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Abstract

In this paper we study whether the creation of a uniform stock trading platform for the Nordic countries (the OMX Nordic merger) has changed the interdependence structure between foreign and domestic stock market returns. To accomplish this a Flexible Dynamic Component Correlations (FDCC) model is outlined facilitating analysis of the long-run trend, as well as, the transitory component in the time-varying conditional return correlations. The results indicate that the long-run trends in conditional correlations have increased due to the creation of a common trading platform. Further, evidence is found that short-run deviations from the long-run trend may approach the long-run trend in an oscillating manner and that the persistency in these short-run deviations have decreased due to the stock exchange mergers.

Keywords: time-varying correlation, long-run trend, transitory component, C-GARCH.

JEL: C14, C22, G12, G15.

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1 Introduction

During the last decade the market structure for stock trading in Europe have 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 concern 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.\footnote{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.} A number of studies exist focusing on effects of stock exchange mergers, e.g. Arnold et al. (1999), Santos and Scheinkman (2001), Padilla and Pagano (2005), Niellson (2009) and Khan and Vieto (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 \textit{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 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, future global macro-economic situation. This is in contrast to the pre-merger period were domestic firms mainly are valued conditional on only domestic investors’ expectations (that possibly could differ between countries). Given this increased commonality in 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 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 favour 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 spirit of the C-GARCH model by Engle and Lee (1993, 1999). The model facilitate 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, Engle and Ghysels, 2011), the current framework do not require similar specifications of the conditional variance and correlation functions. This allows for flexible modelling 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 trend 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 have 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

\(^2\)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.
between return series the Flexible Dynamic Correlations (FDC) model (Tsay, 2002, and Baur, 2005) is utilized. The model is specified as

\[ \mathbf{R}_t = \boldsymbol{\mu}_t + \boldsymbol{\epsilon}_t, \]  

(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 \( \mu_{it} = \theta_0 t + \sum_{l=1}^{L} \theta_l r_{i,t-l} \), while the disturbances in \( \boldsymbol{\epsilon}_t \) are assumed to be normal i.i.d. mean-zero innovations specified as \( \boldsymbol{\epsilon}_it = \sigma_{it} z_t \), where \( z_t \sim N(0,1) \). To gain direct modelling access to the correlation coefficients the covariance matrix, \( \mathbf{H}_t \), conditional on the information set \( \Phi_{t-1} \), is expressed as

\[ \text{Var}(\varepsilon_{it} | \Phi_{t-1}) = \mathbf{H}_t = \mathbf{D}_t \boldsymbol{\rho}_t \mathbf{D}_t, \]  

(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

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

(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, \( \rho_t \), for the time-varying correlation, times the standard deviation for each return series. Under conventional assumptions regarding \( \sigma^2 \), \( \mathbf{H}_t \), 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

\[ \rho_t = q_t + \varphi_1 (z_{1t-1} z_{2t-1} - q_{t-1}) + \varphi_2 (q_{t-1} - q_{t-1}) \]

\[ q_t = \omega + \gamma_1 (q_{t-1} - \omega) + \gamma_2 (z_{1t-1} z_{2t-1} - \rho_{t-1}) \]  

(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 \( \varphi_1 \) and \( \varphi_2 \). Thus, the persistence of the short run component is given by \( \varphi_1 + \varphi_2 \). The shocks in the conditional correlation function is modelled in terms of standardized residuals, \( z_{it} = \varepsilon_{it} / \sigma_{it} \), in line with Engle (2002). To restrict the correlation to the \((-1,1)\) interval we
use the $\hat{\rho}_t = \rho_t / \sqrt{1 + \rho_t^2}$ transformation. To keep the model as simple as possible and to focus upon decomposing the conditional correlation, the process for the conditional variances, $\sigma_{1t}^2$, $\sigma_{2t}^2$, are specified as GARCH(1,1) equations. Estimation of the FDCC model is straightforward using maximum likelihood. The probability density function for $R_t$ is specified as

$$f(R_t|\Phi_{t-1}) = \frac{1}{(2\pi)^{N/2}}|D_{ijt}\rho_tD_{ijt}|^{-1/2} \exp\left[-1/2 \times [\epsilon_t|D_{ijt}\rho_tD_{ijt}]^{-1}\epsilon_t\right].$$

where,

$$\epsilon_t = R_t - \mu_t = \begin{bmatrix} r_{1t} - \mu_{1t} \\ r_{2t} - \mu_{2t} \end{bmatrix}, \quad D_t = \begin{bmatrix} \sqrt{\sigma_{1t}^2} & 0 \\ 0 & \sqrt{\sigma_{2t}^2} \end{bmatrix}, \quad \rho_t = \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix}.$$

The log-likelihood function is then given by $\ln L = \sum_{t=1}^{T} \ln f(R_t|\Phi_{t-1})$.

### 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 3:rd of September, 2003, for the Stockholm and Helsinki, 3:rd of January, 2005, for the Copenhagen, and the 29:th of December, 2006, for the Icelandic stock markets. In Table 1 we report summary statistics for the returns over the pre-, respective, post-merger periods for each market.

[Table 1 about here.]

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.

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3Tsay (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 transformation were used yielding similar results concerning variables of interest.

4A more detailed description of the OMX Nordic merger can be found in Hellström, Liu, Sjögren (2013).
in the post-merger period. Comparing the average unconditional return correlations for each market, with all other markets, reveal 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 percent 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 a common Nordic trading platform upon the conditional stock market correlations a number of specifications of the FDCC model were estimated. 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 ($d_{Merger_{ij}}$). In order to capture the influences from 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 ($d_{Dotcom_{i}}$) and the turbulence from the sub-prime crises in 2008 ($d_{Subprime_{i}}$), 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.

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 percent 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 to 2007-12-31). An increase in global stock market volatility, proxied with the realized variance measure, do in general decrease the long-run trend in return correlations, except

\[5\]Results from the Ljung-Box tests indicate modest seriali correlations in returns and a simple AR(1) model is therefore choosen for the conditional mean.

\[6\]Note here that the explanatory variables, including the merger dummies, are included in the long-run trend component ($q_t$ in eq. 4) as $\omega = \varphi_1 q_t + \phi_1 d_{Merger_{ij}} + \phi_2 RV_{US,t-1} + \phi_3 d_{Dotcom_{i}} + \phi_4 d_{Subprime_{i}}$, and to capture possible changes in the short-run dynamics ($\rho_{t} - q_t$ in eq.4) as an interaction variable, $(\varphi_2 + \phi_3 d_{Merger_{ij}})(\rho_{t-1} - q_{t-1})$. 

[Table 2 about here.]
for the Stockholm and 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 decreased between Stockholm-Copenhagen, Stockholm-Reykjavik and Helsinki-Reykjavik. The similar effect during the sub-prime crises in 2008 are 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 \( \varphi_1 + \varphi_2 + \varphi_3 \), reveal that persistency have significantly decreased for the Stockholm-Helsinki and Helsinki-Copenhagen, while 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 \( \omega \), measured by \( |\gamma_1| \), ranges from 0.123 to 0.948 (although only two are significant at the 5 percent 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 have lead to an on average increase in long-run trends in cross-country return correlations for all of the considered markets. These result adds 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 adjusts 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 seem to work well and provide estimates in line with other studies concerning the conditional variances, i.e. the GARCH components, as well as for the dynamic conditional correlations.

References


Table 1: Summary statistics - Returns.

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<th></th>
<th>Pre-merger period</th>
<th>Post-merger period</th>
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<tr>
<td></td>
<td>Mean</td>
<td>s.d.</td>
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<tr>
<td>Stockhom</td>
<td>0.003</td>
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</tr>
<tr>
<td>Helsinki</td>
<td>0.052</td>
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<tr>
<td>Copenhagen</td>
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<td>1.027</td>
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<tr>
<td>Reykjavik</td>
<td>0.079</td>
<td>0.783</td>
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</table>


$^b$Average unconditional correlation over all pairs.

$^c$Ljung-Box statistic (df: 10) for return $(r)$ and squared return $(r^2)$.
Table 2: Estimation results for FDCC model controlling for stock market merger effects.

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<td>0.082*</td>
<td>(0.020)</td>
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<td>(0.016)</td>
<td>0.044*</td>
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<td>0.189*</td>
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<td>0.896*</td>
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\[
\rho_t = \varphi_1(z_{t-1}2\tau_t - q_{t-1}) + (\varphi_2 + \varphi_3\text{Merger}_{ij})(\rho_{t-1} - q_{t-1}),
q_t = \omega + \gamma_1(q_{t-1} - \omega) + \gamma_2(z_{t-1}2\tau_t - \rho_{t-1})
\]

\[
\varphi = \varphi + \phi_{1}\text{Merger}_{ij} + \phi_2\text{RV}_{US,t-1} + \phi_3\text{Dotcom}_t + \phi_4\text{Subprime}_t
\]

\[
\ln L = -4525 -3010 -4000 -4298 -5493 -2895
\]

| Nr. obs. | 2972       | 2972       | 2972       | 2972       | 2972       | 2972       |