	1.669	0.464	13.083	177.507	1418	0.030	1.436	0.555	17.122	1040.583	1613
Helsinki	0.052	2.662	0.450	16.775	39.968	1418	0.008	1.509	0.526	17.441	452.647	1613
Copenhagen	0.019	1.027	0.406	17.083	521.653	1753	0.017	1.338	0.537	27.896	1113.020	1278
Reykjavik	0.079	0.783	0.096	69.188	417.855	2255	−0.319	4.377	0.041	13.110	0.243	776

[a] Stock market merger dates: Swe: 2003-09-03, Fin: 2003-09-03, Den: 2005-01-03, Ice: 2006-12-29.
[b] Average unconditional correlation over all pairs.
[c] Ljung–Box statistic (df: 10) for return (r) and squared return (r^2).

variances, σ_{1t}^2, σ_{2t}^2, are specified as GARCH(1, 1) equations. Estimation of the FDCC model is straightforward using maximum likelihood. The probability density function for $\mathbf{R}_t$ is specified as

$$f(\mathbf{R}_t|\Phi_{t-1}) = \frac{1}{(2\pi)^{N/2}}|\mathbf{D}_{ijt}\boldsymbol{\rho}_t\mathbf{D}_{ijt}|^{-1/2} \times \exp[-1/2 \times [\boldsymbol{\epsilon}_t[\mathbf{D}_{ijt}\boldsymbol{\rho}_t\mathbf{D}_{ijt}]^{-1}\boldsymbol{\epsilon}_t], \quad (5)$$

where

$$\boldsymbol{\epsilon}_t = \mathbf{R}_t - \boldsymbol{\mu}_t = \begin{bmatrix} r_{1t} - \mu_{1t} \\ r_{2t} - \mu_{2t} \end{bmatrix}, \quad \mathbf{D}_t = \begin{bmatrix} \sqrt{\sigma_{1t}^2} & 0 \\ 0 & \sqrt{\sigma_{2t}^2} \end{bmatrix}, \quad \boldsymbol{\rho}_t = \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix}. \quad (6)$$

The log-likelihood function is then given by $\ln L = \sum_{t=1}^{T} \ln f(\mathbf{R}_t|\boldsymbol{\Phi}_{t-1})$.

3. Return co-movement and merger effects

3.1. Data

Daily closing prices provided by the Thomson Reuters Datastream, starting on January 1, 1998, and ending on February 4, 2010, for the OMX Stockholm, Helsinki, Copenhagen, and Iceland all-share indices are used in the calculation of market returns. The stocks were first traded on the common trading platform on the 3rd of September, 2003, for the Stockholm and Helsinki, 3rd of January, 2005, for the Copenhagen, and the 29th of December, 2006, for the Icelandic stock markets.[4] In Table 1 we report summary statistics for the returns over the pre- respective, post-merger periods for each market.

The mean returns are positive in both the pre- and the post-merger period for all markets, except for Iceland in the post-merger period. The deviating observation for the Icelandic market is explained by the harsh impact that the financial crises in 2008 and the following euro-debt crises have had on the Icelandic market. This is further seen in the high standard deviation of returns on the Icelandic stock market in the post-merger period. Comparing the average unconditional return correlations for each market, with all other markets, reveals that these have increased between the pre- and post-merger period, except for the case of Iceland. The Ljung–Box (Q) statistics (critical value 18.31 from the Chi-2 distribution at the 5% level with df: 10) indicate a modest serial correlation for the return series, except for Iceland in the pre-merger period and Copenhagen in the post-merger period, but strong serial correlation for the squared returns, except for Iceland in the post-merger period.

3.2. Estimation results

To study the effect of the introduction of a common Nordic trading platform upon the conditional stock market correlations[5] a number of specifications of the FDCC model were estimated.[6] To capture possible stock market merger effects dummy variables, with the value one from the date of the merger between two markets and onwards, zero otherwise, are utilized ($dMerger_{tij}$). In order to capture the influences from the international stock market movements, a one period lagged realized variance measure ($RV_{US,t-1}$) based on the returns of the US NASDAQ index (based on the previous 60 trading days) as well as dummy variables indicating the collapse of the dot-com bubble in 2001–2002 ($dDotcom_t$) and the turbulence from the sub-prime crises in 2008 ($dSubprime_t$) are also added as control variables. In Table 2 the estimation results for a model including merger dummies both in the long-run trend, as well as in the transitory component are reported.[7]

Starting with the long-run trend, the results imply that for all pairs of correlations the creation of a common Nordic trading platform have increased the interdependencies between the considered stock market returns. The results are significant at the 5% level for all pairs, except for the correlation between the Stockholm and Copenhagen markets. The results are robust and hold also for other model specifications, for example, when excluding the merger dummy in the transitory component, excluding the dot-com and subprime dummies, and also when re-estimating models on a restricted sample excluding the sub-prime crises and the following Euro-debt crises (a sample covering the period 2000-01-03–2007-12-31). An analysis of possible adjustment effects before the actual merger (when it became publically known), by use of a dummy specification, do further not indicate any significant pre-merger effects upon the long-run trends in correlations.

An increase in global stock market volatility, proxied with the realized variance measure, does in general decrease the long-run trend in return correlations, except for the Stockholm and

[4] A more detailed description of the OMX Nordic merger can be found in Hellström et al. (2013).

[5] An analysis of merger effects upon long-run trends in return volatilities by use of component-GARCH models (Engle and Lee, 1993, 1999) has also been performed. The results from this analysis (available upon request) indicate that the long-run trends in conditional variances significantly (at the 5% level) decreased for the Stockholm and Helsinki, while increased for the Copenhagen and Reykjavik, stock markets following the stock market mergers.

[6] The different specifications include models with higher order return lags, day-of-the-week effects, as well as, monthly effects in the conditional means and non-linear asymmetric conditional variance specifications, such as EGARCH and GJR (Glosten et al., 1993). Given that our empirical results in regard to merger effects are similar in these more elaborate specifications, we do, however, report results for the most parsimonious version.

[7] Results from the Ljung–Box tests indicate modest serial correlations in returns and a simple AR(1) model is therefore chosen for the conditional mean. Also, note here that the explanatory variables (including the merger dummies) are included in the long-run trend component (q_t in Eq. (4)) as $\omega = \tilde{\omega} + \phi_1 dMerger_{ij} + \phi_2 RV_{US,t-1} + \phi_3 dDotcom_t + \phi_4 dSubprime_t$, and to capture possible changes in the short-run dynamics ($\rho_t - q_t$ in Eq. (4)) as an interaction variable, $(\varphi_2 + \varphi_3 dMerger_{ij})(\rho_{t-1} - q_{t-1})$. Further, achieving convergence of multivariate model specifications, including all series, has so far been challenging. We therefore confine our results to bivariate versions.

Table 2
Estimation results for the FDCC model controlling for stock market merger effects.

	(1) Stoc.–(2) Hels.		(1) Stoc.–(2) Cop.		(1) Stoc.–(2) Rey.		(1) Hels.–(2) Cop.		(1) Hels.–(2) Rey.		(1) Cop.–(2) Rey.	
	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.
	$r_{it} = \theta_{0i} + \theta_{1i} r_{it-1} + \varepsilon_{it}$, for $i = 1, 2$.											
θ_{01}	0.082*	(0.020)	0.098*	(0.016)	0.044*	(0.019)	0.096*	(0.023)	0.034	(0.023)	0.024	(0.016)
θ_{11}	−0.009	(0.014)	−0.035*	(0.016)	0.086*	(0.015)	0.006	(0.015)	0.227*	(0.017)	0.192*	(0.016)
θ_{02}	0.082*	(0.024)	0.076*	(0.014)	0.070*	(0.017)	0.051*	(0.018)	0.044*	(0.018)	0.054*	(0.016)
θ_{12}	0.017	(0.013)	0.048*	(0.015)	0.145*	(0.017)	0.054*	(0.015)	0.115*	(0.014)	0.151*	(0.016)
	$\sigma_{it}^2 = \alpha_{0i} + \alpha_{1i}\varepsilon_{it-1}^2 + \alpha_{2i}\sigma_{it-1}^2$, for $i = 1, 2$.											
α_{01}	0.018*	(0.000)	0.035*	(0.002)	0.189*	(0.015)	0.017*	(0.000)	0.063	(0.145)	0.179*	(0.013)
α_{11}	0.072*	(0.000)	0.097*	(0.004)	0.312*	(0.017)	0.059*	(0.000)	0.065*	(0.008)	0.296*	(0.019)
α_{21}	0.926*	(0.024)	0.881*	(0.078)	0.629*	(0.044)	0.936*	(0.022)	0.920*	(0.028)	0.566*	(0.055)
α_{02}	0.006*	(0.000)	0.029*	(0.001)	0.140*	(0.006)	0.027*	(0.000)	0.340*	(0.025)	0.177*	(0.011)
α_{12}	0.148*	(0.001)	0.053*	(0.002)	0.176*	(0.005)	0.014*	(0.000)	0.283*	(0.012)	0.287*	(0.015)
α_{22}	0.904*	(0.133)	0.889*	(0.138)	0.905*	(0.143)	0.912*	(0.151)	0.896*	(0.110)	0.905*	(0.137)
	$\rho_t - q_t = \varphi_1(z_{1t-1}z_{2t-1} - q_{t-1}) + (\varphi_2 + \varphi_3 dMerger_{ij})\,(\rho_{t-1} - q_{t-1})$, $q_t = \omega + \gamma_1(q_{t-1}) - \omega + \gamma_2(z_{1t-1}z_{2t-1} - \rho_{t-1})$ $\omega = \tilde{\omega} + \phi_1\, dMerger_{ij} + \phi_2 RV_{US,t-1} + \phi_3 dDotcom_t + \phi_4 dSubprime_t$												
φ_1	−0.025	(0.019)	0.021*	(0.005)	0.045*	(0.012)	−0.189*	(0.072)	0.042*	(0.008)	0.167	(0.558)
φ_2	−0.794*	(0.160)	0.956*	(0.016)	−0.410**	(0.216)	−0.068	(0.079)	−0.788*	(0.167)	0.319	(0.988)
φ_3 (Merger)	1.076**	(0.470)	−0.005	(0.014)	−0.394**	(0.217)	0.203**	(0.112)	−0.019	(0.167)	−0.277	(0.837)
γ_1	−0.293	(0.637)	−0.160	(0.628)	0.821*	(0.070)	−0.123	(0.161)	0.948*	(0.022)	0.425	(0.556)
γ_2	0.012	(0.019)	0.011	(0.007)	0.039*	(0.011)	0.207*	(0.072)	0.025*	(0.007)	−0.084	(0.556)
$\tilde{\omega}$	0.624*	(0.096)	1.153*	(0.191)	0.667*	(0.176)	0.642*	(0.093)	0.481*	(0.049)	0.544*	(0.162)
ϕ_1 (Merger)	0.166*	(0.063)	0.000	(0.100)	0.402*	(0.071)	0.126*	(0.050)	0.322*	(0.097)	0.425*	(0.074)
ϕ_2 ($RV_{US,t-1}$)	0.220*	(0.070)	−0.223**	(0.135)	−0.595*	(0.154)	−0.027	(0.076)	−0.395*	(0.052)	−0.510*	(0.143)
ϕ_3 (Dot-com)	0.070	(0.073)	−0.379*	(0.135)	−0.299*	(0.108)	−0.030	(0.066)	−0.137*	(0.064)	−0.115	(0.107)
ϕ_4 (Subprime)	0.193*	(0.050)	−0.069	(0.100)	0.013	(0.079)	−0.112**	(0.059)	−0.065	(0.098)	−0.009	(0.070)
lnL	−4525		−3010		−4000		−4298		−5493		−2895	
Nr. obs.	2972		2972		2972		2972		2972		2972	

Note: * Significant at the 5% level; ** Significant at the 10% level.

Helsinki correlation. The dummy for the collapse of the dot-com bubble indicate that the long-run trend in the time-varying correlation increased between Stockholm–Helsinki during this period, while it decreased between Stockholm–Copenhagen, Stockholm–Reykjavik, and Helsinki–Reykjavik. The similar effect during the sub-prime crises in 2008 is only positively significant for Stockholm–Helsinki and negatively significant for Helsinki–Copenhagen. These later effects, i.e. the global stock market volatility, collapse of the dot-com bubble and the sub-prime crises, are likely to be explained by differences in how each country is economically and financially integrated with the global market. Sweden is, for example, one of the most export dependent countries in the world.

Comparing the pre- and post-merger persistency in short-run deviations from the long-run trend, i.e. $\varphi_1 + \varphi_2$ with $\varphi_1 + \varphi_2 + \varphi_3$, reveals that persistency has significantly decreased for the Stockholm–Helsinki and Helsinki–Copenhagen, while it increased for the Stockholm–Reykjavik, pair of correlations. The persistency in short-run deviations are relatively high for the Stockholm–Copenhagen, Stockholm–Helsinki, and Helsinki–Reykjavik pair of correlations in the pre-merger period and for the Stockholm–Copenhagen, Helsinki–Reykjavik, and Stockholm–Reykjavik pair of correlations in the post-merger period. Worth noting is that the adjustment towards the long-run trend is oscillating, i.e. the sum of $\varphi_1 + \varphi_2 < 0$, for four out of the six pair of correlations in the pre-merger period. In the post-merger period an oscillating pattern is found for three pair of correlations. In regard to the dynamics of the long-run trend, q_t, the results are mixed. The estimates for the persistency in deviations from the constant term ω, measured by $|\gamma_1|$, ranges from 0.123 to 0.948 (although only two are significant at the 5% level) and some have negative signs (oscillating pattern of adjustment). This indicates quite different dynamics for different pairs of correlations.

4. Conclusions

In this paper the aggregated effects from the creation of a uniform stock trading platform upon return co-movement is studied for the OMX Nordic merger. A FDCC model is outlined in spirit of Engle and Lee (1993, 1999) to separately analyze the effects on long-run trends, as well as on transitory components (capturing deviations from the long-run trends) in the conditional correlations. The results indicate that the creation of a uniform trading platform has led to an on average increase in long-run trends in cross-country return correlations for all of the considered markets. Thus, possible gains from stock market mergers, e.g. lowered transaction costs—both direct and indirect, should then be weighted against this, on average, decreased potential for cross-border diversification. On a more general level, the results add to the literature focusing on the understanding of determinants of cross-country stock market correlations, e.g. Bekaert et al. (2011), and are of importance in evaluations of future stock market mergers. Regarding the dynamics of time-varying correlations we find mixed evidence. For some pair of correlations short-run deviations adjust towards the long-run trend in an oscillating, while for other in a non-oscillating, manner. In terms of merger effects evidence points towards a decrease in persistence in short-run deviations from the long-run trend, i.e. correlations adjust faster towards its long run trend on the merged market. These results are new and interesting since they provide new information about the dynamics of time-varying stock market return correlations. The outlined FDCC model seems to work well and provides estimates in line with other studies concerning the conditional variances, i.e. the GARCH components, as well as for the dynamic conditional correlations.

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II

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. In the study, 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 which indicates a flight to liquidity effect in the sense that relatively large (small) firms located on relatively large (small) markets experience an improved (reduced) information efficiency and turnover. Although the results indicate that changes in the level of investor attention (measured by turnover) may explain part of the changes in information efficiency, they also lend support to the hypothesis that merger effects may partially be driven by changes in the composition of informed versus uninformed investors following a stock.

Key words: Time-varying return predictability, market structure.
JEL Classifications: G12, G14, G15.

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1 Introduction

A major trend during the last decade is 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.[1] 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 favour 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

[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.

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[2], we in this paper 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[3] countries, have merged into a single trading platform (the OMX merger).[4] To study the effect of these 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

[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.

of Wright's sign test (see Kim and Shamsuddin, 2008) are estimated on moving sub-samples over the considered time period.[5] 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 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.

[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.

2 The OMX merger and information efficiency

2.1 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[6] 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, 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 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.

[Table 1 about here.]

[6] Securities-trading on the these 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.

2.2 Information efficiency and stock exchange mergers

Today there is a literature which 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[7] relate market conditions (mainly financial crises) to market efficiency whereas other studies[8] link financial reforms and changes in the regulatory framework to market efficiency. Yet other studies[9] test how technology improvements (the introduction of electronic trading systems) and the introduction of price limitation systems affect market efficiency.[10]

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

[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.

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.[11] 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 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 favour 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

[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.

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 favour 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.[12] 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 notable 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 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

[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".

has been collected from the Thomson Reuters Datastream. The sample covers the period January 4, 2000 to December 31, 2007[13] and includes stock price data for 236 Swedish, 111 Finish, 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.

[Table 2 about here.]

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 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 falling 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

[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).

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.[14] 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 equal to one. For r_t, $t = 1, ..., T$, asset returns the conventional VR statistic can be written as

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

[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.

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

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

where

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

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 $s_t = 1$ if $r_t > 0$, 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

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

Kim and Shamsuddin (2008), in spirit of Chow and Denning (1993), propose a multiple joint test of $V(k_i) = 1$ for $i = 1, ..., l$, against the alternative hypothesis that $V(k_i) \neq 1$ 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).[15]

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

[15] For example, the 5 and 10 percent critical values for $k_i = \{2, 5, 10, 20, 40\}$ with $T = 500$ are 2.40 and 2.10, while 2.32 and 2.04 for $T = 375$, respectively.

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.[16] 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 covariates and the merger dummies need some consideration. In Figure 1 the basic structure is displayed.

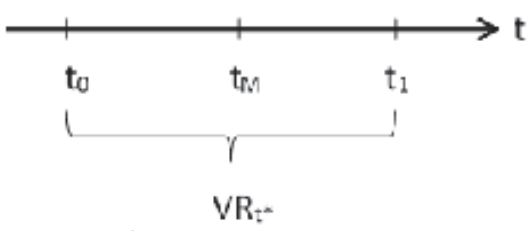

Figure 1: Structure of sub-sample window.

The sub-sample window is from t_0 to t_1, where t_M indicates the date of the merger, i.e. the date from when investors could trade on a common trading platform. Based on the returns in the sub-sample window the VR statistic is calculated. Since the test indicates return predictability within the given sub-

[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 therfore ignored.

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.[17]

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[18], 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.[19] 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

[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 influencial 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.

based on location, size and foreign sales for the pre- and post-merger period, respectively.[20] 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.[21]

[Table 3 about here.]

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

[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.

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.[22]

[Table 4 about here.]

In Model 1 the basic regressions are presented controlling for firm size (market capitalization, MC_{it}), 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

[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, Newy-West robust standard errors are throughout presented.

average increases the number of investors following a stock and that deviations from a fair price becomes less likely. The effect of firm size (MC_{it}) 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 favour 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 heterogenous 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 w.r.t. 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, w.r.t. the firms´s 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 lead 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 heterogenous 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.[23] 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.

[23] Note here that we control for direct effects of firms size through MC_{it}. 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.

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 information 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 heterogenous 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 w.r.t. 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 foreign sales, seem to have lost investor attention primarily to middle sized and small firms with pre-merger foreign sales. These results are interesting since 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.

4.3 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.

[Table 5 about here.]

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 w.r.t. 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 w.r.t. 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 for that merger effects not only depend on changes in the level of investor attention (turnover), but also depends on other mechanisms, e.g. changes in the composition of informed versus uninformed investors following stocks.

4.4 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, $W_{it} \in (0, 1)$, 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.[24] The model is specified as

$$\Pr(W_{it} = 1|X_{it}) = \frac{\exp(\alpha_i + \mathbf{x}_{it}\boldsymbol{\beta})}{1 + \exp(\alpha_i + \mathbf{x}_{it}\boldsymbol{\beta})}, \ i = 1, 2, ...N, \ t = 1, 2, ..., T,$$

where the vector $\mathbf{x}_{it}$ 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 significant 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.[25]

[Table 6 about here.]

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.

[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.

[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.

5 Discussion and conclusions

In this paper we contribute 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 an, on average, significant increase 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 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 resported 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 w.r.t 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 recent 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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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

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 $MC_{\text{Large firms}}$ (thousands, Euro)	9,613,610	14,342,741	11,335,759	4,042,294	440,395
	(27,446,593)	(14,342,741)	(25,937,724)	(3,750,743)	(277,543)
- Mean $MC_{\text{Small firms}}$ (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. [a]Proportion based on fully observed sample, i.e. net of firms missing foreign sales information. Standard deviations in paranthesis.

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

	Pre-merger period					Post-merger period				
Joint sign test	Mean[b]	s.d.	Min.	Max.	Obs.	Mean[b]	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	6.0324	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	6068
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

[a]Note that the merger date differs between markets (Stockholm, Helsinki, Riga, and Tallin: 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. [b] Mean 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: $p<0.05$.

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	
$dOMX_{Sth}$	-	-	-0.30*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Hel}$	-	-	-0.45*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Cop}$	-	-	-0.19*	(0.07)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Baltic}$	-	-	-0.41*	(0.10)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Large}$	-	-	-	-	0.27*	(0.02)	-	-	-	-	-	-	-	-	-	-
$dOMX_{Small}$	-	-	-	-	0.57*	(0.02)	-	-	-	-	-	-	-	-	-	-
$dOMX_{Large - Sth}$	-	-	-	-	-	-	-0.18*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Middle - Sth}$	-	-	-	-	-	-	-0.41*	(0.02)	-	-	-	-	-	-	-	-
$dOMX_{Small - Sth}$	-	-	-	-	-	-	-0.12*	(0.03)	-	-	-	-	-	-	-	-
$dOMX_{Large - Hel}$	-	-	-	-	-	-	0.58*	(0.05)	-	-	-	-	-	-	-	-
$dOMX_{Middle - Hel}$	-	-	-	-	-	-	-0.18*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Small - Hel}$	-	-	-	-	-	-	-0.73*	(0.13)	-	-	-	-	-	-	-	-
$dOMX_{Large - Cop}$	-	-	-	-	-	-	-0.38*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Middle - Cop}$	-	-	-	-	-	-	-0.24*	(0.03)	-	-	-	-	-	-	-	-
$dOMX_{Small - Cop}$	-	-	-	-	-	-	0.19*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Large - Baltic}$	-	-	-	-	-	-	0.66*	(0.13)	-	-	-	-	-	-	-	-
$dOMX_{Middle - Baltic}$	-	-	-	-	-	-	-0.56*	(0.08)	-	-	-	-	-	-	-	-
$dOMX_{Small - Baltic}$	-	-	-	-	-	-	3.76*	(0.11)	-	-	-	-	-	-	-	-
$dOMX_{Pos. size dist.}$	-	-	-	-	-	-	-	-	-0.39*	(0.02)	-	-	-	-	-	-
$dOMX_{Neg. size dist.}$	-	-	-	-	-	-	-	-	-0.31*	(0.01)	-	-	-	-	-	-
$dOMX_{For. sales}$	-	-	-	-	-	-	-	-	-	-	-0.01	(0.01)	-	-	-	-
$dOMX_{F. sale - Large}$	-	-	-	-	-	-	-	-	-	-	-	-	0.28*	(0.02)	-	-
$dOMX_{F. sale - Medium}$	-	-	-	-	-	-	-	-	-	-	-	-	-0.08*	(0.01)	-	-
$dOMX_{F. sale - Small}$	-	-	-	-	-	-	-	-	-	-	-	-	-0.28*	(0.05)	-	-
$dOMX_{F. sale - Sth}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	(0.02)
$dOMX_{F. sale - Hel}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.02	(0.02)
$dOMX_{F. sale - Cop}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.03	(0.02)
$dOMX_{F. sale - Baltic}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(.)
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	
GDP_{Capita}	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	
Constant	-26.32*	(1.02)	-33.87*	(2.02)	-22.42*	(1.02)	-1.15	()	-24.68*	(1.02)	-11.70*	(2.22)	-9.94*	(2.22)	-8.84	
Fixed effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Time specific effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
F-test	481.23		381.37		516.20		450.73		468.13		282.43		271.02		239.31	

	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	
$dOMX_{Sth}$	-	-	0.37*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Hel}$	-	-	0.34*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Cop}$	-	-	0.21*	(0.09)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Baltic}$	-	-	-0.08	(0.13)	-	-	-	-	-	-	-	-	-	-	-	-
$dOMX_{Large}$	-	-	-	-	0.19*	(0.02)	-	-	-	-	-	-	-	-	-	-
$dOMX_{Small}$	-	-	-	-	0.37*	(0.02)	-	-	-	-	-	-	-	-	-	-
$dOMX_{Large\ Sth}$	-	-	-	-	-	-	0.21*	(0.05)	-	-	-	-	-	-	-	-
$dOMX_{Middle\ Sth}$	-	-	-	-	-	-	0.06*	(0.03)	-	-	-	-	-	-	-	-
$dOMX_{Small\ Sth}$	-	-	-	-	-	-	0.32*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Large\ Hel}$	-	-	-	-	-	-	0.28*	(0.07)	-	-	-	-	-	-	-	-
$dOMX_{Middle\ Hel}$	-	-	-	-	-	-	0.03	(0.06)	-	-	-	-	-	-	-	-
$dOMX_{Small\ Hel}$	-	-	-	-	-	-	0.21	(0.17)	-	-	-	-	-	-	-	-
$dOMX_{Large\ Cop}$	-	-	-	-	-	-	0.10*	(0.05)	-	-	-	-	-	-	-	-
$dOMX_{Middle\ Cop}$	-	-	-	-	-	-	-0.12*	(0.04)	-	-	-	-	-	-	-	-
$dOMX_{Small\ Cop}$	-	-	-	-	-	-	0.60*	(0.05)	-	-	-	-	-	-	-	-
$dOMX_{Large\ Baltic}$	-	-	-	-	-	-	-0.28*	(0.16)	-	-	-	-	-	-	-	-
$dOMX_{Middle\ Baltic}$	-	-	-	-	-	-	0.23*	(0.11)	-	-	-	-	-	-	-	-
$dOMX_{Small\ Baltic}$	-	-	-	-	-	-	-0.26*	(0.14)	-	-	-	-	-	-	-	-
$dOMX_{Pos.\ size\ dist.}$	-	-	-	-	-	-	-	-	-0.05*	(0.02)	-	-	-	-	-	-
$dOMX_{Neg.\ size\ dist.}$	-	-	-	-	-	-	-	-	0.12*	(0.02)	-	-	-	-	-	-
$dOMX_{For.\ sales}$	-	-	-	-	-	-	-	-	-	-	0.05*	(0.01)	-	-	-	-
$dOMX_{F.\ sale\ -\ Large}$	-	-	-	-	-	-	-	-	-	-	-	-	0.14*	(0.01)	-	-
$dOMX_{F.\ sale\ -\ Medium}$	-	-	-	-	-	-	-	-	-	-	-	-	0.01	(0.01)	-	-
$dOMX_{F.\ sale\ -\ Small}$	-	-	-	-	-	-	-	-	-	-	-	-	0.48*	(0.03)	-	-
$dOMX_{F.\ sale\ Sth}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.12	
$dOMX_{F.\ sale\ Hel}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	
$dOMX_{F.\ sale\ Cop}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	
$dOMX_{F.\ sale\ Baltic}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	(0.01)
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	
GDP_{Capita}	1.16*	(0.14)	1.48*	(0.29)	0.88*	(0.13)	2.09*	(0.15)	1.28*	(0.14)	1.10*	(0.17)	1.25*	(0.17)	4.02	
Constant	-10.12*	(1.31)	-12.61*	(2.62)	-7.63*	(1.32)	-17.60*	(1.47)	-11.24*	(1.33)	-10.52*	(1.53)	-11.81*	(1.53)	-36.49*	(1.92)
Fixed effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Time specific effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
F-test	46.97		50.72		66 92		47.37		43.40		95.81		104.73		126.87	

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)	-	-	-	-	-	-
$dOMX_{Positive\ size\ dist.}$	-	-	-	-	-	-	-1.021*	(0.266)	-	-	-	-
$dOMX_{Negative\ size\ dist.}$	-	-	-	-	-	-	-0.818*	(0.272)	-	-	-	-
$dOMX_{F.\ sale}$	-	-	-	-	-	-	-	-	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)
Fixed effects	Yes		Yes		Yes		Yes		Yes		Yes	
Time specific effects	Yes		Yes		Yes		Yes		Yes		Yes	
LR χ^2	3625		4103		3926		3650		2494		2616	
Nr. firms	371		371		371		371		250		250	

* Significant level: $p<0.05$. Newy-West robust standard errors in parenthesis.

III

Trust and stock market correlation: A cross-country analysis

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Abstract: Several studies have shown that the level of trust between agents is an important determinant of financial decisions. This paper studies this issue further by analyzing whether the measured level of trust in different countries can explain bilateral stock market correlations. Using a panel of 62 countries and 1891 country-pairs over a period of ten years, the effect of generalized trust on stock market correlations is analyzed. One finding is that generalized trust among nations is a robust predictor for stock market correlation. Another is that the trust effect is larger for countries which are close to each other which indicates that distance mitigates the trust effect. Finally, we confirm the effect of trust upon stock market correlations, by using particular trust data (bilateral trust between country A and country B) as an alternative measurement of trust.

Keywords: International Financial Markets, Stock Market Correlation, Trust, Volatility, Portfolio Diversification, Stock Market Participation

JEL Classifications: G15, F15, D31, G11

1. Introduction

Generalized trust – usually measured as the proportion of people who think that most people can be trusted – is a key component which underlies economic decision-making[1] and has been documented in various contexts. For example, Houser *et al.* (2010) found that trust is not closely connected with risk attitudes and trust influences a person's decisions in investment games. Zak and Knack (2001) found a positive relationship between generalized trust and growth, whereas Dearmon and Grier (2009) linked generalized trust to per capita GDP. Other examples are Berggren *et al.* (2014) who documented a u-shaped relationship between generalized trust and central-bank independence, as well as Guiso *et al.* (2009) who found a positive relationship between bilateral trust and trade. Trust has also been used to address topics within a financial market context. The Ekinci *et al.* (2007) study into financial integration within the EU found that regions where generalized trust levels are high tend to be more financially integrated with each other as compared with regions where generalized trust levels are low. Guiso *et al.* (2009), in turn, looked at how cultural biases may affect economic exchange, and they showed that high bilateral trust levels lead to more portfolio and direct investments between countries.[2]

This paper extends the existing literature on trust in a financial market context by looking at whether trust also has a positive effect on stock market correlations. This hypothesis is based on two observations. First, several studies have documented that there is a strong link between the size of bilateral capital flows and the degree by which stock markets are correlated (see e.g. Forbes and Rigobon (2002) and Dellas and Hess (2005)). Second, if more financial integration leads to more capital moving across borders, the above mentioned studies by Ekinci *et al.* (2007) and Guiso *et al.* (2009) indicate that trust levels may be linked to the size of bilateral capital flows. Taken together, these observations suggest that high trust levels may lead to more bilateral capital flows which, in turn, cause stock markets to be more correlated. As such, we expect that there exists a positive relationship between trust levels and

[1] For example, Arrow (1972) emphasized that "virtually every commercial transaction has within itself an element of trust".

[2] It has also been shown that trust seems to be an important factor underlying both the choice between investing in risky and/or risk-free financial assets (Guiso *et al.* 2008; Georgarakos & Pasini 2011), as well as underlying the decision on whether to invest in real estate and/or financial assets (El-Attar & Poschke 2011). Bottazzi *et al.* (2011), in turn, showed that trust seems to be an important incentive underlying venture capital investments between countries.

bilateral stock market correlations. Therefore the purpose of this paper is to explore this hypothesis.

One can distinguish between two types of trust; generalized trust and particular trust. Generalized trust reflects how an agent looks upon other persons overall, whereas particular trust is related to an agent´s trust for specific persons and/or organizations that they know something about. In the context of international portfolio investment, particular trust is related to whether agents in country A trust agents in country B. This type of particular trust is most likely determined by the underlying trust level in country B. If agents living in country B do not trust each other (i.e. the trust in country B is low) and if this is known in country A, then the particular trust that an agent living in country A has for investing in country B is likely to be low. However, if the trust in country B is high meaning that agents in country B do not believe that they will be cheated or subject to fraud by other agents in country B (and if this is known in country A), then the particular trust that an agent in country A has for investing in country B is likely to be high.

These arguments indicate that in the context of an international portfolio investment, the particular trust that agents in country A (B) have for investing in country B (A) will be determined by the trust level in country B (A). Therefore, the main analysis of the relationship between trust and stock market correlations will be based on a measure of generalized trust. However, we will also use particular trust data to look at whether this alternative measure affects the qualitative results.

To address the link between generalized trust and stock market correlations, we used survey data from 62 countries. From this data we constructed a panel of 1891 country-pairs over a period of ten years. For each country pair (A, B), we used the generalized trust levels in country A and country B as explanatory variables, conditional on a number of control variables.

In this section, we will discuss how to incorporate trust variables, expect of through using them separately in regressions. Suppose the trust in country A is high and the trust in country B is low. On one hand, investors living in country A may hesitate as to whether to participate in stock market B, through observing that people living in country B are less trusting. On the other hand, investors living in country B may increase their possibility to participate in stock market A, through observing that people living in country A generally trust each other and are trustworthy. The former case may lead to a lower stock market correlation, whereas the latter causes a larger

stock market correlation. It is not clear which effect is dominant. Therefore we have used the difference of generalized trusts as an explanatory variable to test whether a dissimilarity of trust between countries affects the bilateral financial market linkage.

In addition, we added interaction terms between trust and distance to test whether larger distances decrease the trust effect upon stock market correlation, i.e. it is hard to transfer information if two countries are situated far away from each other.

The main result is that we found a positive relationship between generalized trust and stock market correlations. In addition, we found that the trust effect is larger in countries which are closer to each other.

During the second step, we also used particular trust survey data to test the link between trust and stock market correlation. Particular trust is measured as the percentage of agents in country A that trust the agents in country B. The particular trust survey data contains 15 European countries which correspond to a panel of 105 country-pair observations. The results from this estimation show that the particular trust is positively related to stock market comovement. Therefore, we have concluded that using this alternative trust measure does not change our previous findings about the trust effect upon stock market correlation.

As well as being related to the literature on trust, this paper is also related to the substantial body of empirical research which tries to pin down the key determinants of stock market correlations (Flavin *et al.* 2002; Pretorius 2002; Dellas & Hess 2005; José 2009; Lucey & Zhang 2010; Beine & Candelon 2011). In these studies, stock market correlations have been related to variables such as GDP growth, bilateral trade, market size, common border dummy, common currency dummy, geographical distance, civil liberty development, broadband infrastructure, volatility, etc.[3] In this context, this paper is most closely related to a study by Lucey and Zhang (2010). Lucey and Zhang (2010) studied the link between culture distance and stock market correlation in emerging markets where cultural distance refers to individualism, masculinity, power distance and uncertainty avoidance. In our study, the influence of another type of cultural factor, trust, is investigated upon stock market correlation.

The outline of this paper is as follows. Section 2 will present the data whereas the empirical model is outlined in Section 3. Section 4 will present the main results and robustness checks, followed by the conclusion in the final section.

[3] These are used as control variables in this study. The details of how to construct the control variables will be discussed in section 2.2.

2. Data and variable description

2.1 Data

In line with the earlier literature on stock market correlation (Flavin *et al.* 2002; Pretorius 2002; Dellas & Hess 2005; Lucey & Zhang 2010), we use the time-varying stock market correlation as the dependent variable. The stock market correlation, $\rho_{ij,t}$, is defined as the correlation between the pairs of daily returns over the calendar year and is calculated as annual correlations between daily returns of the year. Daily stock returns of the various national stock markets are defined as $r_t=100\times(\ln p_t-\ln p_{t-1})$. The stock price indices in the 62 countries are collected from Thomson Datastream beginning from January 1, 2000 until December 31, 2009.[4] The final sample includes 1891 country-pairs over 10 years, and has 18,910 panel observations. Table 1 presents the summary statistics for these correlations.

[Table 1 about here.]

Table 1 displays the characteristics of stock market correlations for each country, as well as the average of the stock market correlations for all country-pairs in each year. For each country *i*, the mean stock market correlation is the average of stock market correlations between country *i* and the other 61 countries over the sample periods. France has the highest mean (0.37), while Ecuador has the lowest (0.00). Another observation is that the mean stock market correlations in Europe are generally higher compared with non-European countries. In each year, the average of the stock market correlations for all country-pairs is calculated as the average of all pair-wise stock market correlations among the 62 countries, which totals 3782 observations. During the considered period, we see that the average for the stock market correlations for all country-pairs follow a time-varying path from 2000 to 2009. The maximum value is 0.38 in 2008 and it falls to 0.28 in 2009. It is generally higher after 2005 than before 2005, which reflects a closer relationship for financial global markets in more recent years.

2.2 Explanatory variables

The key explanatory variable trust is defined as the share of the population in a country who believe that most people can be trusted. The existing literature on trust

[4] Countries in this sample were selected according to the availability of trust data in the sample periods. Weekends and holidays are excluded.

distinguishes between two types of trust: generalized and particular trust. Generalized trust measures whether people have trust in people they are unfamiliar with or have no information on. Particular trust, instead, refers to the trust people have towards people they are familiar with or have information on. In this paper we initially used use generalized trust data for 62 countries, thereafter we used particular trust data for 15 European countries. The measure of generalized trust is based on fives waves from the World Values Survey (WVS) and complementary surveys asking similar survey questions.[5] In all surveys, the respondents were given the following question:

"Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?"

The possible answers are *"yes, most people can be trusted"* or *"no, need to be very careful"*. The generalized trust indicator is measured as the proportion of respondents who answered yes. The years in which each country participated in the WVS are different. Some participated more times than others. Therefore we were not able to obtain a time series of generalized trust measures for each country over a ten-year period. To adjust for this, we worked out an average over all available observations for each country following a similar procedure conducted by Bjørnskov (2007) and Berggren *et al.* (2014). By doing this, the measure of generalized trust is constant for each country. This is consistent with the previous literature. Bjørnskov (2007) found that generalized trust is a fairly stable cultural feature of society trust which was unchanged for two decades. Uslaner (2008) found that generalized trust is a stable value through one's life time and it is not shaped by immediate experiences. Table 2 summarizes the levels of generalized trust over the 62 countries.

[Table 2 about here.]

The levels of generalized trust differ substantially between countries with a minimum of 5.77 in Brazil and a maximum of 64.27 in Sweden. The mean in this sample is 29.50 and the standard deviation is 14.40. Another observation is that the levels of generalized trust are quite high in the Nordic countries. Sweden has the highest level of generalized trust in this sample where 64% of the respondents believe that most people can be trusted. Other Nordic countries, like Norway, Denmark, and Finland, also display high generalized trust towards others. In addition, the levels of

[5] The five waves of the WVS are a large-scale, cross-national and longitudinal survey research program in 87 countries. Complementary surveys are the Latinobarómetro, the AfroBarometer, the Asian Barometer, the East Asia Barometers, and the Danish Social Capital Project.

generalized trust are generally high in developed countries, e.g. eight of the top ten countries in this list are developed countries whereas the countries that rank among the last ten are all emerging markets.

In addition to the generalized trust variable, we use a set of control variables that previous studies have found to be key determinants of stock market correlations (Flavin *et al.* 2002; Pretorius 2002; Dellas & Hess 2005; José 2009; Lucey & Zhang 2010; Beine & Candelon 2011; Coeurdacier & Guibaud 2011).

One key control is GDP growth as it has been found to lead to higher levels of stock market comovement (Lucey and Zhang, 2010). We therefore use the GDP growth differential ($Growth_{ij}$), computed as the difference of the growth rate of gross domestic product (GDP) per capita between countries. Data comes from the World DataBank database from the World Bank.

We have also included bilateral trade Intensity variable between two countries to control for trade relationships ($TradeIntensity_{ij}$) since two stock markets are expected to have a higher correlation if the two countries have a close trade relationship (Coeurdacier and Guibaud, 2011; Pretorius, 2002). The bilateral trade intensity measure is defined as $\log(Trade_{ij,t}/(GDP_{i,t}+GDP_{j,t}))$,[6] where $Trade_{ij,t}$ refers to the total trade flows (imports plus exports) between country A and country B. These values are collected from the Direction of Trade Statistics database from the International Monetary Fund.

To control for financial development, we add the absolute value of the difference in the stock market capitalization (as a percentage of GDP) between countries A and B ($MarketSize_{ij}$), following Lucey and Zhang (2010). It is sourced from the World DataBank database from the World Bank. A similar quality banking system may be related to higher stock market correlation between domestic and world returns.

The regressions are controlled for geographic variables since country-pairs where a smaller geographic distance is expected to have higher stock market correlations (Flavin et al., 2002). We use the logarithm of geographic distance ($logDistance_{ij}$) between the major cities of two countries and a common border dummy ($Border_{ij}$)

[6] Using other measures of trade intensity, such as $\log(Trade_{ij,t}/(GDP_{i,t}\times GDP_{j,t}))$, and $Trade_{ij,t}/(GDP_{i,t}\times GDP_{j,t})$, did not influence our results.

that equals one if two countries share the same border and zero otherwise. This data comes from the CEPII Geography GeoDist Database.[7]

We add a currency union dummy ($CurrenyUnion_{ij}$) since a common currency plays a significant role in diminishing the barrier to foreign equity by easing currency exchange risk (Flavin et al., 2002). It equals one if the two countries use the same currency. Data comes from de Sousa (2012).

The regressions are controlled for legal institution variable since an effective legal institution provides protection to investors, especially to foreign investors, thus the legal institution variable is a determinant of contracting costs in the financial market (Flavin et al., 2002; Lucey and Zhang, 2010). We use the absolute difference of civil liberty index ($CivilLiberty_{ij}$) as a control variable. The civil liberty index measures the political state and freedom where a higher value means low fiscal capacity, poor law enforcement, repression and civil conflict, as sourced from the Freedom House.

The regression is controlled for technology ($Broadband_{ij}$) as a rapid growth in high-speed internet and broadband access in the last decade facilitates easy access to information and quick trade on foreign stock markets. Following Czernich *et al.* (2011), we used broadband infrastructure high-speed internet to capture this technological advance. In particular, we included the sum of fixed broadband subscriptions per 100 inhabitants in countries *i* and *j*, sourced from the World Telecommunication ICT Indicators Database.

Finally, we used the variance of daily world index ($Volatility_{ij}$) to control for market risk since a shock hits one stock market may lead to a rapid reallocation of funds and thereafter increase the returns correlations with other stock markets (Forbes and Rigobon, 2002). Volatility is measured by the squared value of the log-return of world index, sourced from Datastream.

To summarize, Table 3 shows descriptive statistics for all variables used in this study using observations from 2000 to 2009.[8] Table 4 presents the correlation matrix of all variables used in this study.

[Table 3 about here.]

[7] The CEPII databases is the database on the world economy and its evolution, which was produced by the French research center in international economics founded in 1978 and is part of the network coordinated by the Economic Policy Planning for the Prime Minister. The Geography GeoDist Database provides geographic bilateral and cultural data for 225 countries.

[8] For example the highest number of shares with missing value is broadband technology with around 7% of observations missing. We excluded missing values since there is a small percentage of missing values.

[Table 4 about here.]

It can be seen that unadjusted stock market correlation is positively correlated with the country-specific generalized trust variables, which is significant at a 1% significance level. Table 4 provides preliminary evidence on the relationship between stock market correlation and generalized trust and also the determining factors.

3. Empirical specification

The main hypothesis in this paper is that trust acts as a determinant of the correlation between equity markets. On each market, there exist factors that influence the cross-market correlation but which are not captured by our regressors, either because they are unobservable or immeasurable, yet they influence the cross market correlation. Failure to control for these factors might result in biased estimators and misleading conclusions. A panel method with cross-sectional and period-specific random effects is used to exclude heterogeneity. More specifically a fixed effect analysis is not appropriate for two reasons: i) it would result in a big loss of freedom because the cross-sectional dimension (countries) is much larger than the time dimension (years); ii) it requires regressors to vary over time, while the important variable *trust* is time-invariant in this analysis. In order to allow for intra-group correlation, we adjusted for clustered standard errors by country-pairs, relaxing the usual requirement that the observations are independent. This affects the standard errors and variance-covariance matrix of the estimators but not the estimated coefficients.

To do the regressions, we first rescaled the stock market correlation and used it as a dependent variable. The motivation is that the cross-country stock market correlation is restricted in the interval (-1, 1) whereas the right-hand variables in the regression have no restriction in econometric specifications. Following Beine and Candelon (2011), we applied Fisher's *z* transformation to the stock market correlation into the continuous interval (-∞, +∞):

$$\overline{\rho}_{ij,t} = ln\ (\frac{1+\rho_{ij,t}}{1-\rho_{ij,t}}) \quad (1)$$

where the $\rho_{ij,t}$ is the adjusted stock market correlation between country *i* and country *j* in year *t* by Fisher's z transformation; $\rho_{ij,t}$ is the unadjusted stock market correlation between country *i* and country *j* in year *t*.

We have assumed that high trust levels may lead to more bilateral capital flows which, in turn, will cause stock markets to be more correlated. The capital flows not only depend on the trust level in country i but also depend on the underlying trust level in country *j*. To test the relationship between generalized trust and stock market correlation, the following empirical specification is used as the basic model 1:

$$\overline{\rho}_{ij,t} = \alpha + \beta_1 \cdot trust_i + \beta_2 \cdot trust_j + \gamma \cdot X_{ij,t} + \delta_{ij} + \mu_t + \varepsilon_{ij,t}, \quad (2)$$

where the parameter α is the constant, the parameters β_1 and β_2 in model 1 illustrate how adjusted stock market correlation changes because one unit increase trust level in country *i* and country *j*, and $trust_i$ and $trust_j$ are the generalized trust level in country *i* and *j* respectively. $X_{ij,t}$ is a vector of control variables. The parameter δ_{ij} represents cross-sectional effects that capture non time-varying factors as well as time varying but highly persistent factors, e.g. synchronicity in trading hours (Flavin et al., 2002) and industrial structure (Pretorius, 2002).[9] The parameter μ_t represents period-specific effects that influence the stock market correlation, like common shocks to all markets. $\varepsilon_{ij,t}$ is the error term for cross-sectional units observed for dated periods.

Now that we have modeled the relationship between county-specific trust and stock market correlation, the next step is to know how the different levels of trust in the two countries influence return co-movement. Suppose there are two countries: country *i* and country *j*. The trust level in country *i* is high and the trust level in country *j* is low. It is less likely for agents in country *i* to participate in the stock market in country *j*. The agents living in country *j*, on the contrary, are more willing to participate in the stock market in country *i*. A large difference of trusts in the former case may lead to a smaller bilateral capital flow, while it may lead to a larger bilateral capital flow in the latter case. To test the effect of these differences of trust upon stock market correlation, the difference of generalized trust levels is used as explanatory variable in model 2. The regression is given by equation 3:

$$\overline{\rho}_{ij,t} = \alpha + \beta \cdot trust_{diff} + \gamma \cdot X_{ij,t} + \delta_{ij} + \mu_t + \varepsilon_{ij,t}, \quad (3)$$

where $trust_{diff}$ is the absolute difference between generalized trust levels in country i and country j. Note that the country-specific trust levels are not included in model 2.

[9] For robust checking, the pooled ordinary least squares (OLS) regressions are also estimated with clustered standard errors by country-pairs to deal with the serial correlation of residuals for a given pair. Following Lucey and Zhang (2010), we lag these control variables by one year to allow for the non-contemporaneous effects and to mitigate various endogeneity problems. The results support that trust is related to the return correlation of stock markets.

Since they are correlated with the difference of trust levels by 0.27, see Table 4, the country-specific trust levels are dismissed to avoid multicollinearity.

The parameters β_1 and β_2 in model 1 tell how one unit's increase in trust level can influence adjusted stock market correlation. We then wanted to know how changing one unit of any explanatory variable on the right side of model 1 causes the stock market correlation to move together. Therefore, we translated the coefficients obtained from the first step back to the derivatives of unadjusted stock market correlation with respect to any explanatory variable with the following equation[10]:

$$\frac{\partial \rho_{ij,t}}{\partial x} = \frac{(1+E(\rho_{ij,t}))*(1-E(\rho_{ij,t}))}{2} * \frac{\partial \overline{\rho}_{ij,t}}{\partial x} \quad (4)$$

where *x* refers to any explanatory variable in the right side of model 1 and model 2, $E(\rho_{ij,t})$ refers to the average of the stock market correlation which is equal to 0.20 according to Table 3.

It is likely that distance may hinder information transmission and therefore mitigate the effect of trust on stock market linkage. To measure heterogeneous trust effects, we tested whether trust effects are higher in countries which are closer to each other by constructing a distance category variable and added interaction terms between the generalized trust level and this variable. This is presented in model 3. The geographic distance is in the range of [59.62, 19772.34], as shown in Table 3. A short distance category is constructed if the geographic distance is less than 3200 km, a medium distance category is constructed if the geographic distance is larger than 3200 km and less than 12000 km, and finally a long distance category is constructed if the geographic distance is larger than 12000 km.

4. Results

Table 5 reports the estimation results of the panel regression models. To measure the impact of generalized trust on stock market correlation, model 1 uses the country-specific generalized trust levels in both country *i* and country *j* as explanatory variables, as defined by Eq. (2). To measure the impact of the difference between trust levels upon stock market correlation, model 2 includes the difference in absolute value between the country-specific generalized trust level in country *i* and country *j*, as defined in Eq. (3). To test for the heterogeneous effect of trusts in different distance groups in model 3, we have added interaction terms between generalized trust and

[10] The detail of calculation is in the Appendix 1.

distance categories in column 3. To look at the link between trust and unadjusted stock market correlation, column 4 to 6 reports the derivatives of unadjusted stock market correlation with respect to trust variables corresponding to the results in model 1, model 2 and model 3 respectively. They are calculated according to Eq. (4).

[Table 5 about here.]

Let us begin with the country-specific generalized trust. In column 1, the estimates of model 1 show that the country-specific generalized trust in country *i* is positively related with the adjusted stock market correlation by 0.004, and the country-specific generalized trust in country *j* is positively related with the adjusted stock market correlation by 0.004 as well. This shows that the generalized trust among nations is a robust predictor for stock market correlation. In other words, stock market correlation is larger in a country where people are more trusting. To illustrate the link between the country-specific generalized trust and unadjusted stock market correlation, the coefficients in column 1 are transferred to column 4 by Eq. (4). The results show that the country-specific generalized trusts in country *i* and country *j* are both positively related with unadjusted stock market correlation by 0.002, which means a percentage increase in the generalized trust level causes a 0.2 percentage increase in bilateral stock market correlation.

Model 2 measures whether a dissimilarity of the generalized trust affects stock market correlation. The difference between the country-specific generalized trusts is added as an explanatory variable in column 2. It has been found that the difference between generalized trusts is not significantly related with stock market correlation. One possible explanation could be that for investors living in high trusting countries, a larger dissimilarity of trust with a foreign country may lead to a lower stock market correlation. For investors living in low trusting countries, on the contrary, a larger dissimilarity of trust with a foreign country may cause a larger stock market correlation. This argument suggests that two opposite effects may be at work which would cancel each other out.

Turning to the interaction terms between trust and the distance categories, column 3 shows that generalized trust is positively related with adjusted stock market correlation by 0.005 in the short distance group. It indicates that a percentage of difference between generalized trusts causes a 0.2 percentage increase in unadjusted stock market correlation in the short distance group, according to the results in column 6. In the medium distance group, the generalized trust is positively related

with adjusted stock market correlation by 0.003. This indicates that a percentage of difference between generalized trusts causes more than a 0.1 percentage (around 0.14 percentages) increase in unadjusted stock market correlation in the medium distance group, according to the results in column 6. On the other hand, in the long distance group, the generalized trust is positively related with adjusted stock market correlation by 0.002. This indicates that a percentage of difference between generalized trusts causes more than a 0.1 percentage increase in unadjusted stock market correlation in the long distance group. This suggests that the relationship between trust and stock market correlation is larger in countries nearer to each other and indicates that distance mitigates the effects of country-specific generalized trust upon stock market correlation.

The results on the effect of trust have taken into account a number of control variables. Turning to the control variables, the results in Table 5 are generally consistent with the findings in earlier research. Trade, distance, having a common border, common currency, civil liberty development differentials, broadband infrastructure and volatility are associated with an increased level of stock market correlation. However, the GDP growth differential is negatively related to stock return correlation, which is in line with earlier research. The coefficient of the difference of market size is equal to zero, indicating that it is not important in determining stock market correlation. This is in line with Lucey and Zhang (2010) who found that the coefficient of market size is insignificant. The coefficient of the log of geographic distance turns problematic after the estimation is grouped by distance. We therefore omitted the log of geographic distance in column 3. Omitting it does not change the signs and significance of other coefficients.

5. Alternative specification

We have now studied the link between stock market correlation and trust by generalized trust measure. A possible drawback to the study may be that the particular trust that agents living in country A have for investing in country B is determined by the generalized trust level in country B. The other type of trust, particular trust, could possibly be a better measurement of trust level for bilateral countries. Below we intend to implement particular trust data to test the effect of trust upon stock market

correlation, which is collected from the Eurobarometer Surveys.[11] The particular trust data is also used in other financial literature, i.e. Spring and Grossmann (2013). The respondents in the surveys were given the following question:

"Now I would like to ask you about how much trust you have in people from various countries. For each, please tell me whether you tend to trust them or tend not to trust them?"

The possible answers are *"tend to trust them"*, *"tend not to trust them"* or *"Don't know"*. The level of the particular trust indicator is the proportion of the respondents who answered "tend to trust them" for people who live in a various other countries.

In total, 15 European countries are included in the particular trust data which is presented in Table 6.

[Table 6 about here.]

There is a large difference among the sample countries. The particular trust levels are situated in the range [0.27, 0.94]. The highest value (0.94) is the percentage of Danish respondents who trust in the people who live in the same country with them. The lowest value (0.27) is the percentage of respondents living in Greece who trust people living in the UK. Generally speaking, agents in all sample countries tend to display more trust towards people who live in the same country compared with the trust towards people who live in other countries.

Table 6 shows that respondents have different levels of trust for people living in different countries, i.e. Swedes are highly trusting of people living in Denmark (0.88) and Finland (0.86), while not very trusting of people living Spain (0.50), Greece (0.51), and Italy and Portugal (0.52). The difference seems to be caused by the fact that the underlying generalized trust levels in Denmark (with a value of 60.73 in Table 2) and Finland (with a value of 57.97 in Table 2) are higher than that in Spain (with a value of 32.81 in Table 2), Greece (with a value of 21.65 in Table 2), Italy (with a value of 29.65 in Table 2) and Portugal (with a value of 20.01 in Table 2). A correlation matrix is presented in Table 7 to show the relationship between particular trust and generalized trust, where generalized trusts refer to data in Table 2.

[Table 7 about here.]

[11] In 1997, citizens of 15 European countries were asked to indicate the level of trust they had towards citizens of 20 EU and non-EU countries. Since we need trust indicators in bilateral countries, we only focused on these 15 European countries in our regressions.

In Table 7, it is clear that the particular trust of people living in country A towards people living in country B is positively correlated with the underlying generalized trust level in country A by 0.25, and with the underlying generalized trust level in country B by 0.54. Additionally, the particular trust of people living in country B towards people living in country A is positively correlated with the underlying generalized trust level in country A by 0.42, and the underlying generalized trust level in country B by 0.46. Generally speaking, agents in country A has more trusting in investing in country B if the generalized trust level in country B is high (low).

To address the link between particular trust and stock market correlation, model 4 and model 5 are defined by Equation (5) and Equation (6):

$$\overline{\rho}_{ij,t} = \alpha + \beta \cdot Particular_trust_{AB} + \gamma \cdot X_{ij,t} + \delta_{ij} + \mu_t + \varepsilon_{ij,t}, \quad (5)$$

$$\overline{\rho}_{ij,t} = \alpha + \beta \cdot Particular_trust_{BA} + \gamma \cdot X_{ij,t} + \delta_{ij} + \mu_t + \varepsilon_{ij,t}, \quad (6)$$

where *Particular trust_AB* (which is the percentage of agents in country A have trust in people living in country B) and *Particular trust_BA* (which is the percentage of agents in country B have trust in people living in country A) are added into separate estimations to avoid multicollinearity, since they are highly correlated by 0.71 in Table 7.

The regression results are presented in Table 8. The regression results of model 4 and model 5 are presented in column 1 and column 2, respectively. The coefficients in model 4 and model 5 tell how much one unit of any variable influences adjusted stock market correlation. Utilizing Equation (4), column 3 and column 4 reports how much one unit of trust variables will influence stock market correlation corresponding to coefficients of model 4 and model 5. The mean of stock market correlations over countries is 0.60.

[Table 8 about here.]

In Table 8, *Particular trust_AB* is positively related with adjusted stock market correlation by 0.986, and *Particular trust_BA* is positively related with adjusted stock market correlation by 0.648. Column 3 shows that one percentage of increase in *Particular trust_AB* causes the unadjusted stock market correlation to increase by 31.6 percentages in column 3. Meanwhile, one percentage of increase in *Particular trust_BA* causes the unadjusted stock market correlation to increase by 20.7 percentages in column 4. For these, it is clear that trust plays an important role in driving stock market correlation using particular trust data.

We have come to the conclusion that generalized trust is a determinant of stock market correlation from the previous sections. Taken together, trust is therefore an important determinant of the financial market linkage, for both types of trust.

The signs of the control variables are generally the same as that in Table 5. The variable the log of geographic distance is not included as these 15 European countries have small differences in geographic distance among countries.

6. Conclusion

Financial markets not only provide liquidity but also influence portfolio allocation and real sector decision-making. For portfolio managers, understanding the determinants of capital market linkages facilitates the pursuit of international diversification rewards. As for policy makers, it is one of the main causes of financial regulations to shield against financial contagion and thus improve financial stability. Our analysis contributes to previous findings by providing a key explanatory variable, trust, to study the impetus of the correlations between the stock market returns.

We have tested for the effect of country-specific generalized trust and the difference of generalized trusts between two countries on stock market correlation. Moreover, we have constructed a distance category categorized by the geographic distances between major cities, and we have added interaction terms between the trust and distance category to check the heterogeneous trust effects. To do this, we created a dataset including 1891 country-pairs over ten years and applied panel regressions conditional on a number of control variables. The control variables are GDP growth, bilateral trade, market size, common border dummy, common currency dummy, geographical distance, civil liberty development, broadband infrastructure, and volatility. The result is that trust makes a positive effect on stock market correlation, that is, stock market returns move together more in trusting countries than in mistrusting countries. Furthermore, the trust effect on stock market correlation is larger in countries located close to each other, and it is smaller in countries that are more distant from one other. In the next step, we used particular trust data as an alternative test to check the effect of trust on stock market correlation and found that the trust effect still holds. In conclusion, our results suggest that trust, measured either by generalized trust or particular trust, is a determinant of stock market correlation.

Our results could have some implications for international diversification. For actively managed portfolio managers, it is mostly favorable to hold stocks on markets

where the trust level is low to construct a portfolio with low stock market correlation, if all other factors are equal. Meanwhile for hedging, it is preferable to make investments in markets where the trust level is high, if all other factors are equal. Higher returns correlation provides minimized risks to hedge funds that are able to do short transactions.

In the future, this can be refined by using some specific trust measures, such as the investors' trust in financial institutions, banks, and the stock market.

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Table 1: Descriptive statistics for unadjusted stock market correlations.

	Mean	Median	Std. dev.	Min	Max	Skewness	Kurtosis	n
Panel A: by country								
Argentina	0.19	0.13	0.20	-0.19	0.78	0.77	2.69	610
Australia	0.23	0.22	0.17	-0.25	0.73	0.27	2.71	610
Austria	0.29	0.27	0.24	-0.13	0.85	0.42	2.22	610
Bangladesh	0.01	0.02	0.06	-0.21	0.35	0.15	4.29	610
Belgium	0.33	0.28	0.27	-0.18	0.91	0.43	2.09	610
Brazil	0.22	0.18	0.20	-0.16	0.82	0.66	2.72	610
Bulgaria	0.07	0.04	0.13	-0.17	0.57	1.24	4.28	610
Canada	0.24	0.21	0.21	-0.18	0.81	0.41	2.29	610
Chile	0.23	0.21	0.19	-0.13	0.69	0.40	2.34	610
China	0.06	0.05	0.10	-0.18	0.51	0.77	4.12	610
Colombia	0.15	0.08	0.19	-0.27	0.66	1.01	3.02	610
Croatia	0.15	0.11	0.17	-0.23	0.66	1.19	3.82	610
Czech	0.28	0.26	0.21	-0.16	0.77	0.24	2.18	610
Denmark	0.33	0.33	0.24	-0.12	0.90	0.17	2.00	610
Ecuador	0.00	0.00	0.06	-0.23	0.24	-0.04	3.65	610
Egypt	0.10	0.07	0.13	-0.16	0.55	0.80	3.02	610
Estonia	0.17	0.15	0.14	-0.11	0.69	0.53	3.06	610
Finland	0.32	0.30	0.26	-0.17	0.90	0.28	2.03	610
France	0.37	0.34	0.30	-0.17	0.96	0.31	1.99	610
Germany	0.36	0.35	0.27	-0.13	0.92	0.21	1.94	610
Greece	0.27	0.25	0.21	-0.13	0.75	0.35	2.22	610
Hong Kong	0.27	0.28	0.19	-0.11	0.78	0.07	2.43	610
Hungary	0.26	0.26	0.20	-0.17	0.71	0.12	2.10	610
Iceland	0.08	0.05	0.13	-0.27	0.61	1.34	5.80	610
India	0.21	0.19	0.16	-0.14	0.67	0.28	2.30	610
Indonesia	0.20	0.16	0.17	-0.17	0.76	0.50	2.55	610
Ireland	0.29	0.29	0.22	-0.18	0.78	0.26	2.08	610
Israel	0.22	0.22	0.18	-0.17	0.61	0.20	2.14	610
Italy	0.34	0.31	0.28	-0.14	0.95	0.35	2.03	610
Japan	0.22	0.22	0.17	-0.22	0.74	0.34	2.82	610
Jordan	0.05	0.04	0.10	-0.19	0.44	0.86	4.43	610
Kenya	0.03	0.01	0.08	-0.25	0.30	0.73	3.82	610
Kuwait	0.04	0.03	0.07	-0.18	0.33	0.40	3.62	610
Latvia	0.06	0.04	0.11	-0.20	0.65	1.35	5.27	610
Lithuania	0.12	0.08	0.14	-0.16	0.69	1.26	4.24	610
Luxembourg	0.21	0.21	0.16	-0.14	0.66	0.26	2.47	610
Malaysia	0.18	0.15	0.16	-0.20	0.76	0.59	2.85	610
Malta	0.02	0.02	0.07	-0.19	0.30	0.17	3.19	610
Mexico	0.25	0.23	0.21	-0.15	0.82	0.38	2.29	610
Morocco	0.04	0.02	0.10	-0.14	0.38	1.01	3.88	610
Netherlands	0.35	0.33	0.28	-0.16	0.96	0.36	2.13	610
Norway	0.32	0.32	0.24	-0.12	0.82	0.09	1.91	610
Pakistan	0.04	0.04	0.07	-0.15	0.26	0.07	2.79	610
Peru	0.20	0.17	0.18	-0.13	0.70	0.69	2.95	610
Philippines	0.13	0.11	0.14	-0.17	0.60	0.81	3.46	610
Poland	0.28	0.27	0.20	-0.11	0.77	0.25	2.24	610
Portugal	0.30	0.29	0.23	-0.15	0.86	0.29	2.16	610
Romania	0.13	0.06	0.18	-0.21	0.70	1.17	3.38	610
Russian	0.24	0.20	0.20	-0.19	0.70	0.49	2.29	610
Singapore	0.28	0.30	0.19	-0.12	0.78	0.02	2.30	610

Slovak	0.02	0.02	0.06	-0.17	0.24	-0.12	3.16	610
Slovenia	0.11	0.08	0.13	-0.15	0.59	1.22	4.38	610
South Africa	0.29	0.29	0.21	-0.12	0.75	0.13	2.07	610
South Korea	0.24	0.26	0.17	-0.19	0.74	0.13	2.75	610
Spain	0.35	0.33	0.28	-0.14	0.94	0.31	2.02	610
Sweden	0.35	0.33	0.27	-0.15	0.92	0.25	1.92	610
Switzerland	0.33	0.29	0.27	-0.18	0.91	0.37	2.08	610
Thailand	0.20	0.20	0.15	-0.13	0.64	0.31	2.60	610
Turkey	0.23	0.18	0.20	-0.12	0.71	0.64	2.39	610
UK	0.36	0.34	0.28	-0.19	0.96	0.27	1.96	610
US	0.21	0.16	0.21	-0.14	0.81	0.66	2.53	610
Venezuela	0.04	0.03	0.07	-0.17	0.31	0.47	3.77	610
Panel B: by year								
2000	0.13	0.09	0.17	-0.25	0.79	1.02	3.90	3782
2001	0.15	0.10	0.18	-0.19	0.90	1.12	4.19	3782
2002	0.15	0.08	0.20	-0.20	0.96	1.42	4.96	3782
2003	0.14	0.09	0.18	-0.17	0.94	1.43	5.48	3782
2004	0.16	0.12	0.18	-0.21	0.95	1.29	4.99	3782
2005	0.14	0.09	0.18	-0.18	0.90	1.34	4.90	3782
2006	0.22	0.15	0.22	-0.17	0.95	0.86	2.98	3782
2007	0.27	0.25	0.24	-0.18	0.94	0.40	2.23	3782
2008	0.36	0.38	0.25	-0.27	0.96	-0.01	2.28	3782
2009	0.28	0.27	0.24	-0.17	0.94	0.31	2.21	3782

Notes: The mean of stock market correlation in country *i* is the average of stock market correlation between country *i* and the other 61 countries over a ten-year periods. The mean of stock market correlation in each year is the average of all pair-wise stock market correlations among 62 countries in each year.

Table 2: The country-specific level of generalized trust

Country	Trust	Country	Trust	Country	Trust
Sweden	64.27	Belgium	31.36	Slovak	21.19
Norway	63.87	Luxembourg	30.53	Croatia	21.01
Denmark	60.73	Russian	30.15	Poland	20.01
Finland	57.97	South Korea	30	Portugal	20.01
Thailand	54.17	Italy	29.65	South Africa	19.61
Netherlands	53.57	Jordan	29.38	Slovenia	19.57
China	52	Bulgaria	28.97	Argentina	19.39
Canada	48.96	Estonia	28.2	Latvia	18.46
Australia	47.07	Egypt	28.15	Morocco	18.14
Iceland	45.34	Hungary	26.28	Chile	17.24
Indonesia	44.55	Czech	26.24	Romania	16.62
Switzerland	44.33	Pakistan	25.72	Colombia	16.28
US	41.51	Malta	24.62	Ecuador	16.1
Japan	39.71	Mexico	24.21	Venezuela	14.11
Ireland	39.06	Israel	23.46	Peru	9.9
Germany	37.72	Kuwait	23.41	Kenya	9.8
Austria	37.58	Lithuania	23.03	Malaysia	9.56
UK	36.45	Singapore	22.45	Turkey	8.99
India	33.87	France	22.28	Philippines	7.57
Spain	32.81	Bangladesh	22.22	Brazil	5.77
Hong Kong	32.24	Greece	21.65		

Table 3: Descriptive statistics and missing observations

Variable	Obs	Missing	Share	Mean	Std.Dev.	Min	Max
Correlation	18910	0	0	0.20	0.22	-0.27	0.96
Growth	18609	301	1.59%	3.33	2.93	0.00	26.16
Trade Intensity	18511	399	2.11%	-4.51	2.52	-17.29	2.45
Market Size	18433	477	2.52%	5353.46	9179.28	7.27	181863.40
Border	18910	0	0	0.04	0.19	0.00	1.00
Common Currency	18910	0	0	0.04	0.19	0.00	1.00
Geographic distance	18910	0	0	6729	4688	59.61	19772.34
LogDistance	18910	0	0	8.47	0.97	4.74	9.89
Legal Origin	18910	0	0	0.25	0.43	0.00	1.00
Civil Liberty	18300	610	3.23%	1.53	1.32	0.00	5.00
Broadband	17645	1265	6.69%	104.32	203.80	0.00	1336.26
Volatility	18910	0	0	1.24	1.14	0.25	4.23

Note: Correlation represents the unadjusted stock market correlation across countries. Geographic distance presents the simple distance between the major cities of two countries, in km, whereas logDistance presents the logarithm of geographic distance ($logDistance_{ij}$) between the major cities of two countries.

Table 4: Correlation matrix between variables for 62 countries

		[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
Correlation	[1]	0.1760***	0.2300***	0.0640***	-0.1805***	0.4118***	0.0180**	-0.2594***	-0.2949***	0.2429***	0.1639***	0.3344***	0.0939***
trust_A	[2]		-0.0157**	0.2788***	-0.0060	0.1381***	0.0146**	-0.1152***	0.0474***	0.0000	0.0055	0.0755***	0.1089***
trust_B	[3]			0.2730***	-0.1046***	0.1697***	0.0510***	-0.0958***	-0.0586***	-0.0000	-0.0112	0.0424***	0.1473***
trust_diff	[4]				-0.0356***	0.0403***	-0.0114	0.0973***	0.0832***	0.0000	-0.0817***	-0.0446***	0.2509***
Growth	[5]					-0.0874***	-0.0337***	0.0386***	0.1547***	0.1029***	-0.0613***	-0.1043***	0.0677***
Trade Intensity	[6]						-0.0456***	-0.2202***	-0.1034***	0.0388***	0.2635***	0.1551***	-0.0500***
Market Size	[7]							0.0887***	0.0232***	-0.0848***	-0.0525***	-0.0580***	0.1561***
Distance	[8]								0.2615***	-0.0000	-0.4004***	-0.2904***	0.0995***
Civil Liberty	[9]									0.0064	-0.1113***	-0.1961***	0.1875***
Volatility	[10]										0.0000	0.0249***	0.1602***
Border	[11]											0.1685***	-0.1022***
Common Currency	[12]												-0.0680***
Broadband	[13]												1.0000

Note: Correlation represents the unadjusted stock market correlation across countries. Trust_A and trust_B represent the country-specific generalized trust levels. Trust_diff denotes the absolute difference between generalized trusts between country-pairs (A, B). ***, **, * stand for significance at the 1%, 5% and 10% levels, respectively.

Table 5: Impact of generalized trust on stock market correlations: Panel regression random effects (include interaction terms (IT))

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 1	(5) Model 2	(6) Model 3
trust_A	0.004***	-	-	0.002***	-	-
	(0.001)	-	-	(0.001)	-	-
trust_B	0.004***	-	-	0.002***	-	-
	(0.001)	-	-	(0.001)	-	-
trust_diff	-	0.001	-	-	0.000	-
	-	(0.001)	-	-	(0.001)	-
Distance_short*trust_A	-	-	0.005***	-	-	0.002***
	-	-	(0.001)	-	-	(0.001)
Distance_medium*trust_A	-	-	0.003***	-	-	0.001***
	-	-	(0.001)	-	-	(0.001)
Distance_long*trust_A	-	-	0.002***	-	-	0.001***
	-	-	(0.001)	-	-	(0.001)
Distance_short*trust_B	-	-	0.006***	-	-	0.003***
	-	-	(0.001)	-	-	(0.001)
Distance_medium*trust_B	-	-	0.002***	-	-	0.001***
	-	-	(0.001)	-	-	(0.001)
Distance_long*trust_B	-	-	0.001**	-	-	0.001**
	-	-	(0.001)	-	-	(0.001)
Growth	-0.011***	-0.011***	-0.011***	-	-	-
	(0.001)	(0.000)	(0.001)	-	-	-
Trade Intensity	0.057***	0.061***	0.058***	-	-	-
	(0.003)	(0.003)	(0.003)	-	-	-
Market Size	0.000***	0.000***	0.000***	-	-	-
	(0.000)	(0.000)	(0.000)	-	-	-
Distance	-0.062***	-0.077***	-	-	-	-
	(0.010)	(0.011)	-	-	-	-
Border	0.085	0.046	0.109	-	-	-
	(0.076)	(0.081)	(0.070)	-	-	-
Common Currency	0.350***	0.349***	0.329***	-	-	-
	(0.055)	(0.056)	(0.054)	-	-	-
Civil Liberty	-0.059***	-0.057***	-0.055***	-	-	-
	(0.005)	(0.005)	(0.005)	-	-	-
Broadband	0.013***	0.013***	0.013***	-	-	-
	(0.001)	(0.001)	(0.001)	-	-	-
Volatility	0.112***	0.112***	0.112***	-	-	-
	(0.002)	(0.002)	(0.002)	-	-	-
Constant	0.860***	1.210***	0.335***	-	-	-
	(0.099)	(0.103)	(0.032)	-	-	-
N	16473	16473	16473	-	-	-
adj. R^2	0.40	0.38	0.42	-	-	-
F test	8102.91	7944.50	3258.31	-	-	-

Note: ***, ** and * denote the significance level of estimates at 1, 5, and 10 percent levels respectively. The trust variables used in estimations are the country-specific generalized trust. *Distance_short* means the short distance category, which is equal to one if the geographic distance is less than 3200 km. *Distance_medium* means the medium distance category, which is equal to one if the geographic distance is larger than 3200 km and less than 12000 km. *Distance_long* means the long distance category, which is equal to one if the geographic distance is larger than 12000 km.

Table 6: Particular trust data of the percentage of respondents living in country A who trust people from country B, where the first column lists country A and the first row lists country B.

	AUSTRIA	BELGIUM	DENMARK	FINLAND	FRANCE	GERMANY	GREECE	IRELAND	ITALY	LUXEM.	NETHER.	PORTUGAL	SPAIN	SWEDEN	UK
AUSTRIA	0.92	0.63	0.63	0.61	0.48	0.82	0.42	0.49	0.44	0.76	0.75	0.40	0.47	0.73	0.49
BELGIUM	0.62	0.85	0.65	0.62	0.68	0.64	0.42	0.56	0.47	0.84	0.73	0.47	0.53	0.66	0.61
DENMARK	0.81	0.67	0.94	0.83	0.59	0.79	0.46	0.68	0.45	0.77	0.86	0.50	0.52	0.89	0.84
FINLAND	0.76	0.61	0.78	0.92	0.65	0.65	0.48	0.63	0.42	0.64	0.71	0.45	0.41	0.84	0.74
FRANCE	0.65	0.82	0.71	0.71	0.90	0.71	0.50	0.65	0.63	0.80	0.69	0.64	0.72	0.73	0.49
GERMANY	0.74	0.61	0.72	0.63	0.69	0.86	0.50	0.47	0.46	0.72	0.68	0.46	0.54	0.73	0.55
GREECE	0.37	0.35	0.31	0.38	0.43	0.28	0.89	0.38	0.44	0.34	0.33	0.44	0.52	0.48	0.27
IRELAND	0.58	0.55	0.56	0.50	0.67	0.53	0.39	0.90	0.54	0.53	0.63	0.45	0.49	0.59	0.62
ITALY	0.53	0.56	0.67	0.62	0.66	0.54	0.44	0.58	0.72	0.68	0.74	0.56	0.66	0.68	0.55
LUXEMBOURG	0.67	0.57	0.61	0.54	0.67	0.70	0.35	0.50	0.54	0.90	0.76	0.52	0.57	0.60	0.56
NETHERLANDS	0.73	0.79	0.87	0.80	0.50	0.71	0.43	0.70	0.38	0.87	0.91	0.59	0.54	0.87	0.73
PORTUGAL	0.51	0.31	0.46	0.47	0.56	0.38	0.37	0.43	0.48	0.54	0.56	0.86	0.44	0.54	0.57
SPAIN	0.49	0.52	0.52	0.48	0.48	0.54	0.44	0.47	0.59	0.50	0.58	0.53	0.88	0.55	0.38
SWEDEN	0.80	0.62	0.88	0.86	0.61	0.71	0.51	0.71	0.52	0.64	0.74	0.52	0.50	0.89	0.81
UK	0.60	0.53	0.61	0.60	0.44	0.37	0.40	0.61	0.47	0.51	0.68	0.50	0.44	0.68	0.84

Note: LIXEM. denotes LUXEMBOURG, while *NETHER*. denotes NETHERLANDS.

Table 7: The correlation matrix between particular trust and generalized trust for particular trust data

	Particular trust_AB	Particular trust_BA	Generalized trust_A	Generalized trust_B
Particular trust_AB	1.00	0.71	0.25	0.54
Particular trust_BA		1.00	0.42	0.46
Generalized trust_A			1.00	-0.07
Generalized trust_B				1.00

Note: Particular trust_AB stands for the percentage of agents in country A have trust in people living in country B, and *Particular trust_BA* stands for the percentage of agents in country B have trust in people living in country A. *Generalized trust_A* and *Generalized trust_B* stand for the country-specific generalized trust levels in country A and country B, respectively.

Table 8: Random effects panel data regression for particular trust data

	(1) Model 1	(2) Model 2	(3) Model 1	(4) Model 2
Particular trust_AB	0.986***		0.316***	
	(0.342)		(0.342)	
Particular trust_BA		0.648*		0.207*
		(0.370)		(0.370)
Growth	-0.006	-0.007		
	(0.012)	(0.012)		
Market Size	-0.003***	-0.003***		
	(0.000)	(0.000)		
Civil Liberty	-0.255***	-0.259***		
	(0.039)	(0.040)		
Volatility	0.209***	0.209***		
	(0.007)	(0.007)		
Broadband	0.030***	0.030***		
	(0.004)	(0.004)		
constant	0.704***	0.920***		
	(0.204)	(0.239)		
N	1050	1050		
adj. R^2	0.26	0.25		
F test	2010.86	2072.61		

Note: ***, ** and * denote the significance level of estimates at 1, 5, and 10 percent levels respectively.

Appendix 1: Calculate derivatives of standard stock market correlation.

The derivatives of the correlation by Fisher's z transformationare:

$$\frac{\partial \overline{\rho}_{ij,t}}{\partial x} = \frac{\partial \ln\left(\frac{1+\rho_{ij,t}}{1-\rho_{ij,t}}\right)}{\partial x} = \frac{1}{\frac{1+\rho_{ij,t}}{1-\rho_{ij,t}}} * \frac{\partial \frac{1+\rho_{ij,t}}{1-\rho_{ij,t}}}{\partial x}$$

$$= \frac{1-\rho_{ij,t}}{1+\rho_{ij,t}} * \frac{\frac{\partial\left(1+\rho_{ij,t}\right)}{\partial x} * \left(1-\rho_{ij,t}\right) - \left(1+\rho_{ij,t}\right) * \frac{\partial\left(1-\rho_{ij,t}\right)}{\partial x}}{\left(1-\rho_{ij,t}\right)^2}$$

$$= \frac{\frac{\partial \rho_{ij,t}}{\partial x} * \left(1-\rho_{ij,t}\right) - \left(1+\rho_{ij,t}\right) * \frac{\partial\left(-\rho_{ij,t}\right)}{\partial x}}{\left(1+\rho_{ij,t}\right) * \left(1-\rho_{ij,t}\right)}$$

$$= \frac{\frac{\partial \rho_{ij,t}}{\partial x} * \left(1-\rho_{ij,t}\right) - \left(1+\rho_{ij,t}\right) * \frac{-\partial\left(\rho_{ij,t}\right)}{\partial x}}{\left(1+\rho_{ij,t}\right) * \left(1-\rho_{ij,t}\right)}$$

$$= \frac{\frac{\partial \rho_{ij,t}}{\partial x} * \left(1-\rho_{ij,t}\right) + \left(1+\rho_{ij,t}\right) * \frac{\partial \rho_{ij,t}}{\partial x}}{\left(1+\rho_{ij,t}\right) * \left(1-\rho_{ij,t}\right)} = \frac{2\frac{\partial \rho_{ij,t}}{\partial x}}{\left(1+\rho_{ij,t}\right) * (1-\rho_{ij,t})}$$

Therefore the derivative of standard stock market correlation is:

$$\frac{\partial \rho_{ij,t}}{\partial x} = \frac{\left(1+\rho_{ij,t}\right) * \left(1-\rho_{ij,t}\right)}{2} * \frac{\partial \overline{\rho}_{ij,t}}{\partial x}$$

In calculation, we use the average stock market correlation, $E(\rho_{ij,t})$ as an approximation of $\rho_{ij,t}$.

IV

Stock exchange integration and price jump risks
- The case of the OMX Nordic exchange mergers

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Abstract: The impact of the stock market mergers that took place in the Nordic countries during 2000 – 2007 on the probabilities for stock price jumps, i.e. for relatively extreme price movements, are studied. The main finding is that stock market mergers, on average, reduce the likelihood of observing stock price jumps. The effects are asymmetric in the sense that the probability of sudden price jumps is reduced for large and medium size firms whereas the effect is ambiguous for small size firms. The results also indicate that the market risk has been reduced after the stock market consolidations took place.

Keywords: Tests for jumps; International financial markets; Market structure; Integration; Common trading platform; Mergers, Acquisitions

JEL: C22; C51; C58; L10; G15; G34.

1. Introduction

In the last decade, there has been a trend of merging stock markets to create larger and more attractive trading platforms. Examples are the Euronext merger in 2005 (where the New York Stock Exchange, NYSE, acquired Euronext), the OMX mergers of the Nordic and Baltic exchanges during 2003 – 2006 which ended with NASDAQ acquiring the OMX exchange in 2007, the London Stock Exchange merger with Borsa Italia in 2007 and the acquisition by Intercontinental Exchange (ICE) of the NYSE Euronext in 2013.[1] At the same time, stock markets have also been deregulated and opened up to allow for more competition. The latter process has been facilitated by the creation of, for example, Multilateral Trading Facilities (MTF)[2].

A natural question in the presence of these trends is whether the creation of common cross-border stock trading platforms affects the quality of equity markets? Earlier studies have found that stock market mergers do influence the market structure in different ways. For example, Pagano and Padilla (2005) find that the Euronext merger has resulted in lower bid-ask spreads, greater volume and lower volatility. Similar results are reported by Nielsson (2009) who finds that the Euronext merger has increased the liquidity (in terms of turnover, which is defined as the number of shares traded in a particular firm relative to the number of outstanding shares) for large, but not for small and medium size firms. Hellström et al. (2013) find that return correlations increased after the Nordic stock exchange mergers and Hellström et al. (2014), in turn, report that the consolidation of the Nordic stock exchanges have had a positive effect on both information efficiency and on the turnover for an average firm. Khan and Vieito (2012) find a tendency for improved market efficiency after the Euronext mergers while Charles et al. (2014) test the relationship between mergers and market efficiency in a number of countries and find that stock market mergers more often than not improve market efficiency. In particular, Charles et al find that (i)

[1] Euronext is a common stock exchange for Belgium, France, the Netherlands, Portugal and the UK. OMX operates eight exchanges based in the Nordic and Baltic countries and since 2008 has been part of the NASDAQ OMX group. NYSE and NASDAQ are American stock exchanges. Borsa Italiana is the largest Italian exchange. Intercontinental Exchange (ICE) is a US network of exchanges and clearing houses which owns and operates 23 regulated exchanges and marketplaces. Euronext was split from ICE through an initial public offering in June 2014.

[2] In Europe the introduction of the Markets in Financial Instruments Directive (MiFID) in 2007 has stimulated competition between financial trading venues in Europe by allowing the creation of alternative non-regular trading facilities, MTF.

mergers in developed markets, (ii) mergers of large stock exchanges or (iii) cross-border stock exchange mergers improve market efficiency.

Although these earlier studies have contributed to our understanding of how stock exchange mergers may influence market quality, there are not yet any studies which have looked at how stock exchange mergers may affect the likelihood of observing extreme price fluctuations (also referred to as price jumps). The purpose of this paper is to do just that. A price jump is defined as a deviation from the current normal variation in a stock price, where the current normal price variation follows an assumed specific structure which may change over time. This means that a price jump is not just a rate of return above a certain level. Rather, it is a relative concept which depends on the "normal" variation. For example, a 2% rate of return may be viewed as normal during a period of high stock market volatility whereas a 2% rate of return may be viewed as high (i.e. a classified as a price jump) during a calm period.

To address the question of how a stock exchange merger affects price jumps, we study how the process towards a uniform stock trading platform in the Nordic countries in 2000-2007 influenced the probabilities of observing price jumps. The consolidation of the Nordic trading platform was initiated in September 2003 when the stock exchange in Stockholm, Sweden, (OM) merged with the stock exchange in Helsinki, Finland, (HEX) into a unified trading platform called OMX. In October 2005, OMX acquired the stock exchange in Copenhagen, Denmark, and in 2006 OMX also acquired the Icelandic stock exchange. The final step in this process took place on February 27, 2008, when NASDAQ took over OMX.

Why should a consolidation of stock exchanges influence the frequency of price jumps? Here the arguments are based on the observation that stocks which before a merger were listed on isolated stock exchanges, after a merger are accessible to a larger pool of investors. This means that the stock market after a merger may deepen in the sense that the order books contain more buy and sell orders, and that the orders are possibly more evenly distributed than before the merger. As a consequence, there are fewer gaps in the order books which means that individual (large) trades are less likely than before to cause sudden price jumps. This hypothesis is supported by Farmer et al (2004) who find that when a gap exists in the order book, a new order can trigger a price jump. Another possible implication of a stock market merger is that it changes the composition of informed and uninformed investors, where informed investors are professionals who know how to value assets according to the standard

models whereas uninformed investors may have little or no knowledge of how to value a risky asset. If the number of informed investors that follow a given stock increases (after a merger has taken place), then the price of that stock is less likely to deviate from its fundamental price than before. As a consequence, the probability of observing sudden price jumps may be reduced.

To the best of our knowledge, there are no previous studies which have looked at how stock exchange mergers may affect price jumps. The previous literature on price jumps has primarily focused either on the problem of identifying price jumps (Barndorff-Nielsen and Shephard, 2006; Chan and Maheu, 2002; Huang and Tauchen, 2005) or on the question of what type of factors may cause sudden price jumps. For example, Lahaye et al. (2011) study how markets react to unexpected macroeconomic information releases and to market news announcements whereas Lee (2012) looks at how firm-specific news releases, such as earnings releases and analyst recommendations, affect price jumps. Kim and Mei (2001), in turn, study how political events and political developments influence price jumps while Farmer et al. (2004) study the link between gaps in the order book and price jumps. However, less is known about how changes in the market structure may affect the underlying process that generates price jumps.

Studying the relationship between stock exchange mergers and price jumps is important for several reasons. First, since extreme price jumps represent a major risk for stock market participants it is important, both from a risk management perspective and for option pricing, to have a clear understanding of what mechanisms influence the likelihood of observing stock price jumps. Second, it is also of interest for policy makers/regulators to have a better understanding of how mergers affect the functioning of the stock market because this will provide them with a better understanding of what to expect from possible future stock market reforms. Third, this study also contributes to the existing literature by highlighting that stock exchange mergers may also affect price jumps.

To study if the price jump probabilities have been affected by the consolidation of the Nordic stock exchanges,[3] we use a two-step procedure. First, a mixed EARJI-GARCH model (Hellström et al., 2012) is used to identify the probability of a price jump for each firm in our sample. Then we use the estimated jump probabilities as a

[3] Icelandic stocks are excluded from the subsequent analysis due to lack of data.

dependent variable in a regression linking the jump probabilities to different explanatory variables, including dummy variables based on the dates of the stock market mergers. Since the price jump probabilities are likely to depend on the prevailing market sentiment (i.e. the current volatility of the market, which will be referred to as the market risk) which in turn may also be affected by the stock exchange mergers, we in the second-step regressions estimate a simultaneous equation system where both the jump probability and the market risk are dependent variables. This simultaneous equation system is aimed at testing whether, and to what extent, the frequency of price jumps changed after the Swedish and the Finnish stock markets merged on September 3, 2003 and after the Danish stock market joined the common trading platform on January 3, 2005. In the analysis, we also study merger effects based on different groupings of the firms, such as location and size. In all estimations, we use the market capitalisation of individual firms to control for market size, a dummy variable to control for the stock market bubble around 2000 and the variance and the trend, respectively, of the All Share Index in all countries to control for the overall stock market sentiment. In addition, we also test whether the stock market mergers have had asymmetric effects on the probabilities of observing positive and negative jumps.

The analysis yields a number of interesting results. One is that the probability of price jumps has decreased after the stock market mergers. Another finding is that the effects are asymmetric in the sense that the probabilities of sudden price jumps have been reduced for large and medium size firms whereas the effect is ambiguous for small size firms. It is also found that the probability of observing positive jumps increases, whereas the probability of observing negative price jumps decreases, for an average firm after the mergers. Finally, we find that price jumps for individual firms are positively related to market risk.

The paper is organised as follows. In section 2, a short description of the OMX mergers, a brief overview of price jump modelling, as well as the econometric framework, are outlined. The data is presented in section 3, while the results are presented in section 4. Section 5 presents robustness checks and some extensions, while section 6 draws conclusions.

2. History of the Nordic stock exchange mergers and econometric specification

2.1 The OMX mergers

In 1998, the stock exchanges in Copenhagen and Stockholm entered a strategic partnership, called the NOREX Alliance, which aimed to facilitate the interaction between the Nordic exchanges without formally merging them. The NOREX Alliance implemented a joint trading system for equity trading called SAXESS with common trading rules and membership requirements. Within the NOREX Alliance, the Copenhagen Stock Exchange and the OM Stockholm Exchange used the same trading system for equities and they also harmonised their respective trading rules. The Icelandic Stock Exchange joined the alliance in 2000 by moving its share trading to the common trading system SAXESS and the Oslo stock exchange joined in 2001.

In addition to this alliance, formal mergers between the Stockholm, Copenhagen, Helsinki, and Icelandic stock exchanges also took place via the OMX Nordic mergers (today NASDAQ-OMX). In 2003 the Stockholm stock exchange (OMX) merged with the Helsinki (HEX) stock exchange to form a common trading platform called OMHEX. The OMHEX changed its name to OMX in 2004. In 2005, the OMX acquired the Copenhagen stock exchange. In 2006, the OMX Nordic Exchange brand (Stockholm, Helsinki and Copenhagen) was launched together with common listings of all Nordic companies. Finally in 2006, the Icelandic stock exchange merged with OMX.

2.2 Modelling price jumps; a brief overview

To model price jumps a class of GARCH-jump mixture models have been used in various contexts. Jorion (1988) uses a mixed jump-diffusion process to investigate the existence of discontinuities in the sample path of exchange rates and of a stock market index. Chan and Young (2006) apply a bivariate GARCH-jump model to study optimal hedging behaviour of agents trading in the spot and in the futures markets for copper. By using the bivariate GARCH-model, Chan and Young significantly improve the estimations of the jump dynamics in a time-varying optimal hedging strategy. Daal et al. (2007), in turn, find that the asymmetric GARCH jump model provides a better fit for the dynamics of the equity returns in the US and in the emerging Asian markets. Chan and Maheu (2002) extended the GARCH-jump mixture models by adding a time-varying autoregressive moving average (ARMA) jump intensities component. Chan and Maheu (2002) named it the ARJI-GARCH jump model and showed that it produces a good fit for stock market volatility. In a further extension of the ARJI-GARCH jump model, Hellström et al. (2012) employ

an exponential version of the time-varying autoregressive moving average jump intensities model to account for asymmetric responses to jump innovations. That model is referred to as a mixed EARJI-GARCH jump model and it will be used to identify price jumps in our analysis.

The mixed EARJI-GARCH jump model is a discrete time series model which includes a time-varying conditional variance component (GARCH) and an exponential autoregressive jump component. Here the GARCH parameterisation captures the "normal" variation, allowing for volatility clustering, whereas the jump component captures large infrequent price movements.

2.3 The EARJI-GARCH jump model

If we let *P* denote the stock price, the return of stock i at time t is given by $r_{it} = \log(P_{it}/P_{it-1})$. Conditional on the information available up to time $t-1$ for stock i, $\phi_{it-1} = \{r_{it-1}, \dots, r_{i1}\}$, the return in period t for stock i, r_{it}, is captured by the following EARJI-GARCH jump model specification:

$$r_{it} = \mu_{it} + \varepsilon_{1t,i} + \varepsilon_{2t,i}, \quad \mu_{it} = \alpha_{0i} + \sum_{l=1}^{L} \alpha_{li} r_{it-l}, \tag{1}$$

$$\varepsilon_{1t,i} = \sigma_{it} z_{it}, \quad z_{it} \sim N(0,1)$$

where μ_{it} is the time-varying conditional mean return of stock i. Here $\varepsilon_{1t,i}$ is a random disturbance term associated with the "normal" price variation of stock i whereas $\varepsilon_{2t,i}$ is a jump innovation component that is associated with more infrequent "non-normal" market movements of stock i. The random terms $\varepsilon_{1t,i}$ and $\varepsilon_{2t,i}$ are assumed to be independent, and $\varepsilon_{1t,i}$ is assumed to be a normal i.i.d. mean-zero innovation. The volatility, σ_{it}, is assumed to follow a GARCH(p,q) process (Bollerslev, 1986) given by:

$$\sigma_{it}^2 = \omega_{0i} + \sum_{l=1}^{p} \beta_{1,il}\, \sigma_{i,t-l}^2 + \sum_{l=1}^{q} \beta_{2,il}\, \varepsilon_{i,t-l}^2, \tag{2}$$

where the total residual, $\varepsilon_{i,t-1}$, is defined as $\varepsilon_{i,t-1} = r_{i,t-1} - \mu_{i,t-1} = \varepsilon_{1t-1,i} + \varepsilon_{2t-1,i}$. As such the total residual contains the jump component which via equation (2) influences the volatility.

The jump innovation component $\varepsilon_{2t,i}$ in Eq. (1) is defined as:

$$\varepsilon_{2t,i} = \sum_{k=1}^{n_{it}} Y_{it,k} - E\left(\sum_{k=1}^{n_{it}} Y_{it,k}\right) \tag{3}$$

where the $k{:}\,th$ jump size of stock i, $Y_{it,k}$, is assumed to be independently and normally distributed with mean jump size θ_i and variance δ_i^2. The expected value of the jump component is by construction zero, i.e. $E(\varepsilon_{2t,i}) = 0$.

Let $n_{it} \in \{1,2,\dots\}$ denote the number of jumps occurring over the time interval $(t-1,t)$. Conditional on the information set ϕ_{it-1}, n_{it} is assumed to be governed by a Poisson distribution and the conditional density function for n_{it} is given by

$$\Pr\left(n_{it} = k \middle| \phi_{i,t-1}\right) = \frac{\exp\left(-\lambda_{it}\right)\lambda_{it}^{k}}{k!},\ k\ =\ 0,1,2\dots \tag{4}$$

where λ_{it} is the jump intensity and $\mathrm{E}[\mathrm{n_{it}}|\phi_{\mathrm{i,t-1}}] \equiv \lambda_{\mathrm{it}}$. To allow the conditional expected value of n_{it} to be non-negative and time-varying, λ_{it} is specified to follow a first-order exponential autoregressive process (EARJI(1,1)):

$$\ln(\lambda_{it}) = \gamma_{0\mathrm{i}} + \gamma_{1\mathrm{i}} \ln\left(\lambda_{i,t-1}\right) + \gamma_{2\mathrm{i}}\xi_{i,t-1} \tag{5}$$

where the parameter $\gamma_{1\mathrm{i}}$ denotes persistency and $\gamma_{2\mathrm{i}}$ denotes the impact of jump shocks on $\ln(\lambda_{it})$. The exponential specification of the jump intensity, λ_{it}, in Eq. (5) allows for both positive and negative shocks (captured by ξ_{t-1}) to the current value of λ_{it}. Depending on the sign of $\gamma_{2\mathrm{i}}$, these shocks may be asymmetric. For example, if $\gamma_{2\mathrm{i}}$ is positive then a positive shock has a larger impact on the current level of λ_{it} than a negative shock of equal magnitude.

The jump intensity residual, ξ_{t-1}, which denotes the innovation to λ_{t-1} as measured *ex-post* (evaluated at time t), is calculated as

$$\xi_{i,t-1} = \mathrm{E}\left[n_{i,t-1}\middle|\phi_{\mathrm{i,t-1}}\right] - \lambda_{i,t-1} = \sum_{j=0}^{\infty} j\ \Pr\left(n_{i,t-1} = j\middle|\phi_{i,t-1}\right) - \lambda_{i,t-1} \tag{6}$$

where $\mathrm{E}\left[n_{i,t-1}\middle|\phi_{\mathrm{i,t-1}}\right]$ is the ex-post evaluation of the expected number of jumps over the time interval $(t-2,t-1)$ evaluated at time t, given the information set available at the end of time $t-1$. Here $\lambda_{i,t-1}$ is the expected number of jumps in period $t-1$ conditional on the information available at the end of period $t-2$, i.e. $\lambda_{i,t-1} = E[n_{i,t-1}|\Phi_{i,t-2}]$. The jump intensity residual $\xi_{i,t-1}$ represents the change in the conditional forecast of $n_{i,t-1}$ after the information set is updated from time $t-2$ to time $t-1$, i.e. $\xi_{i,t-1} = E[n_{i,t-1}|\Phi_{i,t-1}] - E[n_{i,t-1}|\Phi_{i,t-2}]$. The term $Pr\left(n_{i,t-1} = j\middle|\Phi_{i,t-1}\right)$ in Eq. (6) is the ex-post probability (evaluated at time t) that j jumps occurred over the interval $(t-2,t-1)$, conditional on the information set available at the end of time $t-1$ and which is known in period t. By using Bayes' theorem, the ex-post probability is calculated as:

$$\Pr\left(n_{i,t-1}=j\middle|\phi_{i,t-1}\right)=\frac{f\left(r_{i,t-1}|n_{i,t-1}=j,\phi_{i,t-2}\right)\Pr\left(n_{i,t-1}=j\middle|\phi_{i,t-2}\right)}{\Pr\left(r_{i,t-1}\middle|\phi_{i,t-2}\right)} \quad (7)$$

where $f\left(r_{i,t-1}|n_{i,t-1}=j,\phi_{i,t-2}\right)$ is the conditional density function for the returns conditional on that j jumps occurred over the interval $(t-2,t-1)$, and conditional on the information set available at time $t-2$. The conditional density function is defined in Eq. (9) below, $\Pr\left(r_{i,t-1}\middle|\phi_{i,t-2}\right)$ is defined in Eq. (8) and $\Pr\left(n_{i,t-1}=j\middle|\phi_{i,t-2}\right)$ is defined in Eq. (4).

The conditional density of the return is a discrete mixture of distributions which is given by

$$\Pr\left(r_{it}\middle|\phi_{i,t-1}\right)=\sum_{j=0}^{\infty}f\left(r_{it}|n_{i,t-1}=j,\phi_{i,t-1}\right)\Pr\left(n_{it}=j\middle|\phi_{i,t-1}\right) \quad (8)$$

where

$$f\left(r_{it}\middle|n_{it}=j,\phi_{i,t-1}\right)=\frac{1}{\sqrt{\left(2\pi(\sigma_{it}^2+j\delta_{it}^2\right)}}\times\exp\left(-\frac{\left(r_{it}-\mu_{it}-\theta_{it}j+\theta_{it}\,\lambda_{it}\right)^2}{2(\sigma_{it}^2+j\delta_{it}^2)}\right) \quad (9)$$

The corresponding log likelihood function is the sum of the logged conditional density functions over time; $\ln L=\sum_{t=1}^{T}\ln\Pr\left(r_{it}\middle|\phi_{i,t-1}\right)$. The conditional density function in Eq. (8) contains an infinite sum over all possible number of jumps. To get a finite sum in practice, we truncate the maximum number of jumps to a large value τ so that the probability of observing τ or more jumps is approximately zero. In the empirical estimation, the robustness of τ is checked by trying values for the maximum number of jumps which exceed τ.

2.4 Identification of merger effects

In the analysis below, the merger event is incorporated as an explanatory variable to capture the effect of the stock exchange merger upon the price jump probabilities. The merger event variable takes the value zero before the date when the stock was available to trade on the common OMX trading platform, and the value one on the date of the merger and afterwards. This means that for stocks traded on the Stockholm and Helsinki stock exchanges, this dummy variable takes the value one as of September 3, 2003 and onwards, while the merger event variable associated with the Copenhagen stock exchange takes the value one as of January 3, 2005 and onwards.

Price jumps are likely to be affected by the prevailing market sentiment. To control for this, we include additional explanatory variables. One is a dummy variable (*dotcom dummy*) which takes the value one during the stock market bubble (dotcom

bubble) around 2000 and it is zero otherwise. Following Kim et al. (2011), the dotcom bubble period is defined to be from Jan 1999 to Dec 2000. Another control variable (*market risk*) is intended to control for the overall stock market volatility in each country during the sample period. It is calculated as the squared return of the All Share Index in each country. A third control variable (*trend*) captures if there is an underlying trend in the market. The motivation for including this variable is that the number of observed jumps, as well as the jump probabilities, may be influenced by whether there is an upward or a downward trend in the market. If the market is trending upwards, positive price jumps may be more likely to occur than negative price jumps whereas the opposite argument applies to a market which trends downwards. To construct the trend variable, the Loess method[4] (Cleveland et al., 1990) is used to extract the trend series from the return series of stock market indices in Sweden, Finland and Denmark, respectively. Finally, we also control for firm size by using the market capitalisation for the individual firms (*market capitalisation*).

To study the effects of the mergers on the jump probability, a two-step approach is used.[5] In the first step, an ex-post probability that at least one jump has taken place is calculated based on the EARJI-GARCH model. The ex-post probability that zero jumps happened is given by (based on equation 7):

$$\Pr(n_{it} = 0|\phi_{it}) = \frac{f(r_{it}|n_{it}=0,\phi_{i,t-1}) \Pr(n_{it}=j|\phi_{i,t-1})}{\Pr(r_{it}|\phi_{i,t-1})}, \quad (10)$$

whereas the ex-post probability that at least one jump has taken place is given by:

$$JumpProb = \Pr(n_{it} \geq 1|\phi_{it}) = 1 - \Pr(n_{it} = 0|\phi_{it}). \quad (11)$$

In the second step, the estimated ex-post probability is used as one of the dependent variables in a simultaneous equation system. The motivation for using a simultaneous equation system is that the jump probability is likely to be affected both by the market risk and by the mergers. At the same time, there is also a possibility that the market risk may be affected by the mergers since international mergers of stock exchanges increase the set of available investment opportunities open to investors and decrease the costs of cross-border trading from a market perspective. Therefore, the jump probability and the market risk are both treated as dependent variables in the following simultaneous equation system:

[4] Loess is a general method to decompose a time series into trend, seasonal, and remainder components.

[5] A more efficient approach would be to use the underlying jump intensity λ as the dependent variable. However, this turns out to be very complicated because such an approach would require that we specify a multivariate version of our model for the large number of stocks in our sample.

$$JumpProb_{it} = \rho_0 + \rho_1 MarketCap_i + \rho_2 MarketRisk_{it} + \rho_3 Dotcom_t + \rho_4 Trend_{it} + \rho_5 Merge_{it} + \varepsilon_{i1,t}, \quad (12)$$

$$MarketRisk_{it} = \varphi_0 + \varphi_1 MarketRisk_{i,t-1} + \varphi_2 Dotcom_t + \varphi_3 Trend_{it} + \varphi_4 Merge_{it} + \varepsilon_{i2,t}. \quad (13)$$

where $MarketCap_i$ denotes the market capitalisation for an individual firm, $Dotcom_t$ is the dotcom bubble dummy, $MarketRisk_{it}$ is the volatility of market indices and $Trend_{it}$ is the underlying trend in each market. The variable $MarketRisk_{it}$ is modelled as a function of its lagged value, $\text{MarketRisk}_{i,t-1}$, to allow for volatility clustering. In both equation (12) and in equation (13), the variable $Merge_{it}$ is the merger event variable. The disturbances $\varepsilon_{i1,t}$ and $\varepsilon_{i2,t}$ are reflecting the impact of various unmeasured factors on the jump probability and on the market risk.

3. Data

To study to what extent the price jumps on the Nordic stock markets have been affected by the OMX mergers, we have collected daily prices, market capital values for individual stocks and the All Share Index in each country from the Thomson Reuters Datastream. Returns are calculated as $r_{it} = \log(P_{it}/P_{it-1})$ and the sample period starts on January 4, 2000 and ends on December 31, 2007. The motive for ending the sample period on December 31, 2007, is to isolate the mergers effects both from the effects of the financial crisis in 2008 and from the increased fragmentation of stock trading that started to take place from 2008 and onwards via the introduction of Multilateral Trading Facilities.

Before turning to the summary statistics, let us first describe our sample selection process. We have excluded thinly (i.e. infrequently) traded stocks from the sample because they tend to induce sizable spuriously identified price jumps (Schulz and Mosler, 2011). Following e.g. Hellström et al. (2014), thinly traded stocks are defined as stocks with more than 10% of the full sample consisting of zero volume trading days.[6] Apart from thinly traded stocks, we have also excluded a smaller number of stocks where an unrealistically large number of price changes are defined as jumps. The reason for this is that numerical problems are encountered when fitting the relatively complex EARJI-GARCH model (rendering a poor fit to the data) to these

[6] For a sensitivity analysis, we also defined thinly traded stocks as stocks with more than 20% out of the full sample consisting zero volume trading days. By doing so, more firms are included in the sample. The results do not change when we run regressions.

stock return series. When excluding these stocks we try to find a reasonable cut-off point by looking at earlier studies. For example, Maheu and McCurdy (2004) identify 1.5% daily jumps for IBM and 1.3% daily jumps for Intel whereas Hellström and Soultanaeva (2010) identify 13.8% and 4.8% daily jumps for Tallinn and Riga, 9.9% and 15.1% daily jumps for Tallinn and Vilnius, and 18% and 4.8% daily jumps for Vilnius and Riga. Based on these observations, we conclude that having more than 20% daily jumps seems unrealistically large. Following Maheu and McCurdy (2004), we therefore identify a price jump as if the ex-post probability of observing at least one jump is larger than 0.5, i.e. $\Pr(n_t \geq 1|\phi_{it}) = 1 - \Pr(n_{it} = 0|\phi_{it}) > 0.5$, and then we exclude stocks with more than 20% identified jumps per day. To exemplify, consider Figure 1 which shows the daily returns and the ex-post jump probabilities (calculated by using Eq. 11) for the Volvo stock in 2007.

[Figure 1 about here.]

In total, there were 250 trading days in 2007 out of which 43 were identified as price jumps. This corresponds to 17% price jumps per day. As can be seen, the price jump probabilities tend to be high in periods with more extreme daily returns (here a daily return is defined as extreme if it is equal to, or exceeds, 2.5% in absolute value).

In the robustness checks made in section 5, we have also tried to use 0.7 instead of 0.5 as the ex-post probability of observing at least one jump, and we have also tried to exclude stocks with more than 30% identified jumps per day. Neither of these alternative specifications changes the qualitative results w.r.t signs and significance.

The final data set includes stock price data for 114 Swedish, 39 Finish and 30 Danish stocks. Descriptive statistics for these stocks, both for the full sample and for each country specific stock market, are displayed in Table 1.

[Table 1 about here.]

One notable feature is that the mean returns for the Swedish and the Finnish stocks were negative during the sample period whereas the mean return was positive for the Danish stocks. At the same time, the Swedish stocks featured the highest mean volatility whereas the mean volatility was lowest for Danish stocks. The mean kurtosis is high on all markets which indicates a clear deviation from normality. This feature has also been documented in other studies (see e.g. Hellström et al., 2012).

Table 1 also provides summary statistics for market capitalisations. Here the Finnish firms have the largest, whiles the Danish firms have the lowest mean market

capitalisation values.[7] In the estimations, we rescale the variable *market capitalisation* by dividing it by 100000000 while the variable *market risk* is multiplied by 100. These rescaling procedures do not affect the qualitative results to be presented below. Finally, the variable *market risk* is calculated as the average of the variances of the All Share market indices, both in the full sample and for the individual countries.

4. Empirical results

4.1 Pre- and post-merger jump frequencies

Before turning to the main analysis of how the stock market mergers have affected the price jump probabilities, let us take a look at some characteristics of the price jump probabilities over the whole sample period, i.e. both before and after the mergers took place. Table 2 depicts the distribution of identified price jumps (i.e. conditional on that the probability of jump being larger than 50%) for the 183 stocks that are used in this study separated into years, months, and weekdays, respectively**.**

[Table 2 about here.]

As can be seen, the largest number of price jumps occurred, on average, in October whereas the smallest number of price jumps occurred in December. Note also that the yearly number of price jumps was high in the period 2000 – 2002 whereas the period 2004 - 2005 saw a relatively smaller number of yearly price jumps. As for the distribution of price jumps over weekdays, it follows from Table 2 that the number of price jumps, on average, was highest on a Wednesday or on a Thursday, but lowest on a Friday. Finally, we also observe that there were 0.083 daily price jumps for an average firm, out of which 0.042 daily price jumps were positive whereas 0.041 daily price jumps were negative. The direction of the identified price jumps are determined to be positive or negative according to whether the returns are positive or negative. This will be discussed in more detail in section 4.2.5.

Let us also compare the total number of identified price jumps in the pre-merger period with the number of identified price jumps in the post-merger period. These numbers are presented in Table 3.

[7] Actually, the highest average market capitalisation over all listed firms (includes both frequent and infrequent firms) on separate markets are the Swedish firms, which was presented in a study by Hellström et al., 2014. The sample firms in this study dismissed thinly traded firms to get rid of unreasonable jump series. Small firms are generally correspond to infrequent trading volumes. Some of the smaller firms on the Helsinki stock market (smaller compared to small firms on the Stockholm stock market) are excluded in this sample, causing a higher average Finnish firm size.

[Table 3 about here.]

As can be seen, the model identified 10,944 price jumps in Stockholm, 4,113 price jumps in Helsinki and 3,393 price jumps in Copenhagen during the pre-merger period. These numbers imply that 0.105 price jumps were identified per day for an average Swedish stock whereas the corresponding numbers for the average Finnish and Danish stocks are 0.115 and 0.09, respectively.

As for the number of identified price jumps in the post-merger period, the model identified 7,507 price jumps in Stockholm, 2,764 price jumps in Helsinki and 1,748 price jumps in Copenhagen. This implies that 0.061 price jumps were identified per day for an average Swedish stock whereas the corresponding numbers for the average Finnish and Danish stocks were 0.065 and 0.077, respectively. A straightforward comparison shows that the unconditional probabilities for the price jumps were reduced in all markets after the stock market mergers but the reduction was smallest for stocks listed in Copenhagen.

Another interesting result is that the number of negative price jumps was larger than the number of positive price jumps in all markets during the pre-merger period. This is reversed in the post-merger period. Possible explanations for this will be discussed below.

4.2 Estimation results

Let us now take a look at the results from the estimations of equation system (12) - (13). These estimation results are presented in Table 4 and we start by looking at how the mergers have affected the estimated price jump probabilities in the full sample of 183 stocks.

[Table 4 about here.]

4.2.1 Merger effects

Model 1 presents the estimation results for the full sample where we control for firm size (via the variable *market capitalisation*), the prevailing market sentiment (via the variables *market risk and trend*) and for the stock market bubble around 2000 (via the *dotcom dummy*). The estimation of equation (12) shows that the mergers have had a significant and negative effect on the probability of price jumps. This result is consistent with the hypothesis that a merger (on average) increases the number of investors that follow a given stock which, for reasons discussed earlier, leads to a

lower probability of observing price jumps. Another result is that the variable *market capitalisation* is negatively correlated with the probability of price jumps, i.e. stocks associated with large firms have a lower probability of experiencing price jumps. This result is robust in the sense that it also holds for other specifications of the model (see Models 2 – 4 below) and this result is in line with results found in earlier studies. For example, Farmer et al. (2004) find that lightly traded stocks tend to be associated with higher probabilities of observing large price fluctuations. Our result can also be related to Nielsson (2009) who finds that small firms are usually lightly traded (recall the discussion above that lightly traded stocks may have more and larger gaps in the order book which increases the likelihood of observing price jumps).

As for the variable *market risk*, it is significant and positive which indicates that the probability of price jumps is higher in periods of high volatility. Also, this result is robust and holds for other specifications of the model (Models 2 – 4). In addition, the *dotcom dummy* is positive and significant in Model 1 which suggests that the number of price jumps was higher during the information technology bubble. Moreover, the *trend* variable has a significant and negative effect on the number of jumps (see Table 4 and Table 5) which implies that the total number of price jumps (positive and negative) decreases on a market which trends upwards. We also observe a positive and significant effect of the *trend* variable on the probability of observing positive jumps (see Table 6) and a negative and significant trend effect on the probability of observing negative jumps (see Table 7). Finally, the estimation of equation (13) shows that the mergers have had a negative effect on market risk, i.e. the mergers have reduced the market risk in the Nordic stock exchanges.

4.2.2 Asymmetric merger effects distributed over firm size

Earlier studies have found that the effects of stock exchange mergers tend to be asymmetrically distributed in the sense that liquidity gains are concentrated among larger firms (Hellström et al., 2013; Nielsson, 2009). To study whether there are heterogeneous merger effects associated with firm size, we divide our sample of 183 stocks into three groups. One group contains the 10% largest firms in each market, another contains the 10% smallest firms in each market and the third group contains the remaining firms. This grouping is based on the firm sizes observed at the end of the pre-merger period per market. The pre-merger period for the Stockholm and the Helsinki stock markets is January 3, 2000 - September 2, 2003, while the pre-merger

period for the Copenhagen stock market is January 3, 2000 – January 2, 2005. The estimation of equation system (12) – (13) based on this grouping is referred to as Model 2 and the estimation results are presented in Table 4 above.

The estimation results associated with equation (12) in Model 2 show that the mergers reduce the probability of observing price jumps by 8.8 percentage points for large firms and by 2.2 percentage points for medium size firms, whereas the mergers increase the probability of observing price jumps for small firms. The estimation results associated with equation (13) in Model 2 also show that after mergers have taken place, the market risk for firms of all sizes is reduced by 0.023. These results can be related to the results reported by Nielsson (2009) who found that large firms gain in liquidity, whereas small and medium firms receive no liquidity gains, after a stock market merger has taken place. This indicates that a liquidity effect may explain our finding that the stock market mergers have reduced the probability of observing price jumps for large and medium size firms in the Nordic market. After the mergers, the gaps in the order books may have been reduced which, in turn, may have had a negative effect on the likelihood of observing price jumps. The possible increase in liquidity may, in turn, be caused by the fact that more investors can follow each stock after the stock market mergers have taken place.

A possible explanation for the result that the stock market mergers have increased the probability of observing price jumps for small firms may be that the liquidity has been reduced for these firms. This may be a consequence of the fact that the pool of large and medium size firms available for an investor is larger after the mergers have taken place. As a consequence, fewer investors than before may follow smaller firms implying that the liquidity for these stocks is reduced.

4.2.3 Asymmetric merger effects distributed over location

Another extension is to study how the mergers have affected the price jump probabilities and market risks in Stockholm, Helsinki and Copenhagen, respectively. This is done in Model 3 where we estimate the effects on separate markets by interacting mergers with the stocks' pre-merger listing. These results are also presented in Table 4.

When the pre-merger listing is accounted for, the estimation of equation (12) shows that the merger effects differ between the markets. The results imply that the probability of price jumps is reduced (at 1% significance level) for stocks previously

listed in Stockholm and Helsinki. On average, the probability of a price jump was reduced by 3% for stocks previously listed in Stockholm and by 2.3% for stocks previously listed in Helsinki. For stocks previously listed in Copenhagen, we do not find any significant reduction in the price jump probabilities. A possible explanation may be that the mergers increase the liquidity for the average firm in Stockholm and Helsinki but not for the average firm in Copenhagen. As for the estimation of the variable *Market Risk*, it follows from Table 4 that the stock market mergers have reduced the market risks in Stockholm, Helsinki and Copenhagen.

4.2.4 Asymmetric merger effects distributed over size and location

Let us also look at how the stock market mergers have affected the probabilities of observing price jumps separately for large, medium and small size firms on each listing location. This is done in Model 4 which is presented in Table 5.

[Table 5 about here.]

As can be seen, the stock market mergers have reduced the jump probabilities for the large firms in all markets (at the 1% significance level) and this reduction was largest in Stockholm. On the other hand, the jump probabilities are not reduced for small firms previously listed in Helsinki and for medium and small firms previously listed in Copenhagen. This may reflect that the small stocks in Copenhagen and in Helsinki have become less attractive after the mergers since investors now have a larger pool of large firms to invest in. Clearly, there are asymmetric merger effects between different locations and also over different sizes of firms. These differences are consistent with the previous findings (see Nielsson (2009) and Hellström et al. (2014)). Finally, in Model 4 the estimation of the variable *Market Risk* provides similar results as those in Models 1 – 3 presented above, i.e. the market risks are reduced after the stock market mergers.

4.2.5 Separate probabilities for positive and negative price jumps

The main conclusion so far is that the jump probabilities, overall, have been reduced as a consequence of the stock exchange mergers. However, investors may not only be interested in how likely it is that price jumps occur; they may also be concerned with whether the price jumps are positive (which is good if one has a long position) or negative (which is good if one has a short position). The EARJI-GARCH does not include jump intensity parameters separately for positive and negative

jumps. Extending the present model to include separate jump intensities for positive and negative price jumps is not a straightforward task. To be able to model the probability for positive and negative jumps we use the following approach. First we define indicators $(0/1)$ to identify actual positive and negative jumps and then we use these indicators to estimate how the stock exchange mergers affect the probabilities of observing positive and negative jumps. Recall that the identification of price jumps is based on the assumption that the ex-post probability of observing at least one jump is larger than 0.5. On a given day, an identified positive jump (*Positive Jump*) is a dummy variable which takes the value one if a jump is identified and if the daily return is positive. Otherwise the dummy variable is zero. Hence

$$\textit{Positive Jump} = \begin{cases} 1, & if\ a\ jump\ is\ identified\ and\ r_{it} > 0 \\ 0, & otherwise \end{cases} \quad (14)$$

Analogously, on a given day, an identified negative jump (*Negative Jump*) is a dummy variable which takes the value one if a jump is identified and if the daily return is negative. Otherwise this dummy variable is zero. Hence

$$\textit{Negative Jump} = \begin{cases} 1, & if\ a\ jump\ is\ identified\ and\ r_{it} < 0 \\ 0, & otherwise \end{cases} \quad (15)$$

In the second stage, we use a linear probability model for the binary jump indicator and estimate the positive and the negative jump equations separately in equation system (12) – (13). A more efficient method would be to estimate the positive and negative jump equations simultaneously by constructing a categorical variable to distinguish between no jumps, positive jumps and negative jumps and then test these by using ordered probit models (see Hellström et al. 2012). However, this approach is infeasible in this analysis because of the simultaneous two equation system. We therefore simplify by using the approach described above. The results of these estimations are presented in Table 6 (positive price jumps) and Table 7 (negative price jumps). In Table 6, the dependent variable is the probability of observing at least one positive price jump (*Positive Jump*), whereas the dependent variable in Table 7 is the probability of observing at least one negative price jump (*Negative Jump*).

[Table 6 about here.]

[Table 7 about here.]

In Table 6, Model 1, we see that merging into a common trading platform increases the probability of identifying positive price jumps by 0.3% for an average firm (significant at the 10% level). Another result is that in Model 2, the stock market

mergers reduce the probability of identifying positive jumps by 1.4% for large size firms. However, for medium and small size firms, the probability of identifying positive jumps instead increases. The estimation of Model 3 shows that the mergers have had a positive effect on the jump probabilities but this effect is only significant for Copenhagen. For Model 4, the results are mixed.

In Table 7, the results are more homogenous in the sense that the relationship between the stock market mergers and the probability of identifying negative price jumps is negative in all cases (except in Model 4 for small size firms in Copenhagen). Finally, the estimated coefficients for market risk are similar to the results presented in Tables 4 and 5 above. For brevity, we do not repeat them in Tables 6 and 7.

5. Robustness of results and extensions

The estimation results presented above are based on some critical assumptions. To test the sensitivity of the results, two robustness tests have been performed. First, in the estimations above we have excluded firms that have had more than 20% identified price jumps since such a large number is viewed as unrealistic. To test the sensitivity of this treatment of the data, the analysis has been repeated by excluding firms that have more than 30% of the observations identified as jumps. By doing so, we have constructed a new data set which consists of 210 firms (130 Swedish, 44 Finnish and 36 Danish firms). It turns out that this does not change the results in terms of signs and significances except that the coefficient for the dotcom bubble turns out to be significant.

Second, the estimations above for the models taking into account the probability for positive and negative price jumps are based on the assumption that a price change is identified as a jump if the ex-post probability of observing at least one jump is larger than 0.5. To test how sensitive the estimation results are to this definition, the analysis has been repeated by changing the identification of jumps to a probability of over 0.7, i.e. $\Pr(n_t \geq 1|\phi_{it}) = 1 - \Pr(n_{it} = 0|\phi_{it}) > 0.7$. The estimation results confirm the earlier analysis except for minor differences. For example the merger effect in small size stocks now turns out to be insignificant. Repeating the tests in section 4.2.5, we have not found strong evidence of a decrease in the positive jump probability whereas we do find that a strong reduction in the negative jump probability caused by mergers.

Finally, one cannot rule out that since investors knew of the mergers before hand, they may have changed their behaviour before the actual mergers took place. To test

for this, we include both a pre-merge dummy variable and the merger variable in both equations in the simultaneous equation system. The pre-merge dummy is equal to one six months before the merger date and zero from the start date of merger. The results of these estimations are presented in Table 8.

[Table 8 about here.]

The results in Table 8 show that we do not find any significant pre-merger effect on the probability of observing a price jump in the full sample. At the same time, the merger effect is still significant after we have added the six months pre-merger dummy. However when looking at the asymmetrical effects, we find some pre-merger effects for large and small firms. For example, the probability of observing a price jump was reduced for large firms while it increased for small size firms in the pre-merger periods. Potentially this might be driven by that large institutional traders already being active on the Nordic market and taking positions before the mergers happened.

6. Conclusions

This paper investigates the extent to which stock market mergers influence the probabilities of observing jumps in the stock prices. The question is analysed empirically using a sample of 183 stocks from the OMX Nordic exchange during the period 2000 to 2007. The analysis is conducted using a mixed EARJI-GARCH jump model in the first stage to identify stock price jumps by separating "normal" variation from that the variation caused by price jumps. In the second stage, a simultaneous equation system is estimated where the ex-post probability of observing at least one price jump and the market risk are the dependent variables. Explanatory variables in all regressions are *firm size*, *market risk*, a *dotcom dummy*, *market trend* and additional control variables.

The main finding of the study is that stock market mergers, on average, reduce the likelihood for stock price jumps. The conclusion could potentially be challenged by the conjecture that the merger dummy variable could possibly capture some omitted structural change in the process generating price jumps. But as far as we are aware, we cannot think of any other formal or institutional or other change that seems to coincide with the merger period. We have, at least, not observed anything else happening during this period that could explain the structural changes. Another notable feature of the empirical analysis is that the negative merger effects are

concentrated to large and middle sized firms on larger markets after merging into a common trading platform. Smaller firms on smaller markets receive, on average, a positive effect from the mergers on the jump probabilities. This is consistent with earlier studies that find asymmetric stock exchange merger effects that are larger for larger firms (Hellström et al., 2014; Khan and Vieito, 2012; Nielsson, 2009). We study merger effects on separated positive and negative jump probabilities. It is found that both decrease after mergers, and the reduction in negative jump probability is larger. Apart from jumps, stock market consolidations also influence market risk, i.e. variance of market indices decreases after mergers. Finally, price jumps in individual firms are positively related with the volatility of market indices. These findings are important for risk management, portfolio management, stock derivative pricing, and stock exchange owners and regulators. In future studies it may be fruitful to examine the merger effect with high frequency data, or sorted by, for example, firms in different industries.

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Table 1: Sample summary statistics, 2000-2007.

	Full sample	Stockholm	Helsinki	Copenhagen
Return characteristics:				
-Mean daily return (%)	-0.005	-0.009	-0.030	0.044
-Min daily return (%)	-93.855	-93.855	-89.843	-75.389
-Max daily return (%)	111.269	111.269	84.73	47.017
-Mean volatility (s.d., %)	3.153	3.305	3.200	2.411
-Mean kurtosis	40.673	36.359	45.637	53.576
Controls				
-Mean market capitalisation (millions, Euro):	2928.465	2944.945	3761.703	1782.634
-Market risk (volatility of market indices, %):	0.023	0.019	0.045	0.009
Nr. of frms	183	114	39	30
Percentage of firms	-	62.30%	21.31%	16.39%

Figure 1: Return and ex-post jump probability on 2007, Volvo.

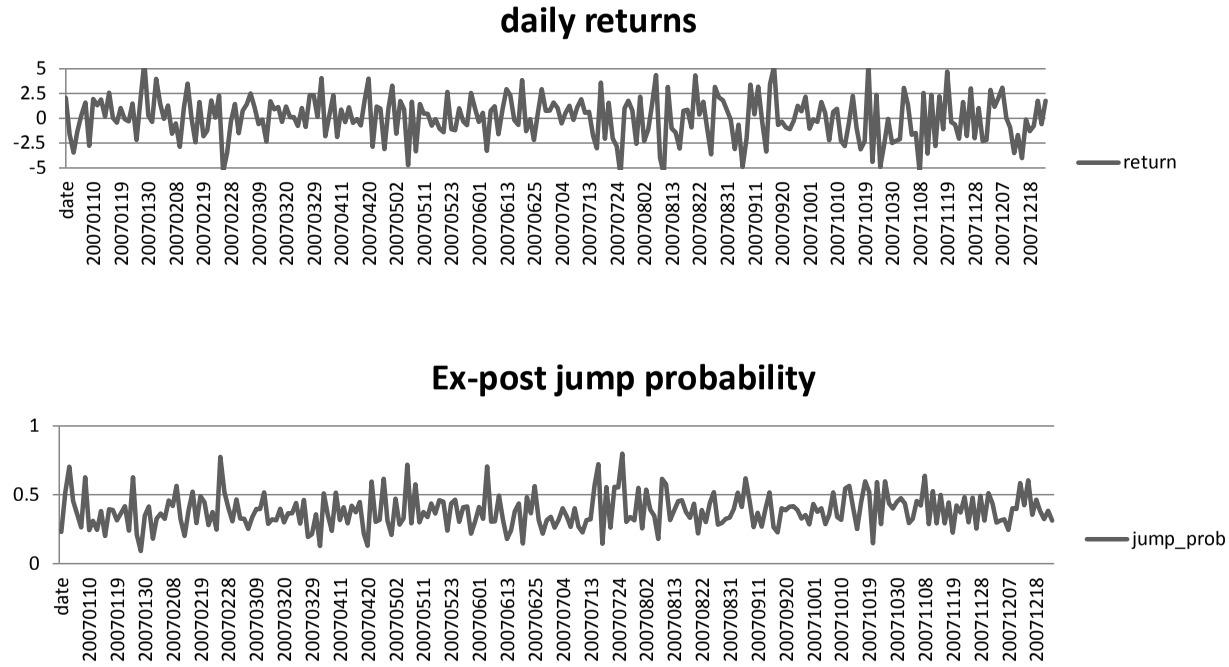

Table 2: Structure of the number of identified actual price jumps (for a total of n=183 firms, T=2005).

	Total	Positive	Negative		Total	Positive	Negative		Total	Positive	Negative
Jan.	2740	1601	1139	2000	5618	2842	2776	Monday	6129	3003	3126
Feb.	2497	1319	1178	2001	4802	2300	2502	Tuesday	6012	3015	2997
Mar.	2704	1355	1349	2002	4807	2185	2622	Wednesday	6305	3011	3294
Apr.	2573	1292	1281	2003	3364	1920	1444	Thursday	6315	3214	3101
May	2623	1240	1383	2004	2671	1502	1169	Friday	5708	3274	2434
Jun.	2353	1082	1271	2005	2437	1457	980				
Jul.	2520	1198	1322	2006	3245	1754	1491				
Aug.	2546	1283	1263	2007	3525	1557	1968				
Sep.	2689	1262	1427								
Oct.	2880	1539	1341								
Nov.	2315	1273	1042								
Dec.	2029	1073	956								
Sum	30469	15517	14952	Sum	30469	15517	14952	Sum	30469	15517	14952
Per day per firm	0.083	0.042	0.041	Per day per firm	0.083	0.042	0.041	Per day per firm	0.083	0.042	0.041

Table 3: Jumps aggregated in the pre- and post merger period.

	Pre-merger period[8]					Post-merger period				
	Total	Positive	Negative	N of days	per day per firm	Total	Positive	Negative	N of days	per day per firm
Stockholm	10944	5331	5613	917	0.105	7507	3838	3669	1088	0.061
Helsinki	4113	2002	2111	917	0.115	2764	1466	1298	1088	0.065
Copenhagen	3393	1865	1528	1252	0.090	1748	1015	733	753	0.077

[8] Stock market merger dates: Swe: 2003-09-03, Fin: 2003-09-03, Den: 2005-01-03.

Table 4: Results from the simultaneous equation regressions, model 1-3.

	Model 1		Model 2		Model 3	
	Estimates	Se.	Estimates	Se.	Estimates	Se.
JumpProb (*Jump probability*)						
Market cap	-0.082***	0.002	-0.060***	0.002	-0.081***	0.002
Market risk	1.187***	0.071	1.182***	0.071	1.192***	0.071
Dotcom	0.005**	0.002	0.004**	0.002	0.004**	0.002
Trend	-0.015***	0.002	-0.015***	0.002	-0.016***	0.002
Merge	-0.025***	0.002				
Merge-large			-0.088***	0.003		
Merge-medium			-0.022***	0.002		
Merge-small			0.007***	0.003		
Merge-Sth					-0.030***	0.002
Merge-Hel					-0.023***	0.002
Merge-Cop					-0.002	0.003
Constant	0.166***	0.002	0.166***	0.002	0.166***	0.002
MarketRisk (*Volatility of Market Indices)*						
L.MarketRisk	0.088***	0.002	0.088***	0.002	0.088***	0.002
Dotcom	0.013***	0.000	0.013***	0.000	0.013***	0.000
Merge	-0.023***	0.000				
Merge-large			-0.023***	0.000		
Merge-medium			-0.023***	0.000		
Merge-small			-0.023***	0.000		
Merge-Sth					-0.023***	0.000
Merge-Hel					-0.020***	0.001
Merge-Cop					-0.025***	0.001
Constant	0.032***	0.000	0.032***	0.000	0.032***	0.000

Note: L.MarketRisk stands for the variance of market indices for respective country in t-1.
* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 5: Results from the simultaneous equation regression, model 4.

	Model 4	
	Estimates	Se.
JumpProb (*Jump probability*)		
Market cap	-0.060***	0.002
Market risk	1.187***	0.071
Dotcom	0.004**	0.002
Trend	-0.016***	0.002
Merge-large-sth	-0.101***	0.003
Merge-medium-sth	-0.024***	0.002
Merge-small-sth	-0.020***	0.003
Merge-large-hel	-0.037***	0.004
Merge-medium-hel	-0.030***	0.002
Merge-small-hel	0.044***	0.004
Merge-large-cop	-0.116***	0.006
Merge-medium-cop	0.002	0.003
Merge-small-cop	0.083***	0.006
Constant	0.166***	0.002
MarketRisk (*Volatility of Market Indices)*		
L.MarketRisk	0.088***	0.002
Dotcom	0.013***	0.000
Merge-large-sth	-0.023***	0.001
Merge-medium-sth	-0.023***	0.000
Merge-small-sth	-0.023***	0.001
Merge-large-hel	-0.020***	0.001
Merge-medium-hel	-0.020***	0.001
Merge-small-hel	-0.020***	0.001
Merge-large-cop	-0.025***	0.002
Merge-medium-cop	-0.025***	0.001
Merge-small-cop	-0.025***	0.002
Constant	0.032***	0.000

Note: * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 6: Separate probabilities for positive price jumps.

	Model 1		Model 2		Model 3		Model 4	
	Estimates	Se.	Estimates	Se.	Estimates	Se.	Estimates	Se.
Positive Jump								
Market cap	-0.022***	0.002	-0.016***	0.002	-0.022***	0.002	-0.016***	0.002
Market risk	0.798***	0.064	0.797***	0.064	0.802***	0.064	0.801***	0.064
Dotcom	0.001	0.002	0.000	0.002	0.000	0.002	0.000	0.002
Trend	0.022***	0.002	0.022***	0.002	0.022***	0.002	0.022***	0.002
Merge	0.004**	0.002						
Merge-large			-0.014***	0.002				
Merge-medium			0.005***	0.002				
Merge-small			0.009***	0.002				
Merge-Sth					0.002	0.002		
Merge-Hel					0.003	0.002		
Merge-Cop					0.018***	0.002		
Merge-large-sth							-0.016***	0.003
Merge-medium-sth							0.003*	0.002
Merge-small-sth							0.009***	0.003
Merge-large-hel							-0.007*	0.004
Merge-medium-hel							0.003*	0.002
Merge-small-hel							0.008**	0.004
Merge-large-cop							-0.014***	0.005
Merge-medium-cop							0.022***	0.002
Merge-small-cop							0.015***	0.005
Constant	0.021***	0.002	0.021***	0.002	0.021***	0.002	0.021***	0.002

Note: The estimated coefficients for Market Risk are the same with results in Tables 4 and 5, therefore dismissed here for brevity. * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 7: Separate probabilities for negative price jumps.

	Model 1		Model 2		Model 3		Model 4	
	Estimates	Se.	Estimates	Se.	Estimates	Se.	Estimates	Se.
Negative Jump								
Market cap	-0.019***	0.002	-0.015***	0.002	-0.019***	0.002	-0.015***	0.002
Market risk	0.301***	0.059	0.300***	0.059	0.301***	0.060	0.300***	0.059
Dotcom	0.007***	0.001	0.007***	0.001	0.007***	0.001	0.007***	0.001
Trend	-0.035***	0.002	-0.035***	0.002	-0.035***	0.002	-0.035***	0.002
Merge	-0.008***	0.002						
Merge-large			-0.019***	0.002				
Merge-medium			-0.006***	0.002				
Merge-small			-0.012***	0.002				
Merge-Sth					-0.009***	0.002		
Merge-Hel					-0.006***	0.002		
Merge-Cop					-0.005**	0.002		
Merge-large-sth							-0.020***	0.003
Merge-medium-sth							-0.006***	0.002
Merge-small-sth							-0.017***	0.003
Merge-large-hel							-0.012***	0.004
Merge-medium-hel							-0.006***	0.002
Merge-small-hel							-0.004	0.004
Merge-large-cop							-0.026***	0.005
Merge-medium-cop							-0.004	0.002
Merge-small-cop							0.004	0.005
Constant	0.036***	0.002	0.036***	0.002	0.036***	0.002	0.036***	0.002

Note: The estimated coefficients for Market Risk are the same with results in Tables 4 and 5, therefore dismissed here for brevity. * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 8: Estimation results from the simultaneous equation regressions of model 1 in pre-merger periods:

	Model 1	
	Estimates	Se.
JumpProb (*Jump probability*)		
Market cap	-0.082***	0.002
Market risk	1.196***	0.073
Dotcom	0.004**	0.002
Trend	-0.013***	0.002
Merge	-0.026***	0.002
Merge-pre	-0.003	0.002
Constant	0.167***	0.003
MarketRisk (*Volatility of Market Indices)*		
L.MarketRisk	0.084***	0.002
Dotcom	0.010***	0.000
Merge	-0.027***	0.000
Merge-pre	-0.022***	0.001
Constant	0.036***	0.000

Note: L.MarketRisk stands for the variance of market indices for respective country in t-1.
* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

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