International Stock Market Integration, Market Risk and Interdependencies: The Nordic Experience.

Jörgen Hellström[Ψ], Yuna Liu* and Tomas Sjögren*

[Ψ]Umeå School of Business, Umeå University, SE-90187 Umeå, Sweden.

*Department of Economics, Umeå University, SE-90187 Umeå, Sweden.

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Abstract

In this paper we study whether the creation of a uniform stock trading platform (OMX, NASDAQ-OMX) for the Nordic countries (Sweden, Finland, Denmark and Iceland), facilitating cross-border trading, has changed the long-run structure of stock market volatilities and correlations on the Nordic stock markets. To accomplish this, the trends in time-varying volatilities and correlations are studied by use of parametric C-GARCH models and extensions of these (Component Correlation-GARCH models). The results indicate, among other, that the long-run trends in conditional correlations between the Nordic stock markets have decreased due to the creation of a common trading platform.

Keywords: conditional correlation, C-GARCH, CC-GARCH.

JEL: C14, C22, G12, G15.

1 Introduction

A major trend[1] during, in particular, the last decade concerning international financial integration is the recent mergers of international stock exchanges (see e.g. Kokkoris and Olivares-Caminal, 2008). A number of mergers have been made, e.g. the NYSE acquired Euronext in 2006 (operates exchanges in Paris, Amsterdam, Brussels and Lisbon) and NASDAQ acquired the Nordic stock exchange operator OMX AB in 2007, but further are to be expected in the future due to pressures to increase competitiveness and to cut costs. The London Stock exchange (LSE) has, for example, been subject to constant speculations since Deutsche Boerse AG launched a takeover bid in December 2004. The harmonization of regulatory environment for capital markets in Europe[2] combined with technological advances is also likely to further fuel merger activities in the European capital markets.

From a market perspective international mergers of stock exchanges significantly increases the set of available investment opportunities to investors and decreases the costs of cross-border trading. This is likely to affect the price formation in local domestic stock markets, market risks and interdependencies between merged markets. Since market risk and interdependencies between markets play a crucial role in portfolio management an understanding of the effects of international stock market integration, specially in the light of possible future mergers, are of key importance for the financial industry as well as for financial regulators.

In the Nordic countries (Sweden, Finland, Denmark and Iceland) trading of stocks have been merged into a single trading platform (OMX, NASDAQ-OMX) facilitating low cost cross-border trading of Nordic stocks. In 2003 the Stockholm (Sweden) stock exchange (OMX) merged with the Helsinki (Finland) stock exchange (HEX), in 2005 OMX-HEX acquired the Copenhagen (Denmark) and later in 2006 the Iceland stock exchange. From a trading perspective gathering stocks from these countries into a single trading platform has stimulated and significantly lowered the cost of cross-border trading.[3] Since increasing access to local stock markets by international investors may change the composition of traders as well as the liquidity of local markets, it is possible that the market risks (long-

[1] Another recent trend is the creation of multilateral trading facilities (MTF:s), e.g. Chi-X, Turquoise, BATS and NEURO, facilitating cross-border listings and trading.

[2] The Investment Service Directive (ISD) (from 1996) later replaced by the Markets in Financial Instruments Directive (MiFID) in 2004 sets the legislative framework for investment firms and securities markets in the European union (EU).

[3] Even tough larger traders, i.e. mainly Nordic banks, utilized all (Nordic) markets before integration into a single trading plattform, their cost for cross-border trading have decreased.

term volatility) and interdependencies between the Nordic stock exchanges has changed due to a changed market structure. The purpose of this paper is thus to empirically study whether the integration of the Nordic stock markets, i.e., the creation of a single trading platform, have affected the underlying market risks (volatilities) and dependencies (correlations) in the Nordic stock exchanges.

To empirical study whether the long-run structure of volatilities in the Nordic stock markets has changed due to the market integration a parametric approach utilizing component-GARCH (C-GARCH, Engle and Lee, 1993; 1999) models are used in the empirical analysis. To study the long-run trend in conditional correlations a component-correlations-GARCH model (CC-GARCH) in spirit of the C-GARCH model is outlined and used in the analysis.

The main findings of the paper indicate that the effect of creating a common trading platform upon long-run stock market volatilities (conditional variance) differs between considered stock markets. The volatility on the Swedish and Finnish stock markets decreased when investors in these countries got easier access to respectively countries stock markets while the volatility increased on all markets when the Icelandic stock market was merged to the common trading platform. This later result should, however, be interpreted with caution since the results may be due to lack of appropriate control variates (specially controlling for the global financial crises during the later parts of the sample period). The volatility on the Danish stock market increased after the merger to the common platform. Concerning the effects upon the long-run levels of correlations between the Nordic stock market returns, these results are easier to summarize. The interdependencies between all stock markets have in general decreased due to the creation of a common trading platform. One explanation for this result may be that the lower cost of cross-border trading have made it easier for investors to move assets from one Nordic market to another in reaction towards local negative shocks in any of the markets. This activity is then likely to create an opposite return reaction (negative returns in market experiencing a negative shock, while an increasing demand for assets in markets where investors move their funds renders positive returns) in the different markets rendering a lower correlation between them.

Section 2 of the paper describes the Nordic stock markets along with the data used in the empirical study. The econometric framework is outlined in Section 3. Section 4 reports on the empirical results, while the final section concludes the paper.

2 The Nordic stock markets - Data

This section gives a short description of the Nordic stock markets as well as presents descriptive data for the different stock markets. Daily, weekly and monthly price data of all-share indices for the four Nordic countries (Sweden, Finland, Denmark and Iceland) are used in the empirical study, which are OMX Stockholm, OMX Helsinki, OMX Copenhagen, and OMX Iceland. In order to capture the oscillation associated with international stock market movements, we use the NASDAQ index as control variable. Daily data is provided by the Thomson Reuters Datastream, commencing on January 1, 1998, and ending on February 4, 2010, containing 3032 observations. Returns are calculated as logarithmic differences of the market indexes. For simplicity, we assume that the Nordic markets operate at approximately the same trading hours while the data for the NASDAQ index is lagged one period due to differences in trading hours. Data are expressed in local currency without dividend.

Dummy variables (d1, d2, d3) are set to explore the influence of the Nordic stock market integrations. On the 3:rd of September in 2003, the Stockholm Stock Exchange (OM) merged with the Helsinki Stock Exchange (HEX) into the joint company OM HEX, which was renamed as OMX on August the 31:st, 2004. In January 2005, the OMX fulfilled the acquisition of the Copenhagen Stock Exchange for €164 million. At the end of 2006, the Icelandic Stock Exchange joined the OMX by a share purchase agreement between OMX and the owners of Eignarhaldsfelagid Verdbrefathing (EV) at 250 million SEK. The dummies are defined as the date (which are on the 3:rd of September in 2003, 3:rd of January in 2005, and the 29:th of December in 2006, respectively) when the integration took place and investors cost of cross-border trading decreased on the Nordic Markets. The dummies are outlining four subgroups; period 1 is defined from the 2:nd of March in 1998 to the 2:nd of September in 2003, when each stock market where accessible through separate trading platforms; period 2 is defined from the 3:rd of September in 2003 to the 2:nd of January in 2005, where the Swedish and Finnish stock markets where accessible through the same trading platform while the Danish and Icelandic stock markets operated on separate trading platforms; period 3 is defined from the 3:rd of January in 2005 to the 28:th of December in 2006, when the Swedish, Finnish and Danish stock markets where available through the same trading platform; and finally period 4 defined from the 29:th of December in 2006 to the 4:th of February in 2010, when all markets where accessible through the same trading platform. In Table 1 summary statistics for the logarithmic returns over the four sub-periods as well as over all periods are reported.

[Table 1 about here.]

The mean returns are positive on all markets, except on the Icelandic, over the full sample period. The highest unconditional standard deviation in returns are found for the Icelandic stock market while the lowest are found for the Danish and Swedish markets also over the full sample period. The unconditional standard deviation in returns generally decrease in period 2 and 3 compared to period 1, then to sharply increase in period 4, for all stock markets, mainly due to the global financial crises. In Table 2 the autocorrelation of the logarithmic returns and squared logarithmic returns over all periods are reported.

[Table 2 about here.]

Based on the Ljung-Box (LB) statistic the return series show a strong time dependence in both the return and squared return for the Swedish, Finnish and Danish stock markets. In contrast, serial correlation only appears in the return series for the Icelandic stock market.

A main channels through which the creation of a common trading platform can possibly affect return, volatilities and correlations are through changes in the liquidity on each stock market. It is thus of interest to include and study some measure of volume in the analysis. In Table 3 summary statistics for the daily number of traded shares on each market are reported.

[Table 3 about here.]

The average volume (average daily number of traded shares) are highest on the Swedish stock market followed by the Finnish, while the volumes are smaller on the Danish and the Icelandic stock markets. Overall the volume series increases for all stock markets, comparing from period one to four, for all series. Since the persistence in volume series is generally high (see e.g. Lo and Wang, 2009) detrended volume series are used in the empirical analysis to mitigate possible non-stationarity problems.

3 Econometric methods

To study whether the integration of the Nordic stock markets (Sweden, Finland, Denmark and Iceland), i.e. the lowered costs for cross-border trading, have affected the individual market risk for each market and interdependencies between 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. In the analysis the main focus is on studying changes in the long term pattern of volatility rather than on short term changes. To accomplish this the modelling is focused on capturing changes in the trend of the return volatilities and correlations due to market integration rather than on short term dynamics. In our analysis a parametric approach using C-GARCH (Engle and Lee, 1993; 1999) models are used to study the effect of market integration upon long-run Nordic stock market volatilities. To study the corresponding effect upon long-run conditional correlations between the Nordic stock markets a component-correlations-GARCH model (CC-GARCH) in spirit of the C-GARCH model is outlined and utilized in the analysis.

3.1 Time-varying conditional variance

To contrast the results based on the C-GARCH models (Engle and Lee, 1993; 1999) initially simple GARCH$(1,1)$ models are estimated. The both types of models are specified as:

$$\text{Mean} \quad : \quad r_t = \theta_t + \varepsilon_t \tag{1}$$

$$\text{Error assumptions} \quad : \quad \varepsilon_t|\Phi_{t-1} = \sigma_t\xi_t \sim N(0, \sigma_t^2),\ \xi_t \sim N(0,1). \tag{2}$$

$$\text{GARCH} \quad : \quad \sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2. \tag{3}$$

$$\text{C-GARCH} \quad : \quad \sigma_t^2 = q_t + \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta(\sigma_{t-1}^2 - q_{t-1}), \tag{4}$$

$$: \quad q_t = \omega + \rho(q_{t-1} - \omega) + \phi(\varepsilon_{t-1}^2 - \sigma_{t-1}^2). \tag{5}$$

The time-varying mean return, θ_t, is specified with an autoregressive structure in the empirical application. The C-GARCH specification enriches the dynamic specification for the conditional variance, compared to the GARCH(1,1) specification, by decomposing the conditional variance into a permanent (long-run) component, q_t, and a transitory component, $(\sigma_t^2 - q_t)$. The later describes the short-run deviations from the underlying long-run conditional variance. In order to guarantee a positive conditional variance in the C-GARCH model the following parameter restrictions must hold: (i) $1 > \rho > (\alpha + \beta) > 0$, (ii) $\beta > \phi > 0$, (iii) $\alpha, \omega > 0$. To test whether the level of the conditional variance differs between the different market regimes, dummy variables (defined as above) are included in the specification of σ_t^2 for the GARCH specification and in q_t for the C-GARCH specification.

3.2 Time-varying conditional correlation - A CC-GARCH model

To parametrically study the possible effect of stock market integration upon the long-run level of conditional correlation a component-correlation-GARCH (CC-GARCH) model is specified in spirit of the C-GARCH model. The model is specified as

$$\mathbf{R}_t = \boldsymbol{\mu}_t + \boldsymbol{\epsilon}_t, \tag{6}$$

where $\mathbf{R}_t$, $\boldsymbol{\mu}_t$, and $\boldsymbol{\epsilon}_t$ are 2×1 vectors denoting the returns, the conditional mean functions specified as $\mu_{it} = \alpha_{0i} + \sum_{l=1}^{L} \alpha_{li} r_{it-l}$, and the random disturbances, respectively. The disturbances in $\boldsymbol{\epsilon}_t$ are assumed to be normal i.i.d. mean-zero innovations with conditional covariance matrix

$$\mathbf{H}_t = Var(\boldsymbol{\varepsilon}_t|\Phi_{t-1}) = \begin{bmatrix} \sigma_{1t}^2 & \sigma_{12t} \\ \sigma_{12t} & \sigma_{2t}^2 \end{bmatrix}.$$

The disturbances are specified as $\varepsilon_{it} = \sigma_{it} z_t$, where $z_t \sim N(0,1)$, and σ_{it}^2 is assumed to follow a GARCH(1,1) process (as outlined above). Note here that to keep the model as simple as possible and to focus upon decomposing the conditional correlation, the process for the conditional variance is not specified in terms of a long-run components model (i.e. as for the C-GARCH model). To derive a model with time-varying return correlation decomposed into a permanent (long-run) and a transitory (short-run) component the covariance for the returns is reparameterized in the spirit of, e.g., Tsay (2002) and Hellström and Soultanaeva (2010), as $\sigma_{12t} = \rho_t \sqrt{\sigma_{1t}^2}\sqrt{\sigma_{2t}^2}$. Thus, the covariance is replaced by a parameter, ρ_t, for the time-varying correlation times the standard deviation of each return series giving direct access to the modelling of the correlation coefficient. The CC-GARCH model is specified as

$$\rho_t = q_t + \beta_0(\varepsilon_{1t-1}^*\varepsilon_{2t-1}^* - q_{t-1}) + \beta_1(\rho_{t-1} - q_{t-1}), \tag{7}$$

$$q_t = \omega + \gamma(q_{t-1} - \omega) + \phi(\varepsilon_{1t-1}^*\varepsilon_{2t-1}^* - \rho_{t-1}), \tag{8}$$

where q_t is the long-run trend component in the correlation and $\varepsilon_{1t-1}^*\varepsilon_{2t-1}^* = \varepsilon_{1t-1}\varepsilon_{2t-1}/\sqrt{\sigma_{1t-1}^2\sigma_{2t-1}^2}$. Since parameter restrictions on the functions for ρ_t and q_t, to restricted them to the $(-1,1)$ interval, are complicated the Fischer transformation $z = (\exp(\hat{z}) - 1)/(\exp(\hat{z}) + 1)$ is utilized. Thus, $\rho_t = (\exp(\hat{\rho}) - 1)/(\exp(\hat{\rho}) + 1)$ with $\hat{\rho}$ given by eq. 7, in a same fashion for q_t.

The probability density function for $\mathbf{R}_t$ is given by

$$f(\mathbf{R}_t|\Phi_{t-1}) = \frac{1}{(2\pi)^{N/2}}|\mathbf{D}_{ijt}\boldsymbol{\rho}_t\mathbf{D}_{ijt}|^{-1/2}\exp[-1/2 \times [\boldsymbol{\epsilon}_t[\mathbf{D}_{ijt}\boldsymbol{\rho}_t\mathbf{D}_{ijt}]^{-1}\boldsymbol{\epsilon}_t], \tag{9}$$

where

$$\boldsymbol{\epsilon}_t = \mathbf{R}_t - \boldsymbol{\mu}_t = \begin{bmatrix} r_{1t} - \mu_{1t} \\ r_{2t} - \mu_{2t} \end{bmatrix}, \quad (10)$$

$$\mathbf{D}_t = \begin{bmatrix} \sqrt{\sigma_{1t}^2} & 0 \\ 0 & \sqrt{\sigma_{2t}^2} \end{bmatrix}, \quad (11)$$

and $\boldsymbol{\rho}_t$ is the conditional correlation matrix

$$\boldsymbol{\rho}_t = \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix}.$$

The log-likelihood function based on this is utilized in the estimation, i.e. $\ln L = \sum_{t=1}^{T} \ln f(\mathbf{R}_t | \mathbf{\Phi}_{t-1})$.

4 Empirical results

Before studying the effect of the creation of a common trading platform for the Nordic stock markets upon stock market volatilities and correlations an initial analysis explores changes in trading volumes during the different sub-periods under study. The analysis is performed on the detrended volume series. In Table 4 simple regressions including dummies for the different sub-periods (dHel., dCop., dRej.), the lagged volume (volume_{t-1}) and the lagged volatility on the US market ($\sigma^2_{US,t-1}$) as control variates, are reported for each of the volume series.

[Table 4 about here.]

The regressions indicate that the daily volumes on the Swedish stock market on average significantly increased after the Swedish and Finnish stock markets were merged to a common trading platform. The opposite effect, i.e. on average a significantly negative effect, on daily trading volumes were found when the Icelandic stock market had become available on the same trading platform. The daily volumes on the Finnish stock market on average significantly increased during the period after the Swedish and Finnish stock markets were merged to a common trading platform, i.e. the total daily volumes for Sweden and Finland increased since trading increased for both markets after being merged to a common trading platform. The daily volumes on the Finnish stock market decreased significantly when the Icelandic stock market later joined. The daily volumes increased significantly on the Danish stock market, on average compared to the period prior to joining a common trading platform with Sweden and Finland. The daily volumes significantly decreased on the Danish market when Iceland had been merged to the common trading platform. The daily volumes on the Icelandic stock market was on average not affected by joining the common trading platform.

4.1 Stock market volatility

To study the effect of introducing a common trading platform upon the long run trend in volatilities C-GARCH models were estimated. In Table 5 and 6 the results for these models are reported. The estimation results for the models reported in Table 5 do not include volume as a control variate while the results reported in Table 6 do.

[Table 5 about here.]

[Table 6 about here.]

Starting with the parameters of interest[4], the results indicate that the stock market risk (volatility[5]) in Sweden decreased after the Swedish and Finnish stock markets were merged into a common trading platform. The result is supported by the model including volume as a control variate (Table 6) but not by the model excluding volume (Table 5). The market risk (volatility) in Sweden was not affected when the Danish stock market was included in the common trading platform, while the inclusion of the Icelandic stock market seem to have increased the volatility (similar results for both models including/excluding volume as control variate). Thus, the greater access to the Swedish stock market by Finnish and Icelandic investors have had an opposite effect upon market risk while no effect from greater access by Danish investors. The effect on market risk (volatility) on the Finnish stock market is similar as for the Swedish stock market, i.e. after the Finnish and Swedish (Icelandic) stock markets were merged the volatility decreased (increased) while there was no effect when the Danish market was included in the common trading platform. The volatility on the Danish stock market was positively affected by greater access from Swedish and Finnish investors through the common trading platform (similar results for both models including/excluding volume as control variate), while the similar result (increasing volatility) is weakly supported after Icelandic investors gained greater access (this is only supported by the model excluding volume).

For the other parameters in the models, first, the inclusion of volume gives mixed results. There is a positive significant correlation between volume and volatility on the

[4] Comments are focused on statistically significant parameters.

[5] In commenting results volatility is used when reffering to the conditional variance.

Swedish stock market, a negative significant correlation on the Danish stock market and no correlation on the Finnish market. Second, accounting for the volatility on the US stock market (previous day due to time differences) is generally statistically significant and with a positive effect on the Nordic stock market volatilities. Further, the estimation results for the transitory volatility component, eq. 4, indicate that the persistence in the process for the impact of short-run innovations is quite high. For all series the sum $\alpha + \beta$ is larger than 0.9. Thus, this indicates that the transitory component, $\sigma_t^2 - q_t$, converges to 0 slowly, i.e. deviations from the long-run trend in volatility (given by q_t) reverts slowly to the long-run trend. The persistence in the permanent component (long-run trend in volatility, eq. 5) is also high as indicated by ρ close to 1 for all models. This indicates that q_t approaches ω very slowly.

4.2 Stock market correlations

To study the effect of introducing a common trading platform upon the long run trend in correlations CC-GARCH models were estimated. In Table 7 estimation results for the parameters in the time-varying correlation equation (eq. 7) and the long-run trend component in correlation (eq. 8) are reported.[6]

[Table 7 about here.]

The estimation results for all pairs of conditional correlations indicate that the creation of a common trading platform for the Nordic stock markets have lowered the interdependencies between the markets. The results concerning the long-run level of conditional correlation are statistically significant at the 5 percent level between the Swedish-Finnish and Finnish-Icelandic stock markets, at the 10 percent level for the Swedish-Danish and Finnish-Danish stock markets, while statistically insignificant between the Swedish and Icelandic stock markets.[7]

5 Discussion and conclusions

In this paper the effect of a increased degree of integration between the Nordic stock markets (Sweden, Finland, Denmark and Iceland) through the creation of a common

[6] Estimates for the parameters in the conditional means and GARCH(1,1) equations for respective series are surpressed to save space, but can be obtained from the authors upon request.

[7] Since the other parameters in the transitory and permanent components of the correlation are estimated by use of a restriction through the Fischer transformation, these are not straight forward to interpret. Marginal effects will be given in a later version of the paper.

trading platform, decreasing the cost of cross-border trading, upon market risk (volatility, i.e. conditional correlation) and interdependencies (conditional correlation) between the markets are studied.

The main findings of the paper indicate that the effect of creating a common trading platform upon long-run stock market volatilities (conditional variance) differs between considered stock markets. The volatility on the Swedish and Finnish stock markets decreased when investors in these countries got easier access to respectively countries stock markets while the volatility increased on all markets when the Icelandic stock market was merged to the common trading platform. This later result should, however, be interpreted with caution since the results may be due to lack of appropriate control variates (specially controlling for the global financial crises during the later parts of the sample period). The volatility on the Danish and Icelandic stock markets both increased after these markets were merger to the common platform. Concerning the effects upon the long-run levels of correlations between the Nordic stock market returns, these results are easier to summarize. The interdependencies between all stock markets have in general decreased due to the creation of a common trading platform. One explanation for this result may be that the lower cost of cross-border trading have made it easier for investors to move assets from one Nordic market to another in reaction towards local negative shocks in any of the markets. This activity is then likely to create an opposite return reaction (negative returns in market experiencing a negative shock, while an increasing demand for assets in markets where investors move their funds renders positive returns) in the different markets rendering a lower correlation between them.

References

Bekaert, G. and Harvey, C.R. (1995). Time-varying world market integration. *Journal of Finance* **50**, 403-444.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Economics* **31**, 307-327.

Cleveland, R.B., Cleveland, W.S., McRae, J.E., and Terpenning, I. (1990). STL: A Seasonal-Trend Decomposition Procedure Based on Loess. *Journal of Official Statistics* **6**, 3-73.

Cleveland, W.S., Devlin, S.J., and Grosse, E. (1988). Regresison by local fitting: methods, properties, and computational algorithms. *Journal of Econometrics* **37**, 87-114.

Engle, R. and Lee, G. (1993). *A permanent and transitory component model of stock return volatility.* Working Paper No. 92-44R, University of California at San Diego.

Engle, R. and Lee, G. (1999). A permanent and transitory component model of stock return volatility. In: R., Engle, H., White (eds) *Cointegration, causality and forecasting: A festschrift in honor of C.W.J. Granger.* Oxford University Press, Oxford, 475-497.

Hellström J., Soultanaeva A. (2010). The Impact of Stock Market Jumps on Time-Varying Return Correlations: Empirical Evidence from the Baltic Countries. Mimeo.

Kearney, C. and Lucey, B.M. (2004). International Equity Market Integration: Theory, Evidence and Implications. *International Review of Financial Analysis* **13**, 571-583.

Kokkoris, I., Olivares-Caminal, R. (2008). Lessons from the recent stock exchange merger activity. *Journal of Competition Law and Economics* **4**, 837-869.

Lo A.W., Wang J. (2009). Stock Market Trading Volume. *The Handbook of Financial Econometrics.* Eds. Y. Ait-Sahalia and L. Hansen. New York: North-Holland.

Tsay, R. S. (2002). *Analysis of financial time series.* Wiley series in probability and statistics, NY, second edition.

Table 1: Summary statistics - Returns.

		Period 1	Period 2	Period 3	Period 4	All periods
Sweden	Mean	0.002	0.068	0.098	-0.028	0.017
	Std.Dev.	1.668	0.899	0.960	1.827	1.549
	Min	-8.070	-3.500	-5.490	-7.380	-8.070
	Max	9.880	3.150	5.370	8.630	9.880
	Obs.	1418	335	502	777	3032
Finland	Mean	0.051	0.007	0.095	-0.044	0.029
	Std.Dev.	2.661	1.261	0.930	1.867	2.127
	Min	-17.400	-9.230	-3.760	-7.920	-17.400
	Max	14.560	5.810	4.020	8.850	14.560
	Obs.	1418	335	502	777	3032
Denmark	Mean	0.019		0.099	-0.034	0.019
	Std.Dev.	1.027		0.801	1.589	1.168
	Min	-5.240		-3.800	-10.58	-10.580
	Max	4.110		2.850	8.200	8.200
	Obs.	1753		502	777	3032
Iceland	Mean	0.078			0.317	-0.023
	Std.Dev.	0.782			4.375	2.320
	Min	-5.620			-109.600	-109.600
	Max	5.130			5.060	5.130
	Obs.	2255			777	3032

Table 2: Descriptive statistics.

		Q statistic	Prob > chi2(40)
r	Sweden	97.559	0.000
	Finland	78.417	0.000
	Denmark	104.832	0.000
	Iceland	300.682	0.000
r^2	Sweden	2582.233	0.000
	Finland	1040.895	0.000
	Denmark	4870.546	0.000
	Iceland	39.802	0.479

Table 3: Summary statistics - Volumes (Nr. of daily traded shares.

		Period 1	Period 2	Period 3	Period 4	All periods
Sweden	Mean	11.941	17.818	19.052	21.246	16.152
	Std.Dev.	4.948	6.389	5.775	6.483	6.990
	Min	3.180	6.340	6.060	6.530	3.180
	Max	44.900	76.080	43.730	76.710	76.71
	Obs.	1418	335	502	777	3032
Finland	Mean	3.209	6.055	7.281	7.308	5.269
	Std.Dev.	1.804	3.029	3.106	2.724	3.122
	Min	0.003	1.710	2.180	1.790	0.003
	Max	22.740	26.82	31.920	24.600	31.92
	Obs.	1418	335	502	777	3032
Denmark	Mean	1.193		3.031	2.102	1.753
	Std.Dev.	0.686		1.732	0.829	1.186
	Min	0.21		1.090	0.700	0.210
	Max	9.350		18.450	8.370	18.450
	Obs.	1753		502	777	3032
Iceland	Mean	0.120			1.688	1.849
	Std.Dev.	1.900			4.554	5.214
	Min	0.020			0.000	0.000
	Max	79.790			56.430	79.79
	Obs.	2255			777	3032

Table 4: OLS parameter estimates for volumes.

	Stockholm		Helsinki		Copenhagen		Rejkavik	
	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.
const.	0.283*	(0.132)	0.214*	(0.064)	0.091*	(0.022)	0.103	(0.494)
volume_{t-1}	0.522*	(0.015)	0.417*	(0.017)	0.449*	(0.016)	0.060**	(0.034)
dHel.	0.833*	(0.280)	0.575*	(0.135)	-	(-)	-	(-)
dCop.	-0.383	(0.320)	0.187	(0.154)	0.628*	(0.047)	-	(-)
dRej.	-0.596*	(0.261)	-0.830*	(0.128)	-0.757*	(0.053)	-0.018	(0.529)
$\sigma^2_{US,t-1}$	325.342*	(71.833)	89.769*	34.611	43.008*	(13.172)	136.938	(179.763)
R^2	0.29		0.21		0.35		0.06	

* Significant at the 5 percent level, ** Significant at the 10 percent level.

Table 5: Parameter estimates for CGARCH models.

	Stockholm		Helsinki		Copenhagen		Rejkavik	
	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.
const.	0.088*	(0.018)	0.081*	(0.023)	0.069*	(0.015)	0.068*	(0.015)
r_{t-1}	0.010	(0.018)	0.031	(0.019)	0.069*	(0.015)	0.069*	(0.018)
α	0.088*	(0.009)	0.065*	(0.004)	0.113*	(0.010)	0.107*	(0.006)
β	0.838*	(0.145)	0.848*	(0.175)	0.835*	(0.053)	0.831*	(0.112)
ω	0.676	(0.730)	1.119	(4.191)	0.136*	(0.001)	0.679	(0.405)
ρ	0.979*	(0.293)	0.981*	(0.195)	0.997*	(0.262)	0.994*	(0.458)
ϕ	0.012*	(0.004)	0.000	(0.000)	0.000*	(0.000)	0.011*	(0.002)
dSH	-0.006	(0.006)	-0.019*	(0.008)	-	-	-	-
dSHC.	0.001	(0.004)	-0.000	(0.004)	0.002*	(0.001)	-	-
dSHCR	0.028*	(0.009)	0.010*	(0.004)	0.003*	(0.001)	0.005*	(0.002)
$r^2_{US,t-1}$	0.006*	(0.002)	0.016*	(0.004)	0.004*	(0.001)	0.003	(0.002)
lnL	-5281		-6178		-4368		-4369	
AIC	10583		12378		8757		8758	
LB	16.282		19.710		30.897		30.895	

dSH=dummy for integration of Stockholm (S) and Helsinki (H) stock market,

dSHC=Stockholm, Helsinki and Copenhagen,

dSHCR=Stockholm, Helsinki, Copenhagen and Rejkavik.

Table 6: Parameter estimates for CGARCH models including volume.

	Stockholm		Helsinki		Copenhagen		Rejkavik	
	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.
const.	0.090*	(0.018)	0.087*	(0.024)	0.069*	(0.014)	0.059*	(0.011)
r_{t-1}	0.013	(0.018)	0.032**	(0.018)	0.071*	(0.018)	0.160*	(0.021)
α	0.091*	(0.010)	0.066*	(0.005)	0.015*	(0.002)	0.198*	(0.008)
β	0.829*	(0.152)	0.835*	(0.198)	0.979*	(0.400)	0.468*	(0.061)
ω	0.062	(0.132)	0.905	(5.993)	0.962	(4.693)	0.009*	(0.000)
ρ	0.973*	(0.309)	0.979*	(0.221)	0.933*	(0.221)	0.989*	(0.310)
ϕ	0.010*	(0.004)	0.001*	(0.000)	0.098*	(0.006)	0.065*	(0.003)
dSH	-0.019**	(0.010)	-0.021**	(0.012)	-	-	-	-
dSHC.	-0.001	(0.005)	-0.001	(0.005)	0.021**	(0.012)	-	-
dSHCR	0.033*	(0.013)	0.011*	(0.005)	0.018	(0.017)	0.009*	(0.004)
$r^2_{US,t-1}$	0.008*	(0.003)	0.019*	(0.004)	0.003	(0.002)	0.000	(0.000)
Vol.	0.016*	(0.008)	0.006	(0.021)	-0.115*	(0.020)	0.001	(0.012)
lnL	-5129		-5983		-4244		-3637	
AIC	10283		11990		8509		7274	
LB	16.869		19.935		31.711		100.600	

dSH=dummy for integration of Stockholm (S) and Helsinki (H) stock market,

dSHC=Stockholm, Helsinki and Copenhagen,

dSHCR=Stockholm, Helsinki, Copenhagen and Rejkavik.

* Significant at 5 percent level, ** Significant at 10 percent level.

Table 7: Correlation and correlation trend component for CC-GARCH models.

	Stoc.-Hels.		Stock.-Cop.		Stoc.-Rejk.		Hels.-Cop.		Hels.-Rejk.		Cop.-Rejk.	
	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.	Est.	s.d.
β_0	-0.020*	(0.009)	0.092*	(0.011)	0.106*	(0.009)	0.032*	(0.009)	0.005	(0.009)		()
β_1	2.409*	(0.066)	2.193*	(0.259)	1.956*	(0.011)	2.145*	(0.187)	1.277*	(0.050)		()
ω	-0.104	(0.131)	-0.008	(0.179)	0.005*	(0.002)	-0.085	(0.340)	-0.206*	(0.091)		()
γ	-2.006*	(0.007)	0.391	(1.245)	-1.120*	(0.223)	-1.797*	(0.102)	0.163	(0.277)		()
ϕ	-0.012	(0.004)	-0.029	(0.019)	0.150*	(0.014)	0.028*	(0.011)	0.772*	(0.142)		()
dSH	-0.673*	(0.093)	-	-	-	-	-	-	-	-	-	-
dSHC.	-	-	-0.088**	(0.052)	-	-	-0.163**	(0.095)	-	-	-	-
dSHCR	-	-	-	-	-0.019	(0.020)	-	-	-1.411*	(0.189)		()
lnL	-4578		-3048		-4020		-4348		-5513			

dSH=dummy for integration of Stockholm (S) and Helsinki (H) stock market,

dSHC=Stockholm, Helsinki and Copenhagen,

dSHCR=Stockholm, Helsinki, Copenhagen and Rejkavik.

* Significant at 5 percent level, ** Significant at 10 percent level.