

1. ON THE LINKAGE BETWEEN THE INTERNATIONAL CRUDE OIL PRICE AND STOCK MARKETS: EVIDENCE FROM THE NORDIC AND OTHER EUROPEAN OIL IMPORTING AND OIL EXPORTING COUNTRIES

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Abstract

The paper investigates the interrelationship between the stock market and the crude oil price for the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) and two other European countries that have the highest imports (Germany) and exports (Russia) of oil using data from 1995 to the end of 2015. We found that the time-varying correlation among the oil exporting (importing) countries are different. We also found that the two oil exporting countries (Norway and Russia) have higher integration with the Brent and West Texas Intermediate (WTI) oil indices, which reveals that these markets are less attractive to international investors during periods of high turbulence. Furthermore, contrary to previous literature documenting negative relations between the stock market and crude oil, our results demonstrate that, although the negative association was evident up to the period prior to the global financial crisis (GFC), starting from the GFC period (especially for the oil importing countries), we noticed a positive time-varying relationship that continued until the end of our sample study. In addition, the time-varying correlation response was more pronounced during the financial market turmoil of 2015. Further, we investigated the two price indices (Brent and WTI) using the Markov regime-switching autoregressive (MRS-AR) approach to model periods of high volatility (turbulence) and low volatility (stable period). The Markov model revealed that in regime 0 (1998-2002, 2008-2009, and 2015), which can be characterized as the most volatile period for the oil market, the probability reached close to 1. We noticed that during the GFC and in the period prior to the GFC, the time-varying relationship

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was positive and at a higher level in high-volatility regimes, whereas during low-volatility regimes the time-varying relationship was negative and at a low level.

Keywords: oil price, oil importing, oil exporting volatility, financial crisis

JEL Classification: C5, G1, G12, G15, Q4

1. Introduction

During the first month of 2016, the global oil price reached its lowest level in 12 years. At the same time, the global stock markets are experiencing greater volatility and turning into bear markets, especially the US and European stock markets and the emerging markets in Russia and China. The panic and loss of confidence among investors in these two markets (i.e., stock markets and oil markets) are due to several factors. For example, the turmoil in the equity markets is the result of a recent policy change on the part of the USA regarding interest rates and the continued dollar appreciation against several currencies, including the Euro, as well as the global contraction in economic growth. On the other hand, the oil price decline is due to the fact that oil production increases as countries like the USA that used to be net importing countries are now net exporters, which continues the supply of oil by the Organization of the Petroleum Exporting Countries (OPEC) and other non-OPEC countries. This increase in oil production is also due to the lifting of the international embargo on Iran, a major oil exporting country, which promises additional supply to the markets. Therefore, the higher production of oil, the excess supply, and the unchanged demand for oil by importers are the main factors behind the continued decline in the oil price. The literature reveals that a high oil price hurts the economy of the oil importing countries if oil is used in production (Backus and Crucini, 2000), while it benefits oil exporting countries since an increase in the oil price is coupled with an increase in income (Bjørnland, 2009). Hence, the continued decline in the oil price may be good news for the oil importing countries if the oil is used in production. Consequently, one expects that a low input price means a lower total cost and a greater profit, which also means more cash for future investment by the company, leading to a higher stock price for that company. However, for the oil exporting countries a decline in the oil price leads to a loss of revenue, which could negatively affect the country's output and expenditure, especially if the country is heavily reliant on oil revenue. At the same time, the declining oil price may lead to opportunities for the country to diversify its exports. Nevertheless, it is important to understand that factors that affect the oil market can also affect the stock market, or vice versa.

Certainly, it will be to the advantage of policy makers (since oil is used as an input for almost all goods from basic needs to luxury ones) and international investors (especially those investors who make considerable investments in oil industry stocks) to study the degree of correlation behavior among these two important markets (i.e., oil market and stock market) and consider whether there is a positive (negative) relationship between them. Therefore, the present paper aims to analyze the dynamic correlation among the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) by including one of the highest European oil importing countries (Germany) and one net oil exporting country (Russia). Among the Nordic countries, Norway is also one of the main crude oil exporting countries in the world.

The paper makes several important contributions. First, this study is among the first to study dynamic behavior among the Nordic countries' stock markets and the crude oil price by including two other important countries. Previous studies mostly concentrated on non-Nordic countries, such as the USA and other developed European countries, as well as some emerging economies. Second, this study includes oil exporting and oil importing countries, which should help in determining whether or not the ongoing decline in the oil price has a greater impact on oil producing stock markets. Third, we have used two oil price indices (Brent Crude Oil and West Texas Intermediate (WTI)), while most of the previous studies made use of only one index at a time. Additionally, these indices represent almost all of the oil exporting countries. Fourth, this study makes use of the Markov switching method to model the crude oil indices during periods of both stability and turmoil, which should help in identifying years in which the oil price has been either bearish or bullish.

The key findings of the paper are as follows. Oil exporting countries' stock markets have high market integration with the two oil indices, whereas the oil importing nations have lower correlation with the crude index. Furthermore, we observed that the oil exporting countries' correlation has been very high since the beginning of the sample. In other words, positive dynamic correlation exists with all the markets. We also observed that the global financial crisis has changed the interrelationship between the stock market and crude oil. However, this change has mostly impacted the oil importing nations. That is to say, the evaluation has changed from a negative interrelationship to a positive one. We investigated the two price indices (Brent and WTI) using the Markov regime-switching autoregressive (MRS-AR) approach to model periods of high volatility (turbulence) and low volatility (stable period). The Markov model revealed that in regime 0 (1998-2002, 2008-2009, and 2015), which can be characterized as the most volatile period for the oil, the probability reached close to 1. Further, we noticed that the time-varying relationship behaves differently depending on the regime. During the low-volatility regime, the time-varying relationship was negative and had low-level correlation, whereas during the high-volatility regime, the time-varying relationship was positive and had high-level correlation. However, this relationship (time-varying and regimes) was during the GFC and in the period prior to the GFC.

The remainder of the paper is organized as follows. Section two discusses the existing literature, while sections three and four present the data and methodology and the modeling of the oil price, respectively. The empirical results are presented in section five and, finally, concluding remarks are offered in section six.

2. Literature Review

A large body of research with a financial/economic focus has studied the evolution of dynamic correlation and volatility between local stock markets as well as across regional and international stock markets (Rotta and Pereira, 2015; Dajčman, 2013; Mohanasundaram and Karthikeyan, 2015; Xu and Hamori, 2012; Gupta and Guidi, 2012). Equally, there have been several studies that focused on the oil markets, especially modeling and forecasting the crude oil price (Bildirici and Ersin, 2014; Wang and Huang, 2010; Sadorsky, 2006; Yu *et al.*, 2008). Furthermore, studies have also investigated the spillover and correlation between the stock markets and other financial

variables, for example the interrelationship and dynamic changes between the exchange rate and the stock market (Saman, 2015; Wong and Li, 2010; Köseoğlu and Çevik, 2013; Moore and Wang, 2014; Reboredo *et al.*, 2015; Walid *et al.*, 2011; Athanasios and Siriopoulos, 2013). Additionally, a considerable number of studies have examined the interdependence and correlation change between the stock market and the international crude oil market (Arouri *et al.*, 2011; Wang *et al.*, 2013; Filis *et al.*, 2011; Zhu, 2014; Avdulaj and Barunik, 2015; Ghosh and Kanjilal, 2014; Bouri, 2015; Kiran, 2011). Those authors all investigated the co-movements among different countries' stock markets. For example, the study by Arouri *et al.* (2011) explored the relationship between the international oil price and the Gulf Cooperation Council (GCC) from 2005-2010 using the vector autoregression-generalized autoregressive conditional heteroscedasticity (VAR-GARCH) approach and found evidence of volatility spillover among the two markets. On the other hand, Filis *et al.* (2011) examined time-varying correlations using the dynamic conditional correlation asymmetric between those two markets for oil exporting countries (Canada, Mexico, Brazil) and oil importing markets (USA, Germany, Netherlands). Their findings documented interesting results. First, they showed that the time-varying behavior among the oil importing and oil exporting countries behaved in the same way. Second, they observed that the correlation between the stock market and the oil price increased (decreased) in response to the demand side effect. However, the supply side does not have an impact on the relationship between the two markets. Avdulaj and Barunik (2015) examined the benefits of diversification of the stock and oil markets utilizing a method that takes into account the higher-order moments and nonlinear dependence of tail events. Their findings showed that the benefit of diversification has declined over time. Ghosh and Kanjilal (2014) studied the interdependence between the world oil price and the Indian stock market for the period January 2002 to July 2011. They divided the sample into three sub-periods (pre-crisis, crisis, and post-crisis period) and then employed nonlinear cointegration and Granger causality. According to their results, cointegration was only identified during the post-crisis period. Further, during the pre-crisis and crisis periods, they observed causality running from the international oil price into the stock market, but not from the stock market to the oil market. Bouri (2015) examined the association between those two markets for oil importing Middle Eastern and North African countries (Jordan, Lebanon, Morocco, Tunisia), and their findings documented that international oil markets have greater volatility spillover into the Jordanian stock market, although the Lebanese market showed less interdependence with the oil markets. There are also authors who have documented a negative relationship between the stock market and the crude oil markets (Reboredo, 2010; Park and Ratti, 2008; Jones and Kaul, 1996; Sadorsky, 1999).

Based on the above, it can be seen that the previous literature has mostly focused on non-Nordic countries and generally used traditional methods such as Granger causality and cointegration methods. Additionally, this vast body of literature has documented that a negative relationship exists and that the time-varying correlations for oil importing and exporting countries is the same. Therefore, given that the Nordic countries are considered to be a hub of investment for international and domestic investors, it is deemed necessary to investigate the relationship between the stock markets in those countries and the crude oil market.

3. Data and Methodology

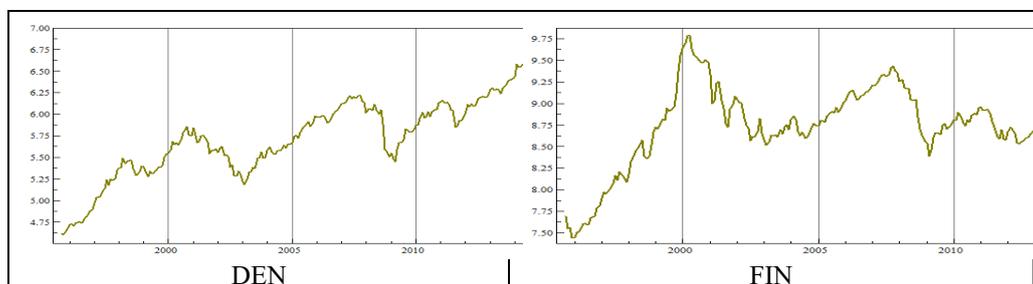
3.1. Data and Descriptive Statistics

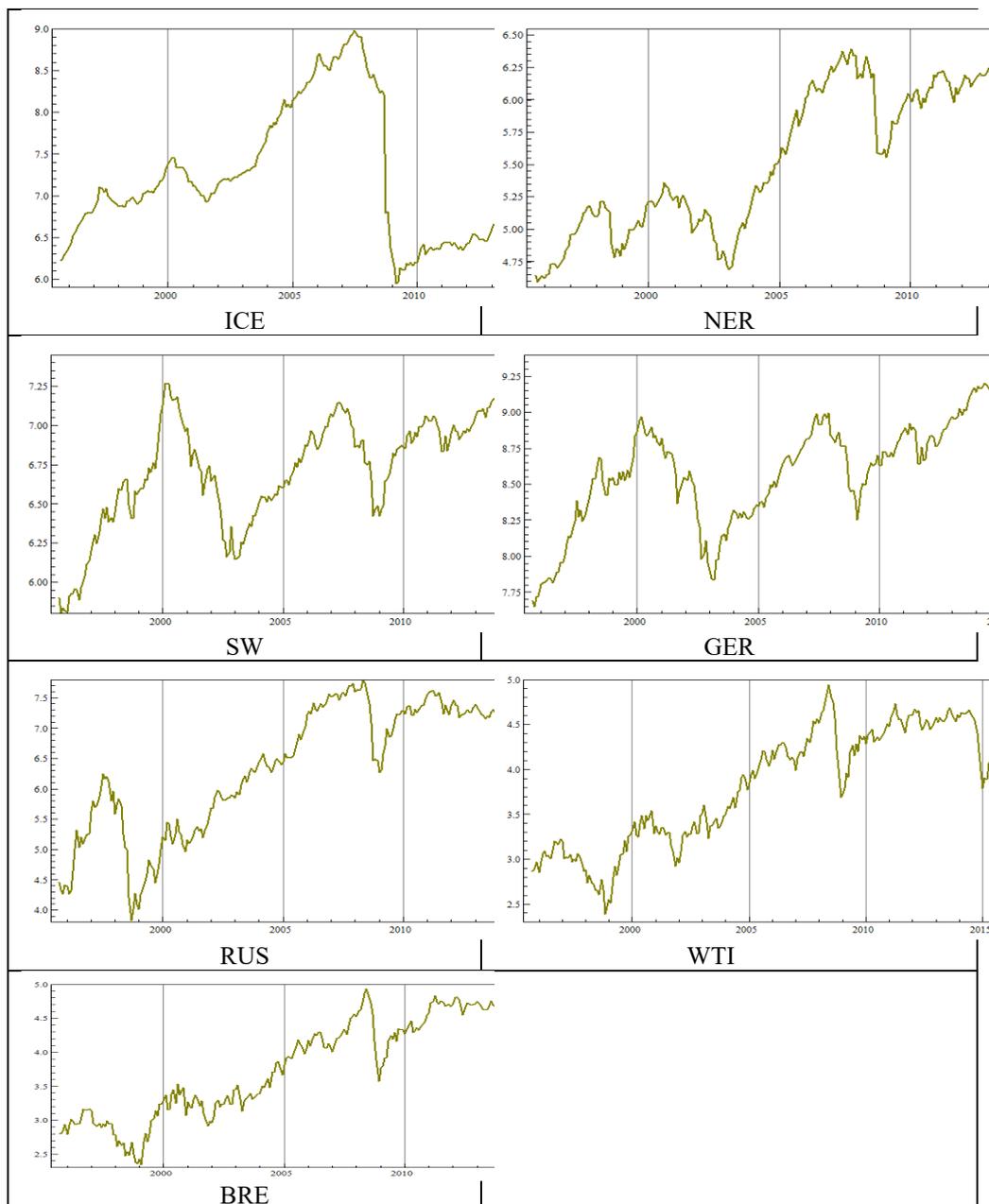
The present study aimed to examine the linkages between stock markets and the international oil price by making use of the major indices for seven countries as well as two major indices. The indices representing the Nordic countries are: OMX COPENHAGEN (OMXC20) for Denmark, OMX HELSINKI (OMXH) for Finland, OMX ICELAND ALL SHARE for Iceland, OSLO EXCHANGE ALL SHARE for Norway, and OMX STOCKHOLM 30 (OMXS30) for Sweden. Germany, a major oil importing country, is represented by DAX 30, while MICEX INDEX represents Russia, a net oil exporting country. As a proxy for the world oil price level, we considered the Brent and West Texas Intermediate crude oil indices. All of the data were obtained from the Thomson Reuters DataStream. The data are monthly, starting from September 1995 and going to December 2015, and are end-of-the-month observations. Using monthly data (hence, low-frequency data) allowed us to capture the economic activity on the stock and oil price markets. Engle and Rangel (2008) argued for the use of low-frequency data to account for the slow-moving macroeconomic trends on market volatility. This is important, since shocks in oil price might not be reflected immediately in stock price but will rather influence stock price over time through macroeconomic variables, and vice versa (i.e., a shock in stock price might not impact directly the oil price). Drost and Nijman (1993) investigated GARCH volatilities with high and low frequencies and stated that it is better to predict volatile high-frequency data with a low-frequency model. They also argued that high-frequency data do not predict lower-frequency volatility well. Several studies make use of monthly returns to examine the relationship between the stock price and the oil market (Bjørnland, 2009, Filis *et al.* 2011).

Figure 1 shows the stock price and crude oil price for the above indices. All of the prices are transformed into logarithmic form. As one may see in Figure 1, both of the price indices have the same trend and pattern from the beginning of the period to the end. Further, starting from the beginning of 2015, the oil price starts falling gradually. In addition, the lowest price seen during 1999 reached below 30 U.S dollars. Looking at the stock price, almost all of the indices have the same trends, especially after 2000. The impacts of the global financial crisis are evident in all the stock prices, including the crude oil price.

Figure 1

Stock Price and Crude Oil Price in Log Form





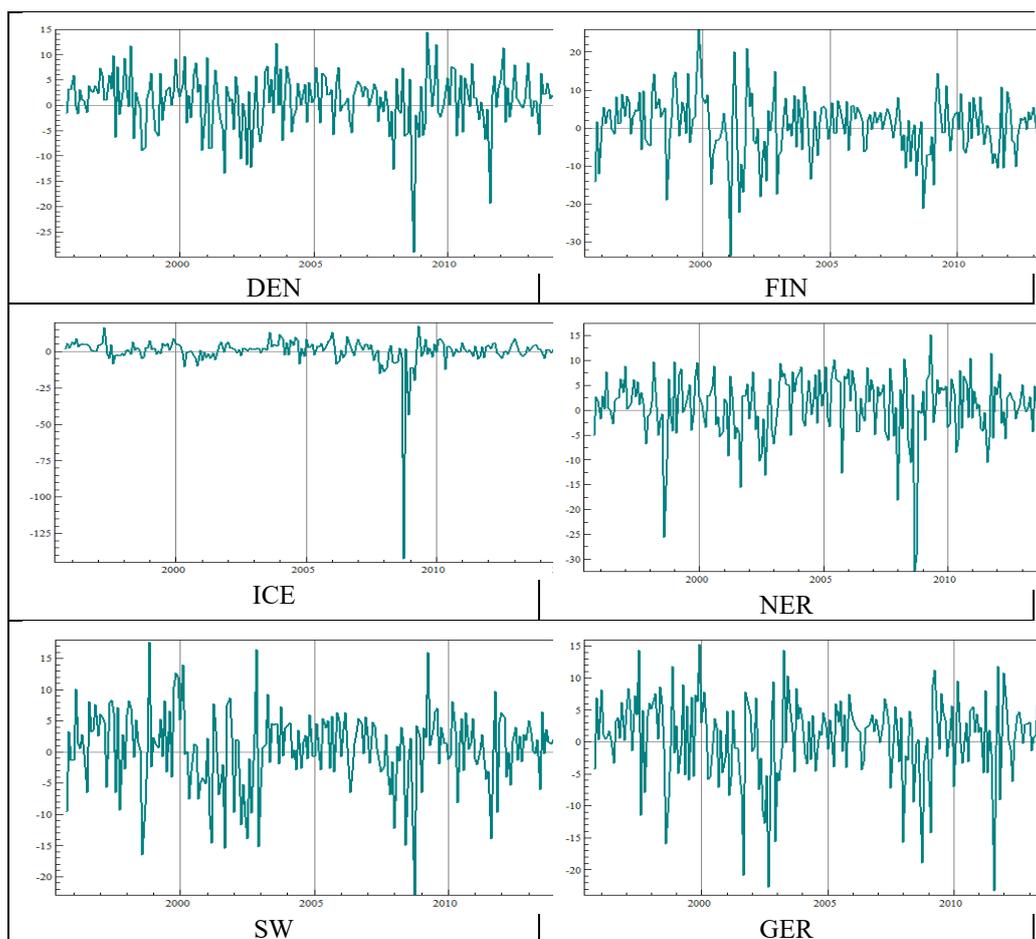
Note: for Denmark (DEN), Finland (FIN), Iceland (ICE), Norway (NER), Sweden (SW), Germany (GER), and Russia (RUS). For the Crude Oil, WTI (West Texas Intermediate) and Brent (BRE)

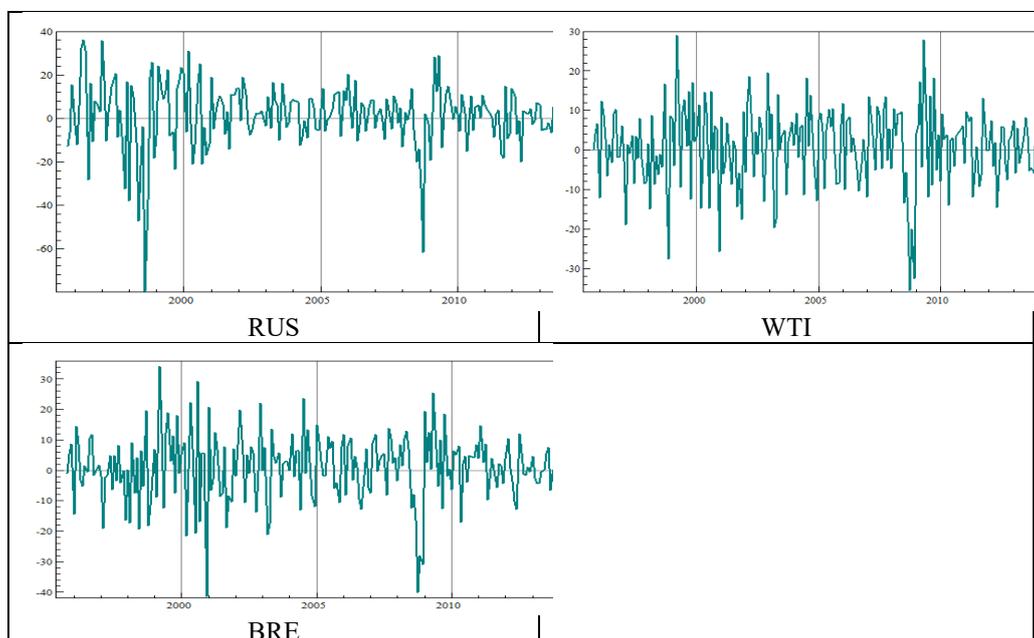
Figure 2 shows the return for the seven countries' stock markets and for crude oil markets. Higher volatility is observed during the period from 1998 to 2000 and during

the GFC for all of the stock markets. The least volatility is observed in the case of Iceland's stock market, while the most volatility is seen for Germany's stock market. Interestingly, almost all the other Nordic countries (Denmark, Finland, Norway, and Sweden) show the same patterns and trends of volatility. Unlike the stock markets, the crude oil prices have been more volatile, especially the WTI.

Figure 2

Returns for Stock Market and Crude Oil





Note: Denmark (DEN), Finland (FIN), Iceland (ICE), Norway (NER), Sweden (SW), Germany (GER), and Russia (RUS) and Crude Oil, WTI (West Texas Intermediate) and Brent (BRE)

Table 1 presents a summary of the descriptive statistics for the seven stock market indices and two international crude oil indices for the whole sample period. A higher return as measured by the mean is observed in the case of the Danish stock market. Considering the volatility as measured by the standard deviation, the Russian stock market is seen to be the most volatile market. This is expected since emerging economies normally have more volatile markets when compared to developed markets. Both of the crude oil markets also remain volatile, with Brent being a bit higher than WTI. The skewness for all of the stock markets and crude oil markets is negatively skewed. The kurtosis is higher than 3 for all of the indices, which is the typical property of time series data. The ARCH test also shows that the series can model and it is consistent with the GARCH family.

Table 1
Descriptive Statistics for Seven Stock Markets and Two Oil Markets

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ARCH (5)	Q(20)	Q ² (20)	ADF
DEN	0.948	5.523	-1.0705	6.838	195***	0.8385	16.729	13.959	-7.47
FIN	0.565	7.553	-0.5302	5.272	63***	5.59***	32.3**	99.5***	-8.19
ICE	0.393	10.90	-9.602	123.78	1515***	0.366	48.4***	2.026	-6.19
NER	0.753	6.147	-1.610	8.884	455***	6.5***	20.39	39.0***	-7.4
SW	0.568	5.928	-0.5788	4.394	32***	1.87	24.04	32.2**	-7.36
GER	0.659	6.175	-0.8983	4.9456	71***	1.668	12.63	24.87	-8.04
RUS	0.901	14.37	-1.168	8.124	321***	5.2***	41.1***	59.5***	-7.60
WTI	0.316	9.960	-0.457	3.753	14.2***	5.7***	29.94*	42.9***	-8.03
BRE	0.338	11.00	-0.375	4.378	24.9***	5.6***	24.9	45.1***	-8.16

Q(20) and Q²(20) are the Ljung-Box statistics for serial correlation in the standardized return and squared standardized return series, respectively. The results reveal the existence of correlation in almost all the markets. Finally, the augmented Dickey-Fuller (ADF) test is used on the first difference, which is obtained using the transformed natural logarithmic series. The results reveal that the all of the returns are stationary.

Table 2 presents the correlation coefficient with the two international crude oil markets using three measures, namely Pearson's r, Kendall's, and Spearman's rho. From the table, the net oil exporting countries (Russia and Norway) have a higher level of correlation with the two crude oil markets when using three of the measures. Additionally, WTI crude oil has a higher correlation than Brent with those two countries. Most of the correlations are higher using Pearson's r, followed by Spearman's rho. Among the oil importing countries, Iceland has the highest correlation with the two oil markets, followed by Denmark. The lowest correlation is observed for Germany and Finland with the two oil markets. Lastly, it is worth noting that the correlation between the two oil markets is very high with Pearson's r, reaching almost 0.91, and lowest with Kendall's, reaching around 0.75.

Table 2

Correlation between Seven Stock Markets and Two Oil Markets

	With Brent			With WTI		
	Pearson's r	Kendall's	Spearman's rho	Pearson's r	Kendall's	Spearman's rho
DEN	.206***	.096**	.144**	.202***	.090**	.130**
FIN	0.079	0.06	0.089	0.087	0.055	0.081
ICE	.258***	0.065	0.095	.272***	0.065	0.099
NER	.370***	.249***	.368***	.385***	.251***	.367***
SW	0.122	0.073	0.107	0.08	0.051	0.078
GER	0.077	0.052	0.079	0.053	0.031	0.047
RUS	.219***	.165***	.227***	.221***	.156***	.216***
DWTI	.910***	.751***	.913***			

Note. ***, **, and * are statistically significant at 1%, 5%, and 10%, respectively.

3.2. The Methodology

To investigate the dynamic relations between the stock market and the crude oil market return multivariate, generalized autoregressive conditional heteroscedasticity (GARCH) is used by incorporating the Engle's (2002) dynamic conditional correlation method. The incorporation of the dynamic conditional correlation (DCC) is becoming popular in a growing body of literature in finance and economics, particularly for studies of the behaviour of two pairs of financial assets. DCC-GARCH estimation involves several steps. At the beginning, the mean equation for the return is obtained by

$$r_{i,t} = \gamma_{i,t} + \mu_{i,t} \tag{1}$$

where: r is the return series for index return i at the time t . Additionally, γ is the constant term and μ is the residual term. The second step is to estimate the conditional variance, which is obtained from the following equation:

$$h_{i,t} = \varphi_i + \theta_i \varepsilon_{i,t-1}^2 + \vartheta_i h_{i,t-1} \tag{2}$$

Here, $h_{i,t}$ is the conditional variance that is estimated by univariate GARCH (1, 1). φ_i is the constant term, whereas θ_i and ϑ_i are the ARCH and GARCH effects, respectively.

In the last step, the DCC is estimated from the following equation:

$$p_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}} \tag{3}$$

where: $p_{ij,t}$ is the DCC between the two stock indices (i and j). Thus, the correlation coefficient at time t is defined as follows:

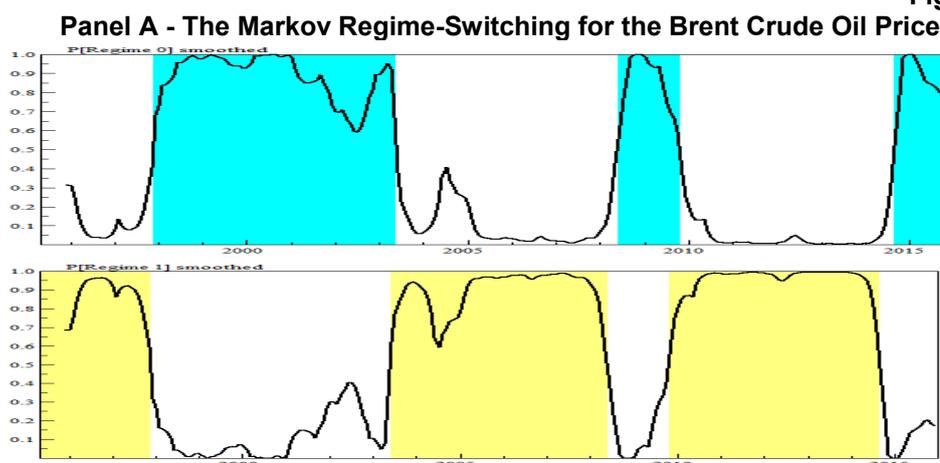
$$\rho_{ij,t} = \frac{(1-\alpha-\beta)\bar{q}_{ij} + \alpha u_{i,t-1}u_{j,t-1} + \beta q_{ij,t-1}}{[(1-\alpha-\beta)\bar{q}_{ii} + \alpha u_{i,t-1}^2 + \beta q_{ii,t-1}]^{1/2} [(1-\alpha-\beta)\bar{q}_{jj} + \alpha u_{j,t-1}^2 + \beta q_{jj,t-1}]^{1/2}} \tag{4}$$

Here, α and β are non-negative scalar parameters satisfying the condition $\alpha + \beta < 1$. α shows the volatility and β is the persistence of the shocks. \bar{q}_{ij} is the unconditional correlation of $u_{i,t}$ and $u_{j,t}$, while q_{ij} is element on the i and j columns of the matrix. The model is estimated using a two-step estimation method (Engle, 2002).

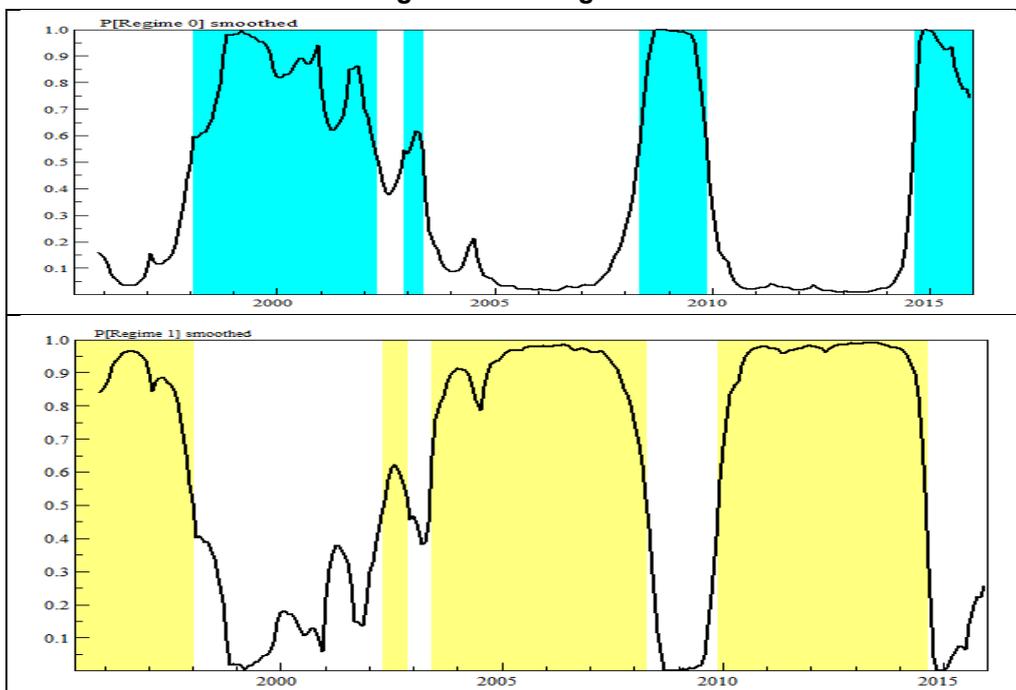
Modeling the Oil Price

The Markov regime-switching autoregressive (MRS-AR) technique is employed in identifying the regime shift and volatility pattern on the international crude oil return. The MR-SAR technique was developed by Hamilton (1989, 1990), and it is able to capture several numbers of regimes over time. Therefore, in the present study we employed Markov regime-switching (MRS) to model the oil price during bear and bullish markets (i.e., during periods of high and low volatility, respectively). The Markov mean-variance switching models are not reported, but they are available upon request. Below, Figure 3 shows the modeling of both oil markets (Brent and WTI). The figure exhibits the X-axis as the year, while the Y-axis on the left side shows probabilities between 0 and 1. The state probabilities are calculated from two-state models. The results reveal that periods of high volatility and low volatility in these two oil price indices are almost exactly the same. For example, Figure 3 Panel A for Brent regimes 0 and 1 demonstrates that in regime 0, which shows a period of high volatility (turbulence) during 1998-2002, 2008-2009, and 2015, the probabilities are reaching 1, meaning a period of high volatility, while regime 1 shows a period of low volatility with very low probabilities (stable period).

Figure 3



Panel B - The Markov Regime-Switching for the WTC Crude Oil Price



Similarity, Figure 3 Panel B for WTI illustrates a period of high (low) volatility, the same as that of the Brent crude oil market. In addition, a period of high volatility can also be seen as a period with a negative return, while low volatility can be seen as a stable period or one with a positive return.

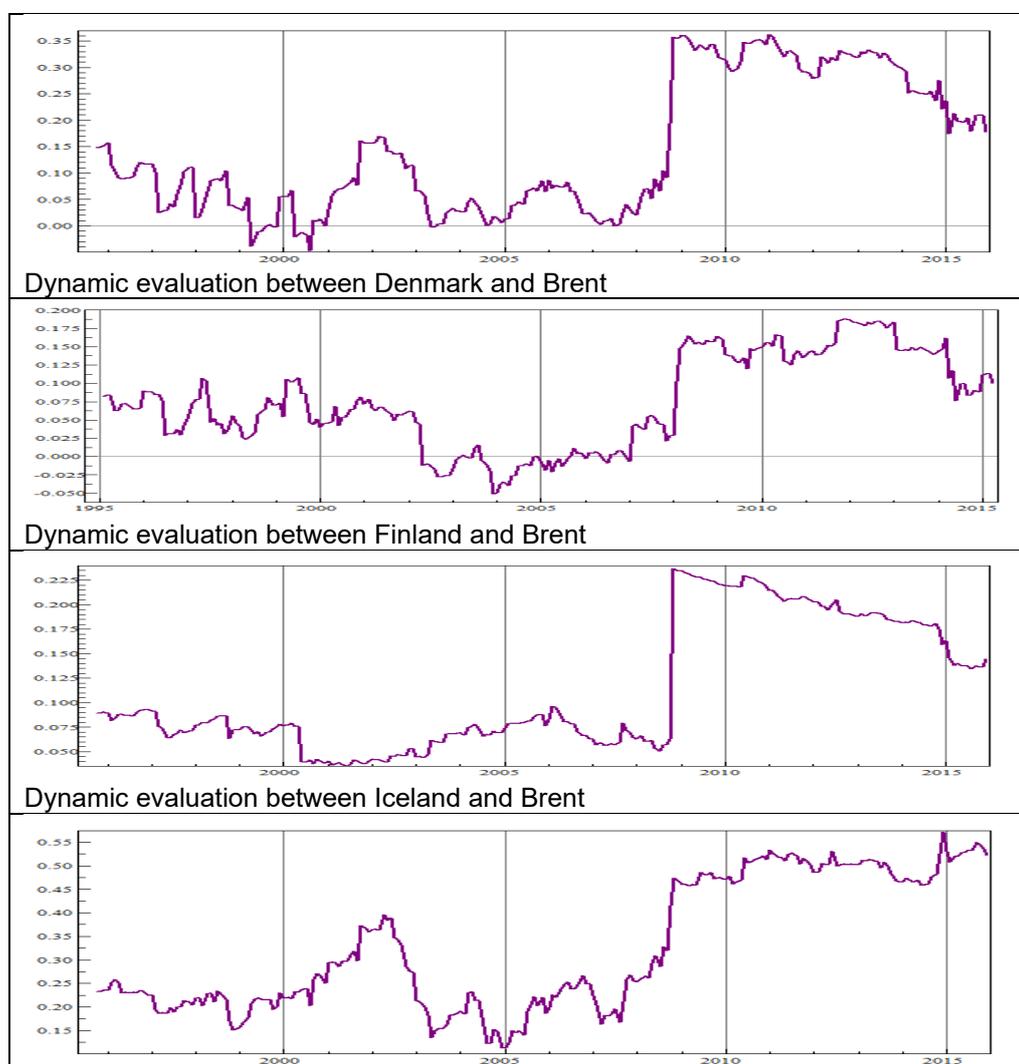
Empirical Results

Figure 4 Panels A-B shows the dynamic evaluation between each country's stock market indices and the two crude oil price indices. Figure 4 Panel A shows the dynamic evaluation with Brent, while Panel B shows the dynamic evaluation with WTI. From Panel A, it is clear that the dynamic evaluation of the stock market and the crude oil markets has changed starting from 2007 and 2008 (i.e., the global financial crisis) for almost all of the stock markets. Furthermore, it may be noticed that before the GFC period, the correlation between the two assets (stocks and oil) was mostly negative or very low, as in the case of Norway and Iceland. However, after the GFC, the relationship changed from negative to positive for all the markets. Finally, it is worth noticing that the oil exporting countries (Russia and Norway) have a higher level of correlation with Brent. For example, with Russia it reached 70% and with Norway it reached as high as 55% for the period after the global financial crisis. For the oil importing countries, the highest correlation varied between 35% (for Denmark) and 25% (for Germany). When looking at the correlation between the stock markets and WTI, we observe that the correlations were negative and very low before the GFC, although after the GFC the correlations

increased considerably, which is also the case with Brent (except for Denmark and Finland). As is the case with Brent, the correlations are much higher for the oil exporting countries, reaching the same level (70% for Russia and 55% for Norway). Taking into account the volatility of dynamic evaluation, it is observed that the dynamic evaluation with WTI were much higher, particularly with the stock markets of Denmark and Finland, and this continued until the end of the sample period. Finally, it can be observed that the evaluation of correlation declined from 2015 due to increases in the world supply of crude oil, especially for the oil importing countries.

Figure 4

Panel A - The Dynamic Evaluation with Brent



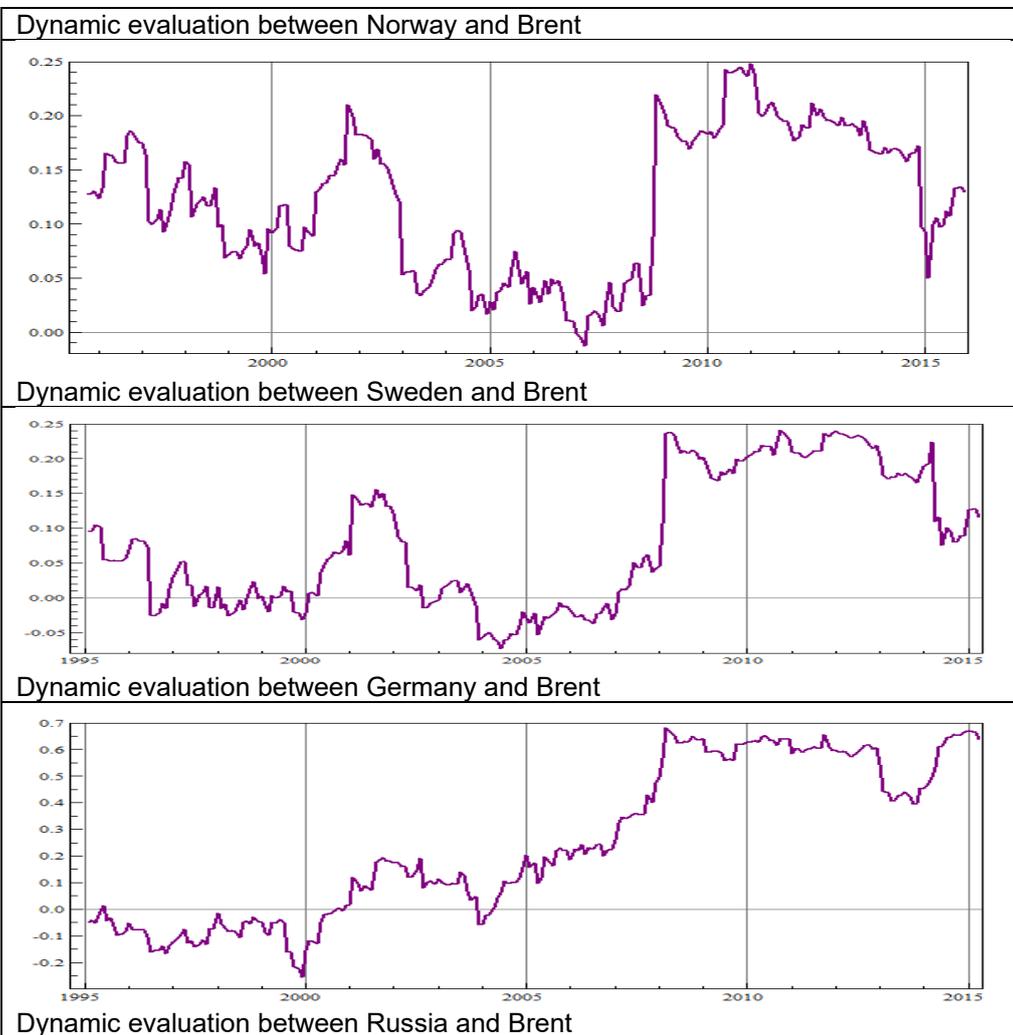
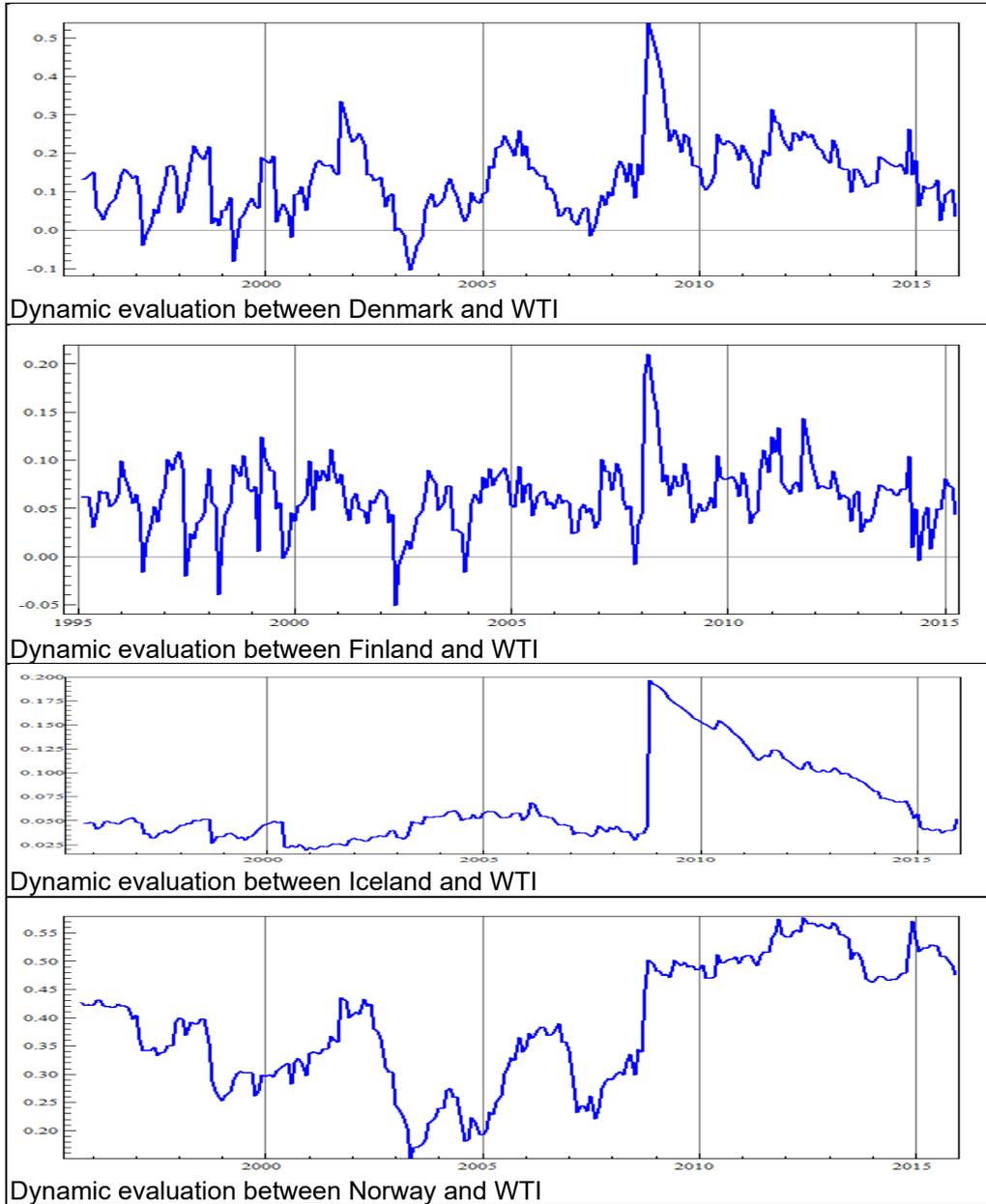


Figure 4

Panel B - The Dynamic Evaluation with WTI



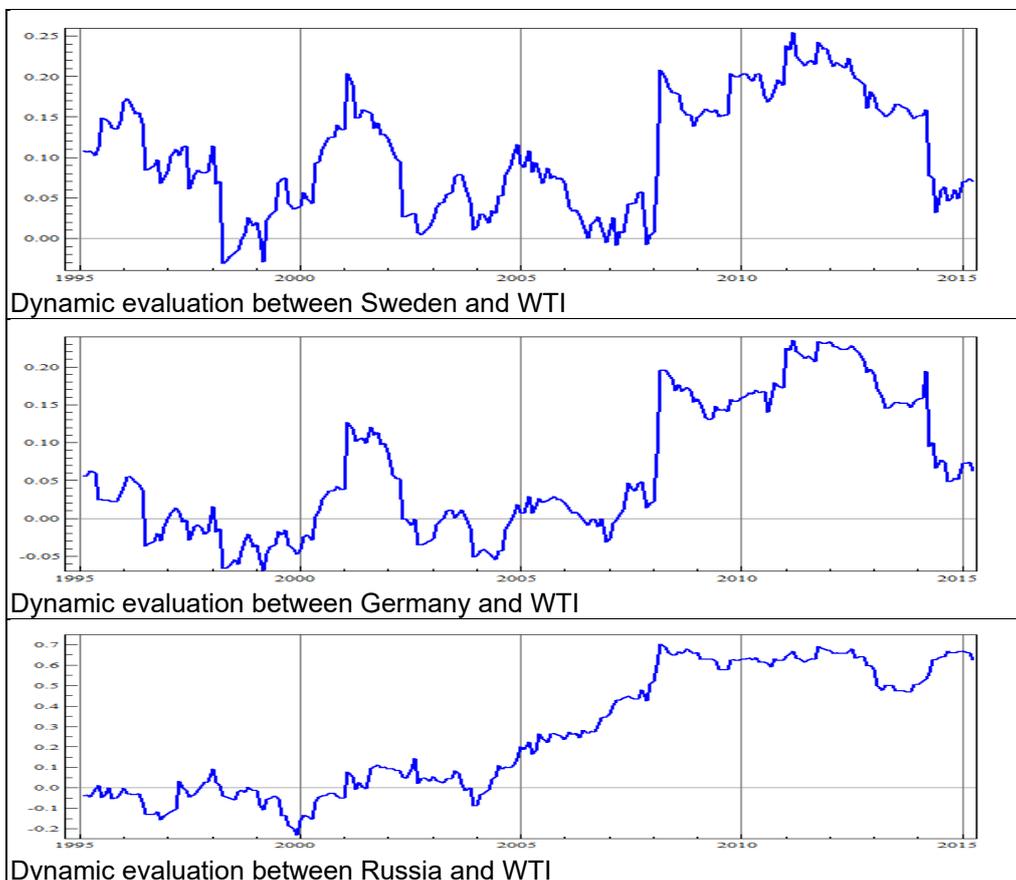


Table 3 illustrates the GARCH (1, 1) estimation results for the seven stock markets (five Nordic countries and Germany and Russia) and two international oil price indices. We have estimated them all (seven stock markets and two oil markets) with the same model in order to capture the volatility and be able to compare the impact of oil shocks and the correlation level. Using a different model would make it difficult to fully compare the effect. The computed coefficients for ARCH and GARCH are mostly significant at 5% or better. The significance of these coefficients means that previous volatilities and events reflect on today's stock and oil returns. Table 4 reports the dynamic conditional correlation generated between the seven stock markets and the crude oil of WTI. The estimated coefficients show that α and β are both positive and satisfy the condition $\alpha + \beta < 1$. Further, the t-student degree of freedom parameters (df) for almost all of the markets is significant at 1%, which justifies the appropriateness of the selected model. The persistence coefficients β are highly statistically significant at 1% for all the markets, which means that the impacts of oil shocks reflect on the stock markets of these countries, especially for Norway as an oil exporting country. In the case of Norway, both coefficients α and β , are significant, and the weighted conditional correlation is also

significant, showing a high correlation level when compared to the other Nordic countries and Germany.

Table 3
Univariate Estimations for Seven Stock Markets and Two International Oil Price Indices

	DEN	FIN	ICE	NER	SW	GER	RUS	WTI	BRE
Mean equations									
C.(M)	1.429*** (0.346)	1.044** (0.417)	2.82*** (0.58)	1.209*** (0.372)	0.993*** (0.330)	1.141*** (0.333)	1.266** (0.597)	0.4307 (0.543)	0.5502 (0.562)
Variance Equations									
C.(V)	4.467* (2.53)	1.517 (1.097)	-0.3181 (2.580)	3.793 (2.764)	1.853* (1.090)	4.310* (2.307)	8.214*** (3.984)	12.144 (6.154)	7.954 (6.618)
Garch	0.142 (0.09)	0.185** (0.081)	0.811 (0.510)	0.1707* (0.094)	0.189*** (0.070)	0.251** (0.114)	0.272*** (0.079)	0.188*** (0.070)	0.239*** (0.091)
Arch	0.71*** (0.11)	0.803*** (0.066)	0.722*** (0.045)	0.745*** (0.050)	0.773*** (0.061)	0.672*** (0.060)	0.706*** (0.059)	0.699*** (0.088)	0.717*** (0.097)

Note: The numbers given in () are standard errors and those in [] are p-values. ***, **, and * are statistically significant at 1%, 5%, and 10%, respectively.

Table 4
Dynamic Conditional Correlations Estimation between Seven Stock Markets and WTI

	DEN	FIN	ICE	NER	SW	GER	RUS
ρ	0.13305 (0.085)	0.0625 (0.071)	0.0471 (0.069)	0.4265*** (0.143)	0.1080 (0.109)	0.0560 (0.123)	-0.0392 (2.173)
α	0.0529 (0.0444)	0.0267 (0.0432)	0.0069 (0.0092)	0.0279** (0.0146)	0.0199 (0.0314)	0.0172 (0.0156)	0.0413 (0.0701)
β	0.7841*** (0.215)	0.5654*** (0.146)	0.9645*** (0.037)	0.9621*** (0.020)	0.9398*** (0.057)	0.9639*** (0.027)	0.958*** (0.115)
df	10.792*** (3.907)	15.830** (7.694)	4.5208*** (0.641)	9.8033*** (3.279)	14.0571** (5.722)	10.46*** (3.083)	73.728 (44.653)
Diagnostic checking							
Log-likelihood	-1635	-1703	-1678	-1635	-1651	-1661	-1816
MQ(20)	225.6 [0.10367]	219.4 [0.1656]	177.8 [0.8683]	209.5 [0.30897]	216.6 [0.19963]	213.9 [0.23730]	214.1 [0.2356]
MQ ² (20)	198.1 [0.484287]	232.6 [0.0465]	116.0 [0.9999]	215.1 [0.1917]	196.5 [0.51631]	222.1 [0.11508]	260.9 [0.0018]

Note: The numbers given in () are standard errors and those in [] are p-values. ***, **, and * are statistically significant at 1%, 5%, and 10%, respectively.

The results show that there is high interdependence between the Norwegian stock market and the WTI oil price. Diagnostic checking was also used between the paired markets to ensure that our model is free of serial correlation. The results of multivariate portmanteau statistics on standardized residuals and squared standardized residuals reveal that our model is free of serial correlations. This is also the case with the DCC

between Brent oil³ and the seven stock markets. In addition, computing the results shows that α and β are both positive and satisfy the condition $\alpha + \beta < 1$. Further, the Student distributions are statistically significant between all the paired markets. Interestingly, both oil exporting countries (Norway and Russia) have a higher level of weighted correlation, and the stock markets in these countries have higher co-movement with the Brent oil market. This can be confirmed by the high significance of the two coefficients α and β . For example, for Norway these coefficients are significant at 1%, whereas for Russia the α coefficient is significant at 5% and the β coefficient at 1%. Therefore, this study documents that the levels of correlations and co-movement between oil importing and oil exporting countries and oil price markets are different.

Concluding Remarks

This study examines the relationship between the stock and crude oil returns for five Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) and two European countries, one being the top oil exporting country (Russia) and the other the highest oil importer (Germany). Studying the Nordic countries is important for several reasons. First, these countries have an open market with a stable social and political environment. They are considered hubs of investment for local and global investors. In addition, most of the previous studies that examined the stock market and/or crude oil price impacts largely neglected these countries despite their major trade and finance linkages with other European countries.

For the analysis in this study, we made use of GARCH, including the DCC of Engle (2002) and the Markov regime-switching autoregressive (MRS-AR) approach, which is used to model the two oil price indices during bear and bullish markets. The results of this paper are as follows. We documented that the dynamic evaluation between the stock market and crude oil market has changed following the global financial crisis. It is worth noting here that prior to the crisis, the correlation between the two assets was mostly negative and/or very low. Furthermore, we observed that the dynamic linkage and level of correlation between the oil exporting countries (Russia and Norway) were very different to those of the oil importing countries. For example, we noticed very high correlations for Russian (reaching as high as 70%) and for Norway (around 55%) during the period of high turbulence, especially during the global financial crisis and European crisis. In addition, we noticed that the oil exporting countries have higher market interdependence. Our finding contradicts that of Filis *et al.* (2011), since those authors documented that the time-varying correlation for oil exporting and oil importing countries is the same. We also observed that the correlation started to decline from summer 2015, which reflected the turmoil of the stock markets and oil price turmoil. It is important to remember that in August 2015, the stock markets worldwide were in turmoil due to mixed policy approaches. Equally, the oil price continued to decline, especially after OPEC decided to remove the output limit in December 2015. Finally, the results from the Markov regime-switching autoregressive (MRS-AR) model revealed that in 1998-2002, 2008-2009, and 2015, regime 0 probability reached close to 1, which can be characterized as the most volatile period for the international oil market. It is also worth

³ The authors provide the results upon request

noting that the time-varying relationship shows different reactions to high- and low-volatility regimes. Specifically, during GFC and the prior period, the time-varying relationship was negative and has a low level of correlation during the low-volatility regime. However, during the high-volatility regime, the time-varying relationship was positive and had a high level of correlation. For example, the time-varying relationship sharply increased during the GFC and in 1998-2002, which has also been criticised as a high-volatility regime. The time-varying relationship was negative and had low correlation for the periods prior to 1998 and between 2002 and 2009. Considering the period after the GFC (i.e., starting in 2009), the time-varying relationship remains high until the end of the sample. This can be explained by the fact that, as documented in the literature, the European sovereign debt crisis (ESDC) affected the European stock market and led to a bear market. This was also the case for oil exporting and importing European stock markets even though the oil market remained high after the initial shock, with oil reaching \$140 per barrel.

The results of the present study have important policy implications as well as implications for investors. The following points are therefore provided as suggestions and recommendations. In terms of policy implications, it is essential to understand the impacts of oil market volatility on the domestic economy, since oil is used as one of the inputs for almost all production. From the point of view of international investors and mutual funds, knowledge of the time-varying behaviour between the stock market and the oil price is important, since any adverse effect in these markets affects their future cash flow. Furthermore, for investors who would like to obtain the benefit of the risk hedging technique, investing in both markets in order to diversify might not be suitable as there is high market co-movement between the stock market and crude oil, particularly for the oil exporting countries since they show high correlation with the international oil price. Future studies should focus on the co-movement between the stock markets and the oil price of other European and non-European countries by considering the recent oil price market instability as well as the stock price instability.

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