Scandinavia: Towards the European Monetary Union?

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Abstract

The EU faces the most important structural crisis of its history, especially after the debt crisis of 2010 in the Euro Area, where the weaknesses of the European common currency were totally unveiled. The main purpose of this paper is to examine if the economies of Scandinavia are historically vulnerable and bound to the European economy (Euro Area). This would aid the further integration of the EU in the long run. Our analysis used the real effective exchange rates of Denmark, Norway, Sweden and Iceland, as a research instrument,by using the Error Correction Model (ECM)and the Asymmetric Dynamic Conditional Correlation GARCH model.Our empirical findings highly support that the economies of Denmark, Norway and Sweden are positively bound to the European economy. On the other hand, the economy of Iceland does not show integration with the European economy, despite its EEA membership. Furthermore, we found out that the currencies of Sweden, Norway and Denmark are more vulnerable to the market positive shock responses of the euro instead of negative shock responses. Finally, our study proposes that Sweden and Denmark might need to re-examine a possible EMU membership and Norway may reconsider a potential EU status. However, there are not enough evidence to provide a similar policy for Iceland.

Keywords: exchange rate risk analysis, ECM, ADCC-GARCH, linkages, Eurozone enlargement, Scandinavian economies, EU integration, spill over effects

JEL: C13, F3, F31, G15, G17, G32

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1.Introduction

The European Union has been forged upon the ashes of the World War II in order to maintain the social security and the economic stability in the European continent. In March 2017, the remaining 27 members of the EU celebrated the 60 years' anniversary from the establishment of the EU (formerly, European Economic Community, Treaty of Rome, 1957). However, the UK has decided, on 23rd June 2016, to withdraw its participation in the EU when the 52% of British people voted in favor of BREXIT. It is true that the EU has entered into an introversion phase after the outbreak of the debt crisis of 2010 in the Euro Area. During the previous seven years, the EU has been occupied with the cohesion of the Eurozone and the partial reformation of the EU. Particularly, the creation of the European Stability Mechanism (ESM) was a first step for the security of the Euro Area. The European banking union was, in fact, the transfer of banking policy responsibility, from the national to the EU level, in several countries of the European Union and it was initiated in 2012 as a response to the Eurozone crisis. In May 2017, the President of France and the German Minister of Finance have announced some thoughts in order to establish a common Ministry of Finance among the members of the Euro Area in the future.

Nowadays (2018), the EU contains officially 28 members-states. Nineteen countries have already participated in the European Monetary Union (EMU), one member has granted an opt-out of the EMU (Denmark) but it is a member of ERM II, one state has officially made an application to withdraw from the EU (UK) and seven countries[3] are obliged to adopt the euro in the future when they meet the convergence criteria of the Maastricht Treaty (1991). Additionally, the EU has an official political agreement with Norway, Iceland, Lichtenstein and Switzerland. These countries have created the European Economic Area (EEA). The Agreement on the EEA provides for the free movement of persons, goods, services and capital within the European Single Market, including the freedom to choose residence in any country within this area. In fact, these countries have accepted the principals and the acts of the EU. They annually participate in the budget of the EU, but they have no right to vote for the decisions in the EU. Also, they have no obligation to adopt the euro or to enter in the ERM II of the European Central Bank (ECB).

[3]According to the Maastricht Treaty (1991), Bulgaria, Croatia, the Czech Republic, Hungary, Romania, Poland and Sweden must adopt the euro when they fulfill the convergence criteria.

The main purpose of this research is to examine whether two members of the EU (Denmark and Sweden) and two members of the EEA (Norway and Iceland) havehighly bound economies to the Euro Area, which consequently means that they could be possible members of the EMU or the EU, respectively. Actually, a possible EMU membership of a Nordic country (except Finland) will change the economic environment in Scandinavia. This will happen because the European common currency will facilitate the trade and the financial transaction among the companies, banks and public sector. In addition, the impact of the exchange rate risk on the corporate financial statements and daily transactions would diminish due to the use of the common currency.

Additionally, one of the most important argument against the Swedish and Danish participation in the EMU was the loss of the monetary policy independence. Read and Volz (2009) suggest that Riksbank (Swedish Central Bank), despite staying outside of the eurosystem, is de facto not master in its own house. Rather, they argue that Sweden is lulled by some kind of monetary independence delusion. By joining the euro, Sweden would give up monetary sovereignty, but the cost in terms of a loss of monetary policy autonomy would be negligible. The argument made by the Calmfors Commission (which was mandated by the Swedish government to assess the consequences of Swedish EMU membership) and others that through EMU membership Sweden would "no longer have the opportunity to pursue an independent monetary policy" (Calmfors*et al.,* 1997) and, hence, face serious consequences for stabilisation policy, is therefore flawed. The cost of ceding monetary sovereignty would arguably be outweighed by Sweden gaining a seat in the ECB's governing council, where the governor of the Riksbank would have a say in formulating the common European monetary policy stance. Instead of being a passive bystander to the ECB's interest rate decisions, the Riksbank could play an integral part in European monetary policy making.

Furthermore, there are more political rather economic reasons that Denmark has not yet participated in the EMU. In fact, DanmarksNationalbank (Danish Central Bank) has an official agreement with the European Central Bank to follow a fixed exchange rate regime. A euro is equal to 7,46 DKK within a range of 2,25% (upper bound 7,62 DKK/euro and 7,29 DKK/euro) since 1999. This means that the Danish Central Bank does not have the power to handle the nominal exchange rate of krone against the

euro. Also, the independence of the Danish monetary policy is an illusion, since Denmark historically follows the monetary policy of the ECB. The expected practical advantages of euro adoption are a decrease of transaction costs with the Eurozone, a better transparency of foreign markets for Danish consumers, and more importantly a decrease of the interest rates which has a positive effect on growth. However, when joining the euro, Denmark would abandon the possibility to adopt a different monetary policy from the ECB. If ever an economic crisis were to strike specifically the country it would have to rely only on fiscal policy and labor market reforms (Sorensen, 2014).

Being a member of the EU, Iceland could be more confident that the benefits of the access to the single market would be in place in the long-run. The membership would also ensure regular consultations and participation in the EU decision making instead of continuing instructions from the European Commission. Regular consultations could help a small country with limited institutional capacity to increase professionalism. Moreover, EU membership could possibly shield Iceland during times of crisis, economically and in terms of security. There is a greater need for external support given the weaker ties with the US during the post-cold war era. Closer cooperation with EU member states and support from EU institutions could contribute to stability, as Iceland has a history of economic boom and bust (Hilmarsson, 2017).

According toCambos (2015), there are substantial benefits from EU membership for Norway. Actually, if Norway had joined the EU in 1995, productivity levels (GDP per hour worked) in the average Norwegian region between 1995 and 2000 would have been 6% higher. Only one of the seven NUTS2 (Nomenclature of territorial units for statistics) regions of Norway (except Oslo) would have had negativeeconomic benefits, due to EU participation. Unsurprisingly, if Norway had joined the EU in 1995, productivity levels (GDP per hour worked) in the average Norwegian region between 1995 and 2000 would have been 9% higher instead. Also, the researchers suggest that these politically-driven payoffs are significant and substantial, and distinctively favor deep (economic and political) over shallow (only economic) integration.

The common characteristic of these countries is that they geographically belong to Scandinavia. According to Oxford Dictionaries (2017), Scandinavia is a cultural

region consisting of the countries of Norway, Sweden, and Denmark and sometimes also of Iceland, Finland, and the Faroe Islands. By taking into account the previous term, we are eligible to study only Norway, Sweden, Denmark and Iceland[4]. Finland is already a member of the Euro Area and the Faroe Islands belong administratively to Denmark.

In this paper, we used the real effective exchange rates (REER), as an empirical instrument, in order to show if these countries are highly linked with the Eurozone economy. The REER is derived by taking a country's nominal effective exchange rate (NEER) and adjusting it to include price indices and other trends. The REER is essentially a country's NEER after removing price inflation or labor cost inflation. The REER represents the value that an individual consumer pays for an imported good at the consumer level. This rate includes any tariffs and transaction costs associated with importing the good (Fender, 2012).

The scope of the real effective exchange rate is based on the Purchasing Power Parity (PPP). In addition, the REER serves two main functions: a) REER can be useful for making comparisons between countries because they stay fairly constant from day to day or week to week and only change modestly, if at all, from year to year, b) over a period of years, nominal exchange rates do tend to move in the general direction of the REER and there is some value to knowing in which direction the nominal exchange rate is more likely to shift over the long run (Schmitz *et al.* 2012).

Moreover, a country's REER is an important measure when assessing its trade capabilities and current import/export situation. The REER can be used to measure the equilibrium value of a country's currency, identify the underlying factors of a country's trade flow, look at any changes in international price or cost competition, and allocate incentives between tradable and non-tradable sectors (Masson and Ruge-Murcia, 2005).

In fact, it is obvious that the real effective exchange rate is an instrument which is able to reflect the pragmatic condition of an open modern economy. This occurs because the real effective rate harmonizes the corrosive effect of the inflation. Also, the REER is a better empirical tool than the real exchange rate against a specific

[4] These Nordic countries have three common features: a) similar cultural background, b) no participation in the EMU, c) strong economic and trade relationships with the EU.

currency. This happens because the REER is based on a basket of currencies. This is very important because the modern world is characterized with the presence of an open and free international trade across the countries.

The current paper utilized separately the Error Correction Model (ECM) (Engle *etal*, 1987) and the Asymmetric Dynamic Conditional Correlation GARCH (ADCC-GARCH) (Cappielo*et al,* 2006). We use the ECM as a mean equation and the ADCC-GARCH as the conditional variance equation.

The results of the ECM, for the whole period, show that there is a continuous and constant positive relationship between the REER of euro and the REER of Danish krone. Also, we observe that there is a similar economic behavior for Swedish krona and Norwegian krone. On the other hand, the linkage between the REER of Icelandic krona and the REER ofeuro seems to be quite different. We observed that the relationship is strictly negative until 2017 with an upturn tendency. This means that historically the real effective exchange rates of Denmark, Norway and Sweden are bound to the real effective exchange rate of euro.

Additionally, the empirical evidence of the ADCC-GARCH model support, for the total era, that the overvaluation of the euro has a greater impact on Icelandic krona instead of its devaluation. A similar effect takes place for Swedish krona and Norwegian krone. However, the magnitude of this effect is larger on the Swedish currency. According to ADCC-GARCH modelresults, the euro has no asymmetric impact on the volatility of the Danish krone. In addition, the outcome of our findings highly support that the Danish krone is more vulnerable to the market shocks of euro. On the other hand, Icelandic krona is less vulnerable to the market shocks of euro, indicating high persistence. Also, the Norwegian krone and the Swedish krona show similar resistance against the economic shocks of euro. The magnitude of their endurance is in the middle compare to the other two currencies (Danish krone and Icelandic krona).

The outcomes of the present paper provide important evidence to academia, EU policy makers, international institutions (IMF, World Bank, BIS), investors, risk managers and individual people across the globe. A potential entry of Scandinavian countries in the Euro Area would definitely change the balances in the international

markets and in the modern world. We provide a long analysis of our results at the conclusions section.

In summary, the present empirical research has been organized into several sections. Section 2 provides a long literature review for the aim of our research. Section 3 displays the data that we used. Section 4 includes the methodology of the paper, and Section 5 presents the preliminary diagnostics tests (unit root test and co-integration test). Section 6 includes the empirical results of the combined methodology, ECM-ADCC-GARCH, and Section 7 concludes the paper.

2. Literature review

Huang and Yang (2015) used the real effective exchange rates of 11 Eurozone countries in order to provide evidence if the introduction of the euro changed the competiveness of these countries. They chose to use the Error Correction model with the common correlated effects (CCE) estimators a la Pesaran (2006). Their empirical results support that a co-integration status among the REER of the Euro Area countries took place after the adoption of the euro. Also, they exhibited similar results for non-euro countries such as Norway, Sweden and Switzerland. Additionally, Clark and Jones (2012) have supported that Iceland should continue the negotiations of the EU in order to join the union, especially after the Icelandic financial crisis of 2008. Pesaran*et al.* (2007) discovered that Sweden would have had higher GDP and higher prices, if the country had joined the euro in 1999. Reade and Volz (2009) support the previous findings by claiming that Sweden would benefit more by entering the Euro area. Miccoet *al.* (2003) explored the impact of the euro on the trade among the non-Euro area members in EU. They discovered that the European common currency boosted the trade linkages between the non-Eurozone states and the Euro area.

According to Miller (2000), in 1992 Denmark obtained a special arrangement allowing the country not to proceed to the third stage of Economic and Monetary Union (EMU or the single currency) unless or until this had been approved in a national referendum. Also, he highly supported that the Danish referendum outcome to reject the euro adoption will lead to the establishment of two European Unions in the EU. Moreover, Idruchova (2013) claims that, although the result of the Danish referendum was “No” to the euro with a majority of 53%, the close link to the euro in

the framework of ERM II and its monetary and exchange rate policy makes Denmark a de facto member of the euro area.Marcussen(2005) claims that despite the fact that Denmark is a euro-outsider, it is performing quite well economically and politically. Thus, Denmark may be an 'out' country but it is definitely not 'over' and done with in regards to the European monetary integration. Actually, the present situation is not historically unprecedented since Danish monetary authorities have traditionally not been used to having monetary sovereignty to any significant extent. This implies that Danish policymakers have found a number of indirect means to influence monetary policy-making in the euro-area.

On the contrary, Cohen (2007) highly supports that a potential enlargement of the Euro Area will diminish the value of the euro, as well as, its attractiveness as an international currency. However, he does not take into account a possible EMU expansion to the Nordic countries, but only that the EU member states have different economic and political interests (especially Post-Communist countries of the EU). Similar concerns are expressed by Rehman (2007). Keppel and Prettner (2015) attempted to examine the interrelationship among the Euro Area and five Central and Eastern European economies by using interest rates and exchanges rates. Their findings strongly suggest inter-regional spillovers of output shocks with the magnitude being similarly strong in both areas.

Recently, Stoupos and Kiohos (2017[a]) used the nominal exchange rates of three leading currencies of Europe in order to explore the EU monetary integration in the UK, Switzerland and Sweden, as well as, in the Post-Communist countries of the EU (Stoupos and Kiohos, 2017[b]) and the already members of the Euro Area (Kiohos and Stoupos, 2018), (Nikas*et al.,* 2018).Moreover, Gkillas*et al.* (2018) combined the Error Correction Model with the APARCH model in order to explore the asymmetries in the African financial markets; both stock and exchanges markets.Jonung (2004) indicates that the Euro Area membership of a country lies upon people's opinion in spite of any encouragements of the governments and European policy maker institutions. Bergvall (2004) used the real exchange rates dynamics of Nordic countries in order to explore the impact of the trade and the labor productivity. The researcher figures out that the trade between the Nordic countries and the EU has positively influenced their real exchange rates. Hoffmann and Holtemöller (2010) display similar findings regarding the interrelationship between nominal exchange

rates and trade in Scandinavia. Finally, Larsson (2004) provided evidence on the behavior of the Swedish real exchange rate relative to Germany, under different currency regimes. In specific, the results suggest that the real exchange rate is co-integrated with Swedish and German productivity.

3. Dataset Analysis

The present study uses the real effective exchange rates (REER) of four Scandinavian countries (Denmark, Iceland, Norway and Sweden). Specifically, we attempt to provide evidence if there are any possible linkages among euro, Danish krone, Icelandic krona, Norwegian krone and Swedish krona. We used daily observations by covering a period of approximately 32 continuous years, from 01 January 1986 to 30 September 2017. The data was extracted from the official database of the Federal Reserve System ® in the United States. We divided our dataset into four sub-periods. Each period contains specific features. We generated the three breakpoints by using the following historical events in the European Union and in Scandinavia:

a) The end of banking crisis in Scandinavia and the participation of the new Nordic counties in the EU or EEA.
b) The physical circulation of the euro in 2002
c) The pick of the financial crisis 2008 in Europe

The selection of these breakpoints is justified by the empirical results of the Silvestre, Kim andPerron unit root test, which are presented at the next section. We decided to explore the characteristics of total period, as well as the four sub-periods in order to estimate whether there is an overall tendency.

Table 1 presents the features of each variable by indicating the nature, the acronym and the official symbol at the international markets.

Table 1: Data Presentation

Variables	Acronym	Symbol
Euro	EUR	€
Danish krone	DKK	kr
Icelandic krona	ISK	Íkr
Norwegian krone	NOK	kr
Swedish krona	SEK	kr

Source: Federal Reserve System (FED)

The four sub-periods are displayed below:

a) ***01 January 1986 to 31 December 1994 or 1996:***The main characteristic of this era isthat only Denmark is a member of the European Union until 1994.The EU welcomed two Scandinavian countries (Sweden and Finland) in January 1995. Also, a significant banking crisis took place from 1988 to 1993 in Norway, Sweden and Finland. During this period, a referendum, on joining the European Union, was held in Norway on 27 and 28 November 1994. The outcome of the referendum was negative and Norway remained a member of the EEA.The European Economic Area was officially established in 01 January 1994. The first breakpoint differs among the examined countries, based on the results of multiple breakpoints unit root test of Silvestre *et al.* (2009) (see section 5.2). In specific, the breakpoint for Iceland and Sweden is January 1994. On the other hand, the cut point for Denmark and Norway is January 1997.

b) ***01 January 1995 or 1997 to 31 December 2001:***
The particular period is named as the pre-Eurozone era. During this period, the leaders of the member-states of the EU attempted to integrate economically and financially the nature of the union. The output of this effort was the creation of the Euro Area which took its physical form with the circulation of the euro on 01 January 2002. The ex-currencies of the 12-initial founding member of the Euro Area had completely stopped to circulate on 28 February 2002. The second breakpoint differs here also, due to the results of the unit root test of Silvestre *et al.* (2009), as we have described previously.

c) ***01 January 2002 to 31 December 2008:*** During this period, the Euro Area tookits physical form and four new member-states adopted the European common currency. In addition, this era is characterized as the most prosperous and thriving after the end of the World War II in Europe. This era covers completely the thriving period of modern human history for advanced economies. The circulation of the euro, the development of the technology and the excessive connection of the international banking system created an economic development of six continuous years.We selected to endthis period on 31st December 2008according to the results of Silvestre et al (2009) unit root test. Also, the majority of the EU countries commenced to face

difficulties in their economy after the end of 2008, since the global financial crisis arrived in Europe in 2009.

d) ***01 January 2009 to 30 September 2017:*** This period is characterized by the presence of the contagion of the global financial crisis of 2008 in the EU and the emergence of the Eurozone debt crisis of 2010. The debt crisis in the Euro Area forced the reformation of the EU. Specifically, Greece was the first member of the EMU which faced significant difficulties to refinance its debt. The European Institutions and Eurogroup were informed in late 2009s about this situation.During this period, primarily, the pilot European Financial Stability Facility (EFSF) was generated (June 2010) in order to safeguard the cohesion of the EU and secondly, the EFSF was replaced by the permanent European Stability Mechanism (ESM) in September 2012. The German Minister of Finance, recently (August 2017) announced the intentions of German government, in order to transform the ESM into a European Monetary Fund (EMF) in the distant future. Finally, the banking union in the EU was agreed in 2014. The banking union consists of two main initiatives, the Single Supervisory Mechanism (SSM) and Single Resolution Mechanism (SRM) (ECB, 2017).

4. Methodology

Our empirical evidence was provided by using two preliminary tests and two advanced econometric models. In the beginning, we tested the stationarity of the time series by using the unit root of Silvestre, Kim and Perron (2009). Also, we auxiliary consulted the research of Kim and Perron (2009). This unit root test allows the calculation of multiple breakpoints in time series. We used this stationarity unit root test in order to provide evidence about our decision to divide our sample into four periods. The results of this test are displayed in section 5. Additionally, the second diagnostic test is the Johansen's Co-integration test, with structural breaks,including a deterministic trend. The use of this test is a prerequisite in order to investigate if the time series are co-integrated in the long-run (Johansen et al. 2000). This co-integration test took place, in order to examine if there is a long-term tendency between the real effective exchange rate of euro and the REER of each examined Nordic currency. The presence of co-integration is a prerequisite, in order to take our analysis to the next step. If we provide evidence, that a co-integration takes place, then we are eligible to utilize the Error Correction Model (Engle *et al*, 1987). We

present the mathematical expression of our methodology at the next sections. Finally, we pattern the errors of the ECM by using the asymmetric generalized dynamic conditional correlation model, which permits for series-specific news and conditional asymmetries in correlation dynamics. The ADCC specification is well suited to examine correlation dynamics among different asset classes and investigate the presence of asymmetric responses in conditional variances and correlations to negative returns (Cappiello*et al.,* 2006). In effect, the ADCC-GARCH estimations in our study highlight evidence of the asymmetric effects of positive and negative shocks on volatilities and correlations of REER variables.

4.1 Silvestre, Kim and Perron multiple breakpoint unit root test

According to Silvestre *et al.* (2009), in order to allowendogenously multiple structural breaks, the following model could be considered:

$$\boldsymbol{y_t = d_t + u_t\ (1)}$$

$$\boldsymbol{u_t = au_t + v_t t = 0, \dots, T\ (2)}$$

Where y_t is a vector and $\{u_t\}$ is an unobserved mean-zero process. u_0 is assumed to be equal to 0. The disturbance v_t is defined by $v_t = \sum_{i=0}^{\infty} \gamma_i \eta_{t-i}$ with $\sum_{i=0}^{\infty} i|\gamma_i| < \infty$ and $\{\eta_i\}$ a martingale difference sequence adapted to the filtration $F_i = \sigma - field\{\eta_{t-i}; i \geq 0\}$. The long- and short-term variances are defined as $\sigma^2 = \sigma_\eta^2 \gamma(1)^2$ and $\sigma_\eta^2 = \lim_{T\to\infty} T^{-1} \sum_{t=1}^{T} E(\eta_t^2)$, respectively.

The deterministic component in equation (1) is given by,

$$\boldsymbol{d_t = z_t'(T_0)\psi_0 + z_t'(T_1)\psi_1 + \cdots + z_t'(T_m)\psi_m \equiv z_t'(\lambda)\psi\ (3)}$$

Where,

$$\boldsymbol{z_t'(\lambda) = \left[z_t'(T_j), z_t'(T_1), \dots, z_t'(T_m)\right] and\ \psi = (\psi_0', \psi_1', \dots, \psi_m')'\ (4)}$$

To estimate the break dates, Silvestre et al. (2009) use the global minimization of the sum of squared residuals (SSR) of the GLS-detrended model,

$$\hat{\lambda} = \arg\min_{\lambda \in \Lambda(\varepsilon)} S(\bar{\bar{a}}, \lambda) \quad (5)$$

Where $S(\bar{\bar{a}}, \lambda)$ is the minimum of an objective function. $\bar{a} = 1 + \bar{c}/T$ is anon-centrality parameter;$\Lambda_\varepsilon\{\lambda: |\lambda_{i+1} - \lambda_i| \geq \varepsilon, \lambda_1 > \varepsilon, \lambda_k > 1 - \varepsilon\}$, and εis a small arbitrary number,where in practice the common value of ε is equal to 0.15.

The proposed tests are defined by:

$$MZ_a^{GLS}(\lambda) = \left(T^{-1}\tilde{y}_T{}^2 - s(\lambda)^2\right)\left(2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{-1} \quad (5)$$

$$MSB^{GLS}(\lambda) = \left(s(\lambda)^2 T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{1/2} \quad (5)$$

$$MZ_t^{GLS}(\lambda) = \left(T^{-1}\tilde{y}_T{}^2 - s(\lambda)^2\right)\left(4s(\lambda)^2 T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{-1/2} \quad (6)$$

$$MP_T^{GLS}(\lambda) = \left(\bar{c}^2 T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2 + (1 - \bar{c})T^{-1}\tilde{y}_T^2\right)/s(\lambda)^2 \quad (7)$$

Where $\tilde{y}_t = y_t - \hat{\psi}' z_t'(\lambda)$ and $\hat{\psi}'$ are the estimated values of ψ,s $(\lambda)^2$which is an estimate of the spectral density at frequency zero of ν_t.

4.2 Johansen's Co-integration test with structural breaks

The Johansen's Co-integration Test with structural breaks is based on a model which allows for any pre-specified number of sample periods (q) of length $T_j - T_{j-1}$ *for* $j = 1,\ldots,q$ *and* $0 = T_0 < T_1 < T_2 < \ldots < T_q = T$. It follows that the last observation in the *j*th sample is $T_j$while T_{j+1} is the first observation in sample period number (j+1). A vector autoregressive model of order k is considered. In analogy with the usual models without structural breaks, the model is formulated conditionally on the first k observations of each sub-sample, XT_{j-1} +1, …, XT_{j-1} +k, and it is given by the equations

$$\Delta X_t = (\Pi, \Pi_j)\binom{X_{t-1}}{t} + \mu_j + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-1} + \varepsilon_t \ (8)$$

for j = 1,…,q and $T_{j-1} + k < t \leq T_j$. The innovations are assumed to be independently and identically normally distributed with mean zero and variance Ω. The parameters vary freely, so Π, Γ_i, Ω which relate to the stochastic component of the time series are the same in all sub-samples and of dimension (p x p) with Ω being symmetric and positive definite, while the p-vectors Π_j, μ_j relate to the deterministic component and could be different in different sample periods (Johansen *et al*. 2000).

4.3 The Error Correction Model (ECM)

Engle and Granger (1987) were the first who claimed that movements of a variable may be best described by using the Error Correction Model (ECM) if the examined series are stationary and co-integrated in the long run. Particularly, an ECM is a VAR model on first differences which is augmented with the stationary disequilibrium term (Brooks, 2008, p.338), (Wooldridge, 2009, p.643).

$$\Delta y_t = a_0 + \beta_0 \Delta x_t + \varphi(Y_{t-1} - \delta X_{t-1}) + u_t \ (9)$$

where,

α_0 is the constant

φ displays the adjustment speed back to equilibrium

β_0 shows the short-term dynamics

δ expresses the long-term equilibrium relationship

The use of Error Correction Model is most suitable when we wish to explore simultaneously a dynamic short-term or long-term linkage among a group of variables. On contrary, we decided not to use the family of Vector Autoregressive models (VAR) because this statistic procedure is used when there is no co-integration condition among the examined series.VAR model is more suitable to explore short-term relationships and the impulse responses in a short time period (McMillan, 2005), (Moosa and Vaz, 2016).

In this research, the mathematic expression of the Error Correction Model is the following:

$$\boldsymbol{\Delta(REER)_t = a_0 + \beta_0 \Delta(EUR)_t + \varphi\big(REER_{t-1} - \delta(EUR_{t-1})\big) + u_t} \ \mathbf{(10)}$$

where, the dependent variable $REER_i$ represents the real effective exchange rate of the Danish krone (DKK), or the Icelandic koruna (ISK), or the Norwegian krone (NOK) or the Swedish koruna (SEK) against a basket of currencies. The independent variable is the real effective exchange rate of the euro (EUR) against a basket of currencies.

4.4 Asymmetric DCC-GARCH model

Engle and Sheppard (2001) proposed the Dynamic Conditional Correlation GARCH (DCC-GARCH) which allows two stage estimation of the conditional variance matrix. In fact, the DCC-GARCH is a multivariate GARCH model which has been built on the idea of modelling the conditional variances and correlations instead of straightforward modelling the conditional covariance matrix. The covariance matrix, H_t, can be decomposed into conditional standard deviations, D_t, and a correlation matrix, R_t. Also, the most interesting part of the DCC-GARCH model is that both D_t and R_t are designed to be time-varying.

If we assume that there are a_t returns from n variables with expected value equal to zero (0) and covariance matrix H_t, then the DCC-GARCH model is defined as:

$$\boldsymbol{r_t = \mu_t + a_t} \ \mathbf{(11)}$$

$$\boldsymbol{a_t = H_t^{0,5} z_t} \ \mathbf{(12)}$$

$$\boldsymbol{H_t = D_t R_t D_t} \ \mathbf{(13)}$$

where,

r_t: n x 1 vector of log returns of n variables at time t

a_t: n x 1 vector of mean-corrected returns of n variables at time t, i.e. $E[a_t] = 0$ and $Cov[a_t] = H_t$.

μ_t: n x 1 vector of the expected value of the conditional r_t

H_t: n x n matrix of conditional variance of $a_t$at time t

D_t: n x n, diagonal matrix of conditional standard deviations of $a_t$at time t.

R_t: n x n conditional correlation matrix of $a_t$at time t

z_t: n x 1 of iid errors such that $E[z_t] = 0$ and $E[z_t z_t^T] = I$

In addition, the mathematical formula of the correlation structure can be extended to the general form DCC(m,n) – GARCH model:

$$\boldsymbol{Q_t = \left(1 - \sum_{m=1}^{M} \lambda_{1_m} - \sum_{n=1}^{N} \lambda_{2_n}\right)\overline{Q_t} + \sum_{m-1}^{M} \lambda_{1_m} a_{t-1} a_{t-1}^T + \sum_{n-1}^{N} \lambda_{2_n} Q_{t-1}} \quad \mathbf{(14)}$$

where,

$\bar{Q}$: the unconditional covariance matrix of the standardized errors ε_t

λ_1,λ_2: are scalars parameters

There aretwo imposed conditions, the parameters λ_1 and λ_2, in order to guarantee $\boldsymbol{H_t}$to be positive definite. Also, the conditions for the univariate GARCH model to ensure positive unconditional variances, the scalars λ_1 and λ_2 must satisfy the following restrictions:

$$\boldsymbol{\lambda_1 \geq 0, \lambda_2 \geq 0 \ and \ \lambda_1 + \lambda_2 \leq 1} \ \mathbf{(15)}$$

During the first stage, univariate volatility models are fit for each variable, and estimates of h_{it} are taken. In fact, the first stage R_t is replaced with the identity matrix I_n, which results in the quasi-likelihood function:

$$\boldsymbol{\ln\big(L_1(\varphi)\big) = \sum_{i=1}^{n}\left(-0,5\sum_{\tau=1}^{T}[\ln(h_{it}) + \frac{a_{it}^2}{h_{it}} + c\right)} \ \mathbf{(16)}$$

From the first step, the parameter set $\varphi = \varphi_1, \ldots, \varphi_n$ is estimated. When φ is estimated, also the conditional variance h_{it} is estimated for each variable i = 1, …, n. When, the first step is ended, only the parameters λ_1 and λ_2 are unknown. These parameters are calculated in the second step.

During the second stage, variable returns, transformed by their estimated standard deviations, are used to produce the constant parameters of the conditional correlation.

In fact, $\psi = (\lambda_1, \lambda_2)$ is estimated using the correctly specified log-likelihood. The second stage quasi-likelihood function is then:

$$\ln\big(L_2(\psi)\big) = -0,5 \sum_{t=1}^{T} (nln(2\pi) + 2\ln(|D_t|) + \ln(|R_t|) + \varepsilon_t^T R_t^{-1} \varepsilon_t \quad (17)$$

Since D_t is constant when conditioning on the parameters from first step, we can exclude the constant terms and maximize:

$$\ln\big(L_2^*(\psi)\big) = -0,5 \sum_{t=1}^{T} \ln(|R_t|) + \varepsilon_t^T R_t^{-1} \varepsilon_t \quad (18)$$

This can be shown under certain conditions that the pseudo-maximum-likelihood method yields consistent and asymptotically normal estimators.

Cappielo*et al.* (2006) clearly support that the DCC-GARCH model of Engle and Sheppard (2001) has a limitation. Particularly, the dynamics of the conditional correlation do not account for asymmetric impacts. This means that the model includes the magnitude of past shocks' impacts on potential conditional volatility and correlation, however it presents no differences between the negative and positive volatility responses. Cappielo*et al.* (2006) proposed the Asymmetric DCC-GARCH model in order to account for these future asymmetries in the conditional correlation between the times series. Therefore, the following equation (19) can be extended:

$$Q_{ij,t} = (1 - \lambda_1 - \lambda_2)\overline{Q_t} - \gamma\overline{\Psi_t} + \lambda_1\big(\varepsilon_{i,t-1}\varepsilon'_{j,t-1}\big) + \lambda_2\big(Q_{ij,t-1}\big) + \theta\big(\xi_{i,t-1}\xi'_{j,t-1}\big) \quad (19)$$

where, $\overline{\Psi_t} = E\big[\overline{\xi_{it}\,\xi_{jt}'}\big]$and $\overline{\xi_{it}} = (I[\overline{\varepsilon_{it}} < 0], o\ \overline{\varepsilon_{it}}\ ]$, the latter being the element by element Hadamard product of the residuals if sector shocks are negative, and $\overline{\xi_t} =$ **0**otherwise. Therefore,the asymmetric factor, γ, captures periods where both markets experience bad news (negative shocks), making $\big[\overline{\xi_{it}\,\xi_{jt}'}\big] = I_t$.

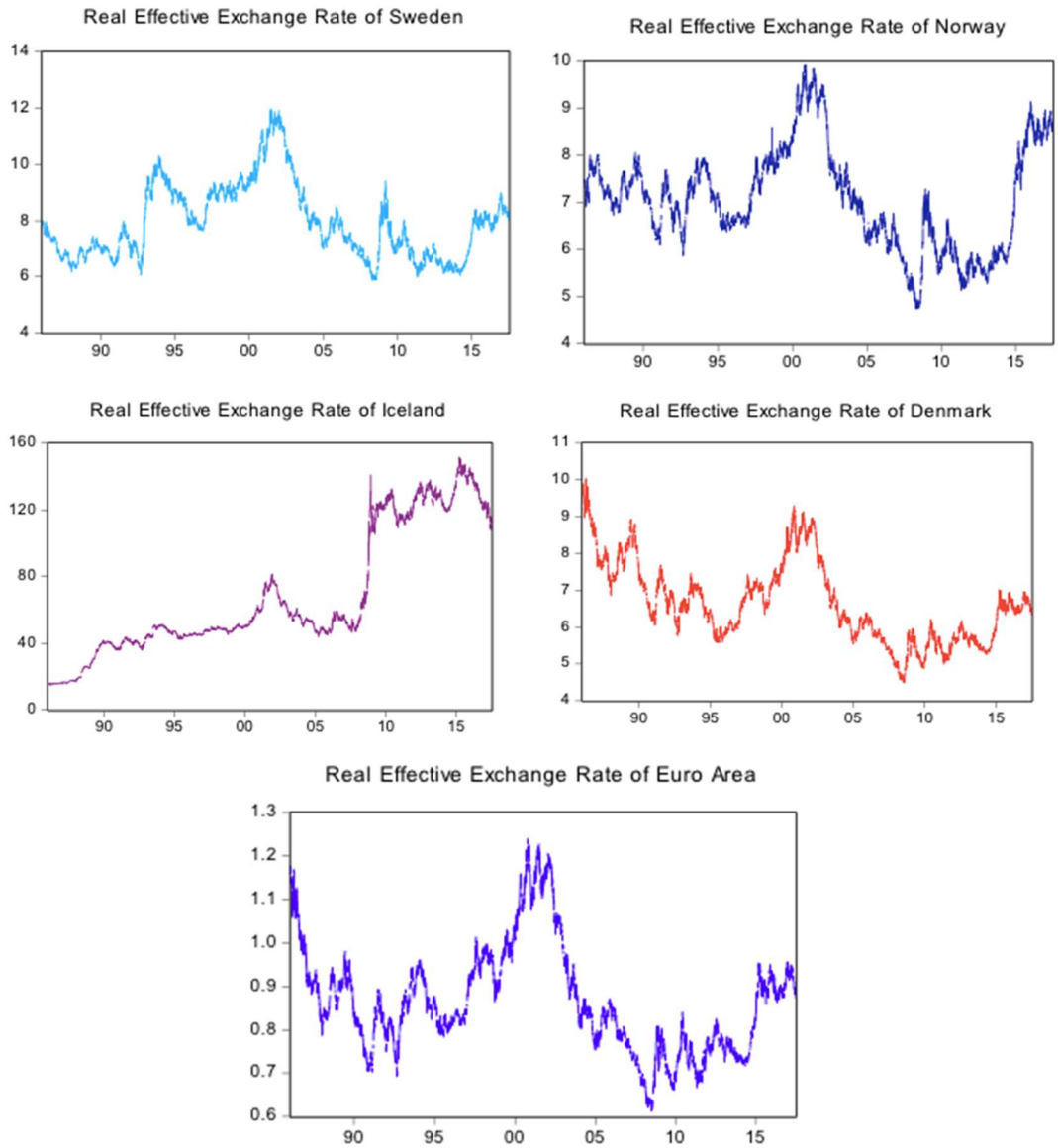
5. Results of the preliminary analysis

This section provides evidence about the diagnostics test of our empirical analysis. In particular, we present the findings of timeline analysis, Silvestre, Kim and Perron (2009) unit root multiple breakpoint test, as well as the result of the co-integration with structural breakpoints testing (Johansen, 2000).

5.1 Timeline Analysis

Figure 1 shows the historical evolution of the real effective exchange rate (REER) of each examined country from 1986 to third trimester 2017. The timelines reveal that there is a clear long-term economic behavior among the euro, the Swedish krona and the Norwegian krone and the Danish krone. However, we cannot support the same for Iceland. The use of the Johansen co-integration test would offer the appropriate evidence about the existence of a dynamic interrelationship between the euro and the Icelandic krona in the long-run.

Figure 1: Timeline Analysis of REER



Note: The figures report the movement of real effective exchange rates against a basket of currencies from 01/01/1986 to 30/09/2017. The data was extracted from the official database of the Federal Reserve System®.

5.2 Silvestre, Kim and Perron multiple breakpoint test

The exploration of a random walk (unit root) is very important in time series analysis. A stationarity test is a prerequisite before executing a co-integration test. We ran a Silvestre, Kim and Perron (2009) with three breakpoints stationarity test. The Silvestre, Kim and Perron test was executed by using value of the real effective exchange rate (REER) of each currency. The results of the Sivlestre et al. (2009) unit

root with structural breaks test (in levels and in first differences) are reported in Table 2. The results show that all the series are integrated with first order I(1).

Table 2: Estimation Results of Silvestre, Kim and Perron unit root test in levels and in first differences

Series – Values	MZ_a^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}	Break Dates
In level					
EUR	-19.24	-2.869	0.139	13.45	January 1997,December2001,
	(-32.11)	(-4.043)	(0.122)	(7.32)	December 2008
DKK	-15.99	-2.793	0.171	13.22	January 1997, January 2002, December
	(-31.02)	(-3.932)	(0.129)	(6.89)	2008
ISK	-6.49	-1.507	0.318	53.42	December 1994, December 2001,
	(-32.94)	(-3.993)	(0.142)	(7.68)	January 2009
NOK	-22.85	-3.574	0.133	9.52	January 1997, January 2002, December
	(-33.87)	(-4.027)	(0.125)	(8.01)	2008
SEK	-27.52	-3.391	0.122	11.76	December 1994, January 2002, January
	(-34.02)	(-4.075)	(0.117)	(7.59)	2009
In First Difference					
ΔEUR	-37.22	-4.256	0.113	6.72	March 1997, February 2002,
	(-32.64)	(-4.041)	(0.123)	(7.32)	November 2008
ΔDKK	-33.95	-4.096	0.124	7.08	December 1996, January 2002, January
	(-32.99)	(-4.029)	(0.126)	(7.34)	2009
ΔISK	-39.17	-4.471	0.111	6.39	February 1995, February 2002, October
	(-32.51)	(-4.085)	(0.119)	(7.61)	2008
ΔNOK	-35.78	-4.634	0.115	6.56	January 1997, March 2002, December
	(-30.43)	(-4.033)	(0.126)	(7.47)	2008
ΔSEK	-41.21	-4.653	0.108	5.95	December 1994, February 2002, January
	(-33.38)	(-4.079)	(0.127)	(7.22)	2009

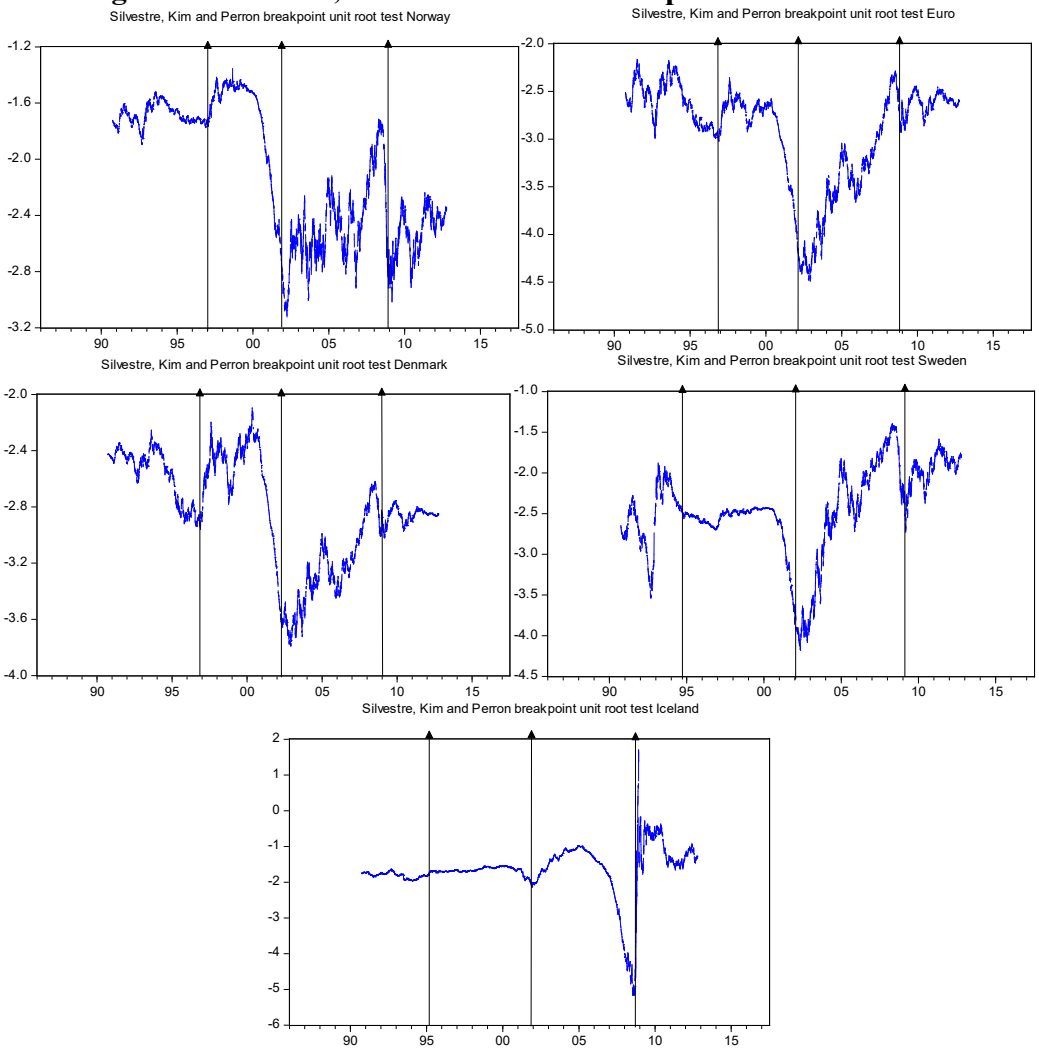
Note: critical values in the parentheses at 0.05 level

This means that all the series are non-stationary in level and stationary in the first difference. Furthermore, the results indicate strong evidence for the presence of three structural breaks inside these time series. The break dates differ between variables. Specifically, according to in levels sequence, the first break date corresponds to January 1997 for all variables except Iceland and Sweden where the break is in January 1995. The second break date is the same between variables and it corresponds to January 2002. Finally, the third break date corresponds around to January 2009.

Specifically, figure 2 shows the three breakpoints of each time series that we used. The main characteristic of each time series is that the second and third break point is the same, around 01/01/2002 and 01/01/2009, respectively. Also, there are two time series which have a breakpoint around 01/01/1995. On the other hand, there are three time series which show a cut point around 01/01/1997. Therefore, we have selected these dates as the three breakpoints, in order to create the three sub periods that we have already described in section 3.The following figure (2) presents the breakpoints

of each time series according to the Silvestre, Kim and Perron(2009) unit root test. The breakpoints are presented with the use of arrows.

Figure 2: Silvestre, Kim and Perron Breakpoints Unit Root Test



Note: The figures show the breakpoints of Silvestre, Kim and Perron (2009) unit root test. The arrows indicate the exact breakpoint dates.

5.3 Johansen's Co-integration test with structural breaks

The results of Johansen Co-integration testing with structural breaks are presented in Table 3 to Table 6. We used the real effective exchange rate of each currency, in order to discover if the series are co-integrated in the long-run. We selected the deterministic trend assumption of test that there is a trend and an intercept in co-integrating equations (CE) and no intercept in VAR with three lags according to Schwarz criterion.

Table 3: Johansen's Co-integration Structural Breaks Test in series DKK and EUR

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value a=0.1	Probability
None	0.000458	3.761	2.706	0.0524*
At most 1	0.001191	13.549	13.429	0.0962

Note: (*) denotes statistically significant at 0.1 level

The results of Johansen's Co-integration test with structural breaks show that there is a long-term tendency between the euro and the Danish krone. This trend takes place during the entire period at 10% level of significance.

Table 4: Johansen's Co-integration Structural Breaks Test in series ISK and EUR

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value a=0.1	Probability
None	0.000419	3.442	2.706	0.0664*
At most 1	0.001185	13.185	13.429	0.1253

Note: (*) denotes statistically significant at 0.1 level

Moreover, we found out that a similar behaviour exists between the Icelandic krona and the euro. These two currencies are co-integrated during the examined period at 10% level of significance.

Table 5: Johansen's Co-integration Structural Breaks Test in series NOK and EUR

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value a=0.01	Probability
None	0.002231	21.417	19.937	0.0061***
At most 1	0.000374	3.071	6.635	0.0797

Note: (***) denotes statistically significant at 0.01 level

A co-integration takes place between the euro and the Norwegian krone during the total period at 1% level of significance.

Table 6: Johansen's Co-integration Structural Breaks Test in series SEK and EUR

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value a=0.01	Probability
None	0.002022	20.264	19.937	0.0077***
At most 1	0.000443	3.637	6.635	0.0969

Note: (***) denotes statistically significant at 0.01 level

The findings of Johansen's Co-integration test with structural breaks express that there is a long-term tendency between the euro and the Swedish krone. This trend takes place during the total period at 1% level of significance.

6. Empirical Evidence

During this section, we provide the empirical evidence about the advanced econometric procedures of this paper. As we previously displayed, the Error Correction Model is suitable in order to explore short- and long-term interrelationships among a group of variables and the condition of their equilibrium. The ECM is a multivariate model, as it includes the error correction term (EC) and the independent variable, REER of euro.

6.1 Error Correction Model results

Table 7 shows the findings of the ECM for Denmark. The dependent variable is the REER of the Danish krone and the control variable is the REER of the euro. During the total period, we observe that the short-term factor (β) is negative. The same tendency takes place for all sub-periods. This implies that the REER of the euro influences negatively the REER in Denmark in the short-run. On the other hand, the long-term parameter (δ) is positive for the total period, as well as, during the sub-periods. This happens because the Danish krone is traditionally bound to a basket of European currencies (only euro after 1999). Especially, the Danish krone was fixed to a basket of European currencies during the 1980s (1st period). This was formalized in the European Monetary System (EMS). Prior to that, Denmark had participated in the "European currency snake" in the years after the collapse of the Bretton Woods system. This means that the most of the EEC countries agreed, in 1972, to maintain stable exchange rates, by preventing exchange rate fluctuations of more than 2.25%. During the second period, we observe that the long-term factor increased, despite the decision of Denmark to obtain an opt-out right from the participation in the EMU. However, the Danish Central Bank (DCB) decided to participate in the second stage of the EMU by maintaining a fixed exchange rate against the German mark and then against the euro (after 1999). According to Abildgren (2010), the Danish Central Bank announced that, it was important to create a solid framework for price stability in the euro area, making it an appropriate anchor for the Danish fixed-exchange-rate policy. Also, Denmark had an interest in developing an expedient framework for exchange rate cooperation between the euro area and the non-euro area member

states. Thirdly, Denmark had a general interest in the formulation of the ground rules for Stage 3 of EMU to ensure that Denmark would be able to adopt the single currency at a later stage on the same terms as those applying to the initial euro area member states.

Table 7: Estimation Results of Error Correction Model - DKKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
α	0.0006	0.0001	0.0071	-0.0069	0.0036
	(0.17)	(0.26)	(0.91)	(-1.29)	(0.50)
EC	0.0018	-0.0018	-0.2166	-0.1744	-0.1166
	(0.14)	(-2.77)**	(-13.24)**	(-13.32)**	(-10.83)**
β	-0.0427	-0.0143	-0.0035	-0.0023	-0.1299
	(-6.92)**	(-1.57)	(-0.71)	(-0.22)	(-9.01)**
δ	0.103	0.099	0.075	0.097	0.119
	(134.82)**	(94.01)**	(27.53)**	(44.62)**	(37.90)**

Note: (**) denotes statistically significant at 0.05 level

Additionally, we observe that the value of the long-term factor reduced during the third period, where the euro physically had been circulated. This may happen due to the Danish referendum on 28 September 2000, where the majority of the people rejected the participation of Denmark in the Euro Area. After this historical event, the politicians in Demark paused occupying with a possible Danish Eurozone membership. However, the Danish krone remained a member of the ERM II. In fact, this fixed exchange rate against the euro removed several monetary tools from the Danish Central Bank and a small monetary union between the Eurozone and Denmark was implemented.

It is clear that the long-term parameter increased significantly during the 4th period (debt crisis in the Euro Area). This may occur due to the monetary policy of the Danish Central Bank. The DCB decided to reduce the interest rate of the Danish krone from 1% in 2010 to -0.65% in 2017. This monetary policy took place in order to safeguard the fixed exchange rate of the Danish krone against the euro. It was observed that thousands of people and investors began to demand the Danish krone by exchanging their euros due to the uncertainty of Eurozone cohesion after 2010. Also,

during the 4th period, we observe similar monetary policy between the DCB and the ECB, as well as, the inflation rate in Denmark and in the Euro Area followed the same tendency. Therefore, it is logical to have a higher long-term parameter of the ECM during the 4thperiod. Finally, we noticed that the equilibrium (EC) factor is not statistically significant during the total period. This means that there is a constant and continuous equilibrium between the REER of Denmark and the REER of Euro Area. On the contrary, disequilibria take place when we examine each period separately. Actually, from 1986 to 1997, the value of EC term is equal to -0.018 or -0.18% which indicates that 0.18% of a deviation from the error correction mechanism is corrected within 1 day. Also, from 1998 to 2001, the value of EC term is -0.2166 or 21,66% which shows that 21.66% of a deviation from the error correction mechanism is corrected within 1 day. Similar results take place from 2002 and thereafter, but the value of term decreases continuously.

Table 8 indicates the results of the ECM for Iceland. The dependent variable is the REER of the Icelandic krona and the independent variable is the REER of the euro. The findings of our analysis show that the short-term factor is statistically significant during the overall period.

Table 8: Estimation Results of Error Correction Model - ISKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
α	-0.0061	-0.0002	0.0076	-0.0003	0.0008
	(-1.02)	(-2.38)**	(0.45)	(-2.31)**	(0.85)
EC	-0.00096	-0.0038	-0.0016	-0.0018	0.0003
	(-1.87)	(-4.08)**	(-1.73)	(-2.06)**	(0.53)
β	0.0019	0.0095	0.0087	-0.0081	-0.155
	(2.69)**	(6.33)**	(2.39)**	(-0.35)	(-7.76)**
δ	-0.0292	-0.0999	-0.0861	0.0008	0.0030
	(-23.78)**	(-21.06)**	(-15.53)**	(8.28)**	(23.47)**

Note: (**) denotes statistically significant at 0.05 level

This tendency remained approximately the same from 1986 to 2002 (1st and 2nd period). This means that the REER of the euro has positive impact on the REER of the Icelandic krona. On the other hand, this parameter is negative from 2009 to 2017.

The euro presents a negative effect on the Icelandic krona. Additionally, adisequilibrium (DEC) between the euro and the Icelandic krona takes place from 1986to 1994 and from 2002 to 2008. Actually, from 1986 to 1994, the value of EC term is equal to -0.0038 or -0.38% which indicates that 0.38% of a deviation from the error correction mechanism is corrected within 1 day. Also, from 2002 to 2008, the value of EC term is -0.0018 or -0.18% which shows that 0.18% of a deviation from the error correction mechanism is corrected within 1 day. On the other hand, an equilibrium exists from 1995 to 2001 and from 2009 and hence after.

As, we have already pointed out, the long-term factor is the most important parameter to our analysis. The results clearly present that a strictly negative effect takes place from 1986 to 2001. This factor increased slightly (upturn trend) during the examined period. Nevertheless, the long-term parameter changed from negative to positive during the third period (2002-2008). Its impact seems to be near to zero (weak positive effect). Historically, Icelandic governments showed no attention or political will concerning a possible EU membership of Iceland. Particularly, the Icelandic governments opposed to the EU because they wanted a political and economic flexibility. Therefore, the Icelandic governments decided to participate in the Economic European Area (EEA) in order to benefit from the European Single Market. Apart from EEA, Iceland has signed the Schengen Area Agreement and the European Free Trade Association (EFTA). The Icelandic economy had been thriving until 2008, when the global financial crisis of 2008 crushed the Icelandic economic "miracle". Thus, it was expected to observe an upturn tendency of the long-term parameter. Despite its geographical position, Iceland has increased trade relationships with the EU. According to the Observatory of Economic Complexity (2016), Iceland exports 21% to the Netherlands, 11% to the UK and 10% to Germany. Also, Iceland imports goods 9.6% from Norway, 8.5% from Germany and 7.5% from the United States. This means that the Icelandic economy is more vulnerable to the European economy. During the 4th period, we found out that the euro influences positively the Icelandic krona in the long-run. This may have occurred due to the official application of the Icelandic government for the EU membership in July 2009. The Icelandic government believed that a EU participation would assist the economy to recover fast without the implementation of unpopular austerity measures. However, the negotiations with the EU were paused unofficially in July 2013, from the new-elected government of that

time. On 12 March 2015, the Foreign Minister of Iceland stated that he had sent a letter to the EU withdrawing the application for membership, without the approval of the Althing (Icelandic Parliament), although the European Union stated that Iceland had not formally withdrawn the application. In 2017, Iceland's newly elected government announced that it would hold a vote in parliament on whether to hold a referendum on resuming EU membership negotiations. Under the recent (2017) political aspect of view, it is very unclear if Iceland could be a member of the EU in the near future. Our empirical evidence supports the outcome that the Icelandic economy is more and more integrated to EU economy and a possible participation would be beneficial. However, our evidence is not enough to totally support this tendency.

Table 9 provides evidence for Norway. We used the Norwegian REER as a dependent variable of the ECM and the REER of the euro as a control variable. The outcome of our analysis shows that a negative dis-equilibrium (DEC) takes place between the euro and the Norwegian krone from 1986 to 2002 and from 2009 to 2017. The overall short-term spillover effect is negative which means that the euro influences negatively the Norwegian krone in the short-run. However, this phenomenon is not valid from 1997 to 2008. Moreover, the long-term factor is positive, showing a downturn trend from 1986 to 2017.

Table 9: Estimation Results of Error Correction Model - NOKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
α	-0.0005	-0.0009	0.0008	-0.0015	0.0004
	(-1.04)	(-1.42)	(0.61)	(-1.89)	(0.45)
EC	-0.0038	-0.0057	-0.0113	-0.0011	-0.0095
	(-4.73)**	(-5.12)**	(-2.62)**	(-0.95)	(-3.38)**
β	-0.032	-0.025	0.0064	-0.0063	-0.088
	(-3.99)**	(-2.29)**	(0.31)	(-0.39)	(-4.91)**
δ	0.074	0.101	0.082	0.072	0.049
	(83.41)**	(72.94)**	(31.67)**	(43.19)**	(30.30)**

Note: (**) denotes statistically significant at 0.05 level

Historically, Norway applied for European Economic Communities (EEC) membership in 1962 and in 1967, but France rebuffed Britain's application and the

accession negotiations with Norway. In 1972 and 1994, the Norwegian government held a referendum about EEC and EU membership, respectively. The majority of Norwegians rejected a possible EEC/EU membership, despite the will of the Norwegian governments.

The status of this membership is in favor of the Norwegian economy because the country enjoys the benefits of the European Single Market without being obliged to accept the decision of the European Parliament or the European Council.In addition, the positive relationship between the NOK and the euro may exist due to a similar monetary policy which has been followed by the Norwegian Central Bank (Norges Bank) and the European Central Bank (ECB). In fact, the NCB reacted positively to the decision of the ECB according to the interest rates policy. We observed that the long-term impact increased rapidly (2.55) during the fourth period. This may occur due to two reasons. Firstly, the NCB followed the monetary policy of ECB, and secondly Norway raised the trade linkages with the EU member states. According to Observatory of Economic Complexity (2016), Norway exports 17% to Germany, 17% to the UK and 12% to the Netherlands. Also, Norway imports goods 12% from Sweden, 11% from Germany and 9.8% from China. This means that the Norwegian economy is more bound to the European economy. In summary, the main outcome of the long-term parameter reveals that the Norwegian economy was positively integrated in the European economy from 1986 to 2017. Despite this strong economic and trade bond between the EU and Norway, there is not a political will for EU membership at this time (2018). This appears to be very logical because the majority of Norwegians wish a higher independence of their country. Also, 56% of the Norwegian GDP comes from petroleum and gas products. Hence, Norway does not need any financial assistance from the EU via its findings.

Table 10 displays the empirical results for Sweden. By following the same procedure, we used the ECM model and the dependent variable is the REER of Swedish krona and the independent variable is the REER of the euro. According to the empirical results, the adjustment speed back to equilibrium seems to be statistically significant during the majority of the examined periods, except from 1994 to 2001. This means that the Euro Area and Sweden enjoys a long-term negativedis-equilibrium (DEC). It is clear that the REER of the euro shows a negative impact on the REER of the

Swedish krona in the short-run (overall period). The impact is zero (statistically insignificant) from 1986 to 2008. The effect turns to negative from 2009 and thereafter. On the other hand, we observe that the REER of the euro influences positively the REER of Swedish krona in the long-run. The effect is continuously increasing. This event occurs because the economic and trade interrelationships between the EU and Sweden increased significantly when Sweden join the EU. According to the Observatory of Economic Complexity (2016), Sweden exports 11% to Germany, 7.6% to Denmark and 7.5% to the UK.

Table 10: Estimation Results of Error Correction Model - SEKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
α	-0.0004	-0.0002	0.0008	-0.0002	0.0008
	(-0.83)	(-1.66)	(0.75)	(-1.46)	(0.85)
EC	-0.0025	-0.0024	-0.0032	-0.0141	-0.0036
	(-4.16)**	(-2.42)**	(-1.51)	(-3.49)**	(-2.36)**
β	-0.022	0.0021	0.0087	-0.0119	-0.0922
	(-2.65)**	(0.14)	(0.48)	(-0.81)	(-5.34)**
δ	0.064	0.081	0.064	0.051	0.083
	(80.60)**	(49.50)**	(34.37)**	(47.26)**	(34.26)**

Note: (**) denotes statistically significant at 0.05 level

Also, Sweden imports goods 18% from Germany, 8.4% from the Netherlands, and 7.4% from Denmark. This means that the Swedish economy is influenced significantly by the European economy since the EU is its major trade partner. Furthermore, the Swedish economy is influenced by the Finnish economy because there are common borders between the countries. Common borders support and aid the trade relationships.Finland is a member-state of the Euro Area. Also, Sweden has strong trade and economic relationships with Germany and other Euro Area member, such as the Netherlands. Finally, it is important to mention that there are plenty of Swedish cities across the Finnish-Swedish borders where the euro has been unofficially circulated for commercial transactions since 2009. Therefore, this condition increases the integration of the Swedish economy with the Euro Area. In conclusion, we could point out that, despite the Swedish referendum of 2003, where the majority of Swedish rejected the euro, the major political parties in Sweden,

including the formerly governing coalition Alliance for Sweden (except the Centre Party) and the currently governing Social Democratic party, which won the 2014 election, are in principle in favor of introducing the euro. Our results also show that the long-term factor increased from 2009 and henceafter. There are strong political indications that present a possible Swedish partnership in the EMU in the distant future. Our empirical results highly support that an economic integration takes place between the Euro Area and Sweden. Hence, it is not unlikely to see Sweden being the 20th member of the Eurozone.

6.2 ADCC-GARCH results

The ADCC-GARCH methodology expresses a GARCH model which estimates volatility asymmetry, volatility persistence and the leverage effect. Particularly, we utilisedan ADCC-GARCH model in order to capture kurtosis, skewness and volatility clustering and asymmetry. It is important to mention that we used the GJR-GARCH model (Glosten*et al.* 1993) as an auxiliary in order to estimate the leverage effect of the ADCC-GARCH.

Table 11 estimates the ADCC-GARCH(1,1) results with 1 asymmetric order for Denmark by using the returns of the DKK and the EUR.The sum of ARCH and GARCH coefficients is not very close to unity, expressing that the Danish krone's volatility shocks are not quite persistent, especially from 1986 to 2001. Also, the coefficient of the lagged squared is positive and statistically significant. Thus, we are able to support that a strong GARCH effect is apparent. The coefficient of lagged conditional variance is statistically significant, but its value is lower than the unity. This supports that the impact of the "old" news on volatility is significant. The magnitude of the GARCH coefficient is medium from 1986 to 2001 and high from 2002 to 2017.

Table 11: Estimation Results of ADCC-GARCH - DKKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
Constant	0.0007	0.0014	0.0003	0.0008	0.0004
	(1.67)	(1.77)	(4.74)**	(2.22)**	(3.38)**
ARCH	0.121	0.133	0.159	0.102	0.055
	(7.77)**	(3.66)**	(5.87)**	(5.40)**	(6.89)**

γ	-0.011	0.0019	0.136	-0.095	-0.024
	(-1.39)	(0.33)	(4.88)**	(-0.58)	(-3.12)**
GARCH	0.812	0.777	0.699	0.978	0.957
	(8.11)**	(4.18)**	(13.52)	(6.81)**	(13.52)**
λ1	0.033	0.058	0.051	0.029	0.019
	(32.89)**	(3.31)**	(18.63)**	(6.05)**	(5.29)**
λ2	0.965	0.941	0.933	0.959	0.972
	(11.56)**	(10.25)**	(25.46)**	(17.47)**	(7.83)**

Note: (**) denotes statistically significant at 0.05 level

This means that there is a medium memory in the variance (1st and 2nd period) and a long memory in the variance during the 3rd and 4th period. The γ parameter (leverage effect) is not statistically significant from 1986 to 1993 and 2001 to 2009 indicating that bad/good news of the euro has no impact on the volatility of the Danish krone.On the contrary, the γ parameter is positive from 1994 to 2001 expressing that the news effect is asymmetric and the bad news of the euro has larger effect on the volatility of the Danish krone than the good news.

Lastly, we observe that the volatility asymmetry is negative from 2009 to 2017 indicating that the good news of the euro has a larger impact on the Danish krone's volatility than the bad news. The sum of λ1 and λ2 parameters is below the unity. This means that the structural stability conditions of the ADCC-GARCH are fulfilled.

Table 12 estimates the ADCC-GARCH(1,1) results with 1 asymmetric order for Iceland returns of the ISK and the EUR. A typical ADCC-GARCH formula is used for the conditional variance equation. The sum of ARCH and GARCH coefficients is not very close to unity from 1986 to 2017, expressing that the Icelandic krona's volatility shocks are not quite persistent. An opposite phenomenon takes place from 2002 to 2008 where Iceland enjoyed the most prosperous and thriving era after the World War II. Also, the coefficient of the lagged squared is positive and statistically significant. Thus, we are able to support that a strong GARCH effect is apparent. The coefficient of lagged conditional variance is statistically significant, but its price is lower than the one. This means that the effect of the "old" news on volatility is significant. The size of the GARCH coefficient is low from 1986 to 2001 and 2009 to 2017. This indicates that there is a short memory in the variance of the Icelandic krona during these eras. On the other hand, the size of the GARCH coefficient is

medium from 2002 to 2008. This supports that there is a medium memory in the variance of the Icelandic krona.

The γ parameter is not statistically significant from 1986 to 1993 and 2009 to 2017 indicating that the impact of the bad or the good news on the volatility of Icelandic krona is symmetric. On the other hand, we provide evidence that the news' impact is asymmetric from 1994 to 2008 and the good news of the euro has larger effect on the volatility of the Icelandic krona instead of the bad news. In fact, an overvaluation of the euro has larger impact on the Icelandic than a devaluation during these periods. The sum of λ1 and λ2 parameters is below the unity. This means that the structural stability conditions of the ADCC-GARCH are met.

Table 12: Estimation Results of ADCC-GARCH - ISKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
Constant	0.0011	0.0008	0.0006	0.0007	0.0005
	(13.52)*	(9.95)**	(4.32)**	(10.22)**	(3.03)**
ARCH	0.132	0.274	0.154	0.148	0.188
	(28.52)**	(5.33)**	(8.88)**	(17.29)**	(4.21)**
γ	-0.043	-0.154	-0.112	-0.176	-0.06
	(-10.55)**	(-1.41)	(-4.99)**	(-10.29)**	(0.77)
GARCH	0.941	0.704	0.808	0.845	0.536
	(9.86)**	(2.17)**	(10.22)**	(10.58)**	(2.91)**
λ1	0.031	0.042	0.048	0.036	0.039
	(7.99)**	(4.89)**	(2.31)**	(5.91)**	(4.27)**
λ2	0.925	0.952	0.948	0.959	0.947
	(3.39)**	(8.05)**	(9.27)**	(3.19)**	(5.27)**

Note: (**) denotes statistically significant at 0.05 level

Table 13 estimates the ADCC-GARCH(1,1) results with 1 asymmetric order for Norway returns of the NOK and the EUR.A typical ADCC-GARCH formula is used for the conditional variance equation. The sum of ARCH and GARCH effect is not very close to one from 1986 to 2001 indicating that Norwegian krone's volatility shocks are not quite persistent. A totally different phenomenon takes place from 2002 to 2017. The coefficient of the lagged squared is positive and statistically significant. Thus, we are able to support that a strong GARCH effect is clear. Moreover, the size

of the GARCH coefficient is high from 2002 to 2017.This indicates that a long memory in the variance exists during these periods. However, the GARCH coefficient is low from 1986 to 2001. Hence, we could support that a short memory in the variance takes place. The γ parameter represents the leverage effect on the conditional variance. The factor of volatility asymmetry is not statistically significant from 1986 to 1993 and from 2001 to 2017. This means that the bad or the good news of the euro does not influence the volatility of the Norwegian krone. Also, the leverage effect is negative from 1994 to 2001, expressing that good news of the euro has higher effect on the volatility of the Norwegian krone than the bad news. This phenomenon may be linked with the participation of Norway in the European Economic Area in 1994. The sum of λ1 and λ2 parameters is below the unity. This means that the structural stability conditions of the ADCC-GARCH are met.

Table 13: Estimation Results of ADCC-GARCH - NOKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
Constant	0.0009	0.0003	0.0006	0.0001	0.0008
	(1.13)	(1.66)	(1.88)	(-0.79)	(2.77)**
ARCH	0.128	0.158	0.198	0.059	0.041
	(8.88)**	(4.36)**	(5.41)**	(4.66)**	(5.56)**
γ	-0.011	0.025	-0.055	-0.013	0.014
	(-2.06)**	(1.33)	(-6.44)**	(-1.22)	(0.11)
GARCH	0.851	0.649	0.696	0.979	0.969
	(9.59)**	(5.02)**	(5.12)**	(6.22)**	(9.85)**
λ1	0.041	0.022	0.038	0.041	0.039
	(7.11)**	(5.12)**	(3.02)**	(3.62)**	(4.09)**
λ2	0.948	0.963	0.958	0.948	0.952
	(3.33)**	(2.81)**	(3.67)**	(6.78)**	(2.19)**

Note: (**) denotes statistically significant at 0.05 level

Table 14 presents the ADCC-GARCH(1,1) results with 1 asymmetric order for Swedenreturns of the SEK and the EUR.A typical ADCC-GARCH formula is used for the conditional variance equation.We observe that the sum of ARCH and GARCH coefficients is not very close to unity from 1986 to 2001 expressing that the Swedish

krona's volatility shocks are quite persistent.A totally different phenomenon takes place from 2002 to 2017, where the volatility of Swedish krona is more persistent against the shocks of euro's volatility. Furthermore, the magnitude of the GARCH coefficient is low and stable within the first two periods. Therefore, we may support that a short memory in the conditional variance exists and the "old" news of volatility has no effect. On the other hand, the GARCH effect is high from 2002 to 2017 where a long memory in the conditional variance takes place. The γ parameter, which represents the leverage effect on the conditional variance, is statistically significant and negative from 1986 to 2017. This means that the good news of the euro has larger impact on the volatility of the Swedish krona than the bad news. Actually, an overvaluation of the euro influences more the Swedish krona instead of a devaluation of the European common currency. The sum of λ1 and λ2 parameters is below the unity. This means that the structural stability conditions of the ADCC-GARCH are met.

Table 14: Estimation Results of ADCC-GARCH - SEKvsEUR

Parameter	Total period	1st period	2nd period	3rd period	4th period
Constant	0.0002	0.0007	0.0006	0.0004	0.0011
	(0.13)	(2.11)**	(1.75)	(2.51)**	(2.52)**
ARCH	0.118	0.172	0.108	0.068	0.077
	(8.25)**	(5.23)**	(3.44)**	(6.01)**	(3.88)**
γ	-0.027	-0.036	-0.044	-0.029	-0.046
	(-4.36)**	(-3.01)**	(-3.78)**	(-2.65)**	(2.99)**
GARCH	0.852	0.658	0.602	0.954	0.943
	(10.95)**	(5.96)**	(3.52)**	(13.25)**	(9.86)**
λ1	0.025	0.039	0.041	0.039	0.033
	(5.52)**	(6.95)**	(2.23)**	(5.21)**	(4.01)**
λ2	0.965	0.951	0.932	0.959	0.962
	(9.18)**	(7.95)**	(6.18)**	(7.11)**	(3.95)**

Note: (**) denotes statistically significant at 0.05 level

7. Conclusion

The Treaty of Maastricht (1992) was the vital keystone to the European integration. In fact, it had transformed the European Communities into the European Union. The next step of that time was the establishment of the Economic and Monetary Union among the member-states of the Euro Area. The European integration successfully accelerated from 2002 to 2009, since the Euro Area welcomed four new member states (Cyprus, Malta, Slovenia and Slovakia). The global financial crisis of 2008 did not shock the cohesion of the Euro Area, despite the economic recession. The sovereign debt crisis of 2010 was the most important hit which raised discussion about the potential endurance of the monetary union. Despite the difficulties where the Euro Area suffered from 2010 to 2015, it was proved that the euro is too hard to "die". The leaders of the Euro Area decided to safeguard the union by establishing new institutions, such as the ESM. The reinforcement of the Euro Area did not persuade other EU member-states to adopt the European common currency. For instance, the Scandinavian economies have no structural weakness and they are eligible to join the Eurozone. However, the people and their governments are very sceptical to a possible EMU participation.

The aim of this paper is to explore if the Scandinavian economies are bound to the European economy (Euro Area). We used the ECM and the ADCC-GARCH, separately, in order to discover any possible spill over effects among the euro and the Scandinavian countries. Also, we explored if the volatility responses of the euro have large impacts on the volatility of the Scandinavian currencies. Our empirical results highly support that there are historical positive interrelationships between the euro and the Norwegian krone, the euro and the Swedish krona, and the euro and the Danish krone. However, we did not find enough evidence that a similar phenomenon takes place for Iceland. On the contrary, Iceland is negatively integrated with the European economy despite the participation of the country in the European Economic Area. The empirical evidence of our study is aligned with the findings of Pesaran*et al.* (2007), as well as, Reade and Volz (2009).

The outcomes of the present paper provide important evidence to academia, EU policy makers, international institutions (IMF, World Bank, BIS), investors, risk managers, multinational companies (MNCs) and individual people across the globe. A potential entry of Scandinavian countries in the Euro Area would definitely change the balances in the international markets and in the modern world. Especially, due to

the fact that the economic magnitude of Norway and Sweden is high, we could possibly assume that the exchange rate of the euro would be overvalued against other leading currencies, such as the US dollar (USD), the Great Britain pound (GBP) and the Japanese Yen (JPY). Furthermore, a possible euro partnership of Iceland and Denmark would increase the borders of the Euro Area to the Northern Atlantic Ocean (Iceland) and to the Northern American Continent (Greenland, as a province of Denmark). Except the economic and political influence of the Euro Area to America, a potential enlargement of the Eurozone would influence the investors and the speculators. The investments will be paid back at a different currency. Also, the speculators would earn reduced profits, because the euro is a more stable currency. A possible enlargement of the Euro Area will aid the multinational enterprises (MNEs), as well as, the small and medium-sized enterprises (SMEs) to diminish their exchange rate risk when they plan to transfer money (corporate transactions). The asset and liability (ALM) risk managers could achieve an efficient matching or hedging of their portfolios, in order to be able to predict more accurately the potential economic behaviour of the euro. Lastly, the depositors will see their savings being converted to a different currency.

In conclusion, the outcome of this paper may influence the politicians and the policy makers in Norway and Iceland to rethink firstly their participation in the EU and the adoption of the euro in the distant future. In addition, the Swedish and Danishgovernment may re-evaluate their participation in the Euro Area by holding a second euro referendum at their countries. Finally, the findings of this paper may influence the Swedish National Bank (SverigesRiksbank) to create a fixed exchange rate between the Swedish koruna and the euro by following the monetary strategy of the Danish National Bank (DanmarksNationalbank) (ERM II participation). Actually, we are able to indicate that the Norwegian government may reconsider the present status of Norway (EEA member). A possible next step should be the entrance in the EU, since its economy is bound to the Euro Area economy. Additionally, there are strong evidence that the Swedish economy is totally linked, under the social, political and economic aspect of view, with the Euro Area. Therefore, a potential step might be a participation to ERM II or EMU. In fact, the Danish economy shows similar behaviour, as Sweden. This means that Denmark would be more benefited by entering in the EMU, since the country enjoys no monetary or exchange rate independence.

Finally, Iceland is neutral or semi-negative entering to the EU. Additionally, we did not discover enough evidence which are able to support that a potential EU status would be beneficial to the Icelandic economy. Actually, the country has recently recovered from the economic and financial catastrophe of 2008 crisis. Nevertheless, the parameter of politics is really important, but this is out of the aims of the current research.

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