Financial Integration in Europe
- a Cointegration Analysis of European Stock Markets

Finansiell integration i Europa
- en kointegrationsanalys av europeiska aktiemarknader

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Abstract

This thesis has studied short and long-term dependence structures between European stock markets. Johansen's test for cointegration and Granger's test for non-causality have been applied in order to measure the degree of financial integration in Europe. The cointegration analysis has employed a comparative perspective in which different countries with different institutional adaptation to the economic cooperation within Europe have been considered.

The study finds strong support for the existence of cointegration between the Belgian, Norwegian, Swiss and British stock markets in the period after the launch of the euro. This result indicates that financial integration has increased in Europe since no cointegration was identified prior to the introduction of the euro. However, it is more difficult to determine to what extent the European financial cooperation has affected the degree of integration because of the difficulties with isolating formal treaties contribution to the stationary equilibrium. Both the EU and the euro's importance may have affected the integration process, but this thesis finds that this is not the only explanation. Thus, it is more likely that the liberalization of financial markets and the overall integration process best explain the increase in financial integration.

The most significant finding is that the cointegrated stock markets in the long-term can be regarded as a regional financial market characterized by similar systematic risk factors. This has implications for both policy-makers who adjust existing policies in Europe and investors looking to allocate portfolios in an efficient manner.

**Keywords:** Economics, Financial integration, Cointegration, Johansen, Granger Causality, Euro, EU, European cooperation, Engle, Granger.
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Chapter 1 - Introduction

1.1 Background

Financial markets around the world have witnessed an increased financial integration, inside and outside the state borders, due to deregulations, globalization and technological advances. Electronic payment and communication systems have greatly reduced the opportunities for arbitrage and have also stimulated and facilitated cross-border movement of capital. Along with these developments, political goals of achieving greater integration and harmonization have been stated. More recently, the European financial integration has been put on the agenda as a result of the recent debt crisis for a number of the EU member states. Problems associated with growing budget deficits and debt levels, in combination with credit rating downgrades for some of the participating countries, have caused increasing concern on the European financial markets with stock exchange collapses as a result.

The increased financial integration in Europe is not a new phenomenon. Ever since the end of the Second World War, the Western European states have extended their economic cooperation. However, it was not until the signing of the Maastricht Treaty in 1992 this process accelerated. The treaty is one of the founding treaties of the European Union and lays down the general framework for the formation of the Economic and Monetary Union. At the time of the signing, the European Union consisted of twelve member states, among these were the United Kingdom and Belgium. The Union expanded further in 1995 when Austria, Finland and Sweden joined the collaboration. Other European countries like Norway and Switzerland have chosen not to enter the Union. Around the millennium, the economic cooperation expanded further as a result of the introduction of the euro, although Sweden, the UK and several other member states chose to remain outside of the monetary union. The expansion process has continued and currently the European Union consists of twenty-seven member states of which seventeen have the euro as official currency.

The debt crisis in Europe has revived the debate in other member states regarding the adoption of the euro. In the spring of 2012, negotiations have been taking place between several member states in relation to a new Euro Pact. This pact stipulates, among other things, that a country must accept certain frameworks concerning budget deficits and receive fines if the framework is ignored. The agreement also enacts that the regulations should be written into the national constitutions. The agreement concerns all of the euro area countries and those who voluntarily join the Euro Pact. This harmonization is an additional step to a more centralized and economically integrated Europe. These structural and institutional changes are likely to have an impact on the degree of financial integration in Europe. On the stock markets, this integration has specifically meant that it has become easier for actors to trade assets in markets that were previously closed to foreign investors. One sign of this integration is that the total amount of the ownership held by foreign investors on, for example, the
Stockholm Stock Exchange, has increased from 7 % in 1989 to 38,1 % in June 2011.\(^1\) The foreign ownership in Norway is not as vast as in Sweden, but still accounted for approximately 14 % in early 2011.\(^2\) This indicates that the European states have been affected differently by their own institutional adaptations to an increasingly integrated Europe.

**1.2 Statement of the problem**

The degree of integration between markets has become one of the main issues in international financial economics.\(^3\) Unfortunately, despite its importance, there is still no explicit answer to what extent the European financial markets are integrated.\(^4\) The definition of financial integration is also ambiguous, but can be said to represent the process of how a country’s financial markets become more interconnected with those in other countries.\(^5\) It is also well accepted in the literature that the integration between financial markets is clearly linked to economic growth, socio-economic benefits, lower macroeconomic volatility and welfare gains.\(^6\) On the other hand, an increase in financial integration entails that national or regional shocks which previously had limited impact on other parts of the world now can spread and cause major global problems.\(^7\) Nyberg (2011) points out that an amplified financial integration between countries will require more comprehensive transnational legal framework in order to maintain financial stability.\(^8\)

There is yet no universal standard to measure the degree of financial integration, but a common measurement is the correlation between the returns on countries’ stock market indices.\(^9\) Influential studies by Levy and Sarnat (1970) and Solnik (1974) began an extensive empirical research regarding the correlation between different stock markets. This research was based upon Markowitz (1952) revolutionary conclusions that investors are able to reduce their risk by spreading out their investments geographically and across asset classes. The lower the correlation between assets, the greater the risk reduction. Solnik *et al.* (1996) identifies that the correlation between the world’s major stock markets has increased during 1957 to 1995, which demonstrates that the global financial markets have become more integrated. They also show that the correlation seems to increase in times of crisis.\(^10\) These findings have implications for an investor who follows a correlation and geographic based diversification strategy, as the benefits of diversification are lost. Moreover, similar trends have also been identified in Europe. Beckers (1999) establishes gradually increasing correlations between stock markets of the EU member states until the introduction of the

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euro. He also argues that the degree of financial integration is likely to increase in Europe due to the removal of the exchange risk as a consequence of a common currency.\textsuperscript{11}

Although the measure of correlation is widely used in previous research, it has its shortcomings when studying how various stock markets interact over time. Alexander (2002) argues that the financial markets by nature are mutually dependent, but that it is unfortunate that many financial actors still base their analyses on the limited correlation measurement. Correlation measures only the movement between two variables at a time and offers no coherent measurement of the dependence between several variables.\textsuperscript{12}

Unlike correlation, cointegration measures if a long-run relationship exists and, if so, a long-run equilibrium\textsuperscript{13} can be identified. Cointegration does not reflect the comovement between yields as correlation does, but rather the comovement between asset prices. If asset prices are cointegrated, they tend to converge in a common stochastic trend. This means that any short-term deviations from this trend will disappear, because the asset prices are expected to return to their long-run equilibrium. If cointegration exists, it is possible to forecast one market’s long-term movement based on historical price movements of the other cointegrated markets.\textsuperscript{14} According to Fama (1970) asset prices in financial markets should reflect all available information, which renders it impossible to predict future price movements.\textsuperscript{15} Granger (1986) alleges that there should not be evidence of cointegration between several asset prices in an efficient market. If such were discovered, it would violate Fama’s definition of a weakly efficient market.\textsuperscript{16} However, Richards (1995) stresses that such a conclusion may not be drawn unless risk-adjusted returns are considered.\textsuperscript{17}

Cointegration does not necessarily imply a high correlation because the latter concept focuses solely on short-term dependence structures. However, it is entirely possible that two assets exhibit both cointegration and high correlation. Conversely, cointegration may also exist in the presence of low correlation. This would be the case when a large stock portfolio is well-diversified to a stock index. In the long-run, the portfolio and the index are expected to be cointegrated and follow each other. Yet, at different times, large price variations in stocks excluded from the portfolio may reduce the correlation between the portfolio and the index. Consequently, correlation reveals nothing about the long-run relationship between two variables and is therefore also incapable of capturing long-run dependence structures.\textsuperscript{18}

\textsuperscript{11} Beckers (1999), pp. 7-17.
\textsuperscript{12} Alexander et al. (2002), p. 68.
\textsuperscript{13} Statistically, this is the steady state of the underlying process, but if an economic interpretation is established it can be seen as a long-run equilibrium.
\textsuperscript{14} Alexander et al. (2002), pp. 68-71.
\textsuperscript{15} Fama (1970), pp. 383-417.
\textsuperscript{16} Granger (1986), pp. 213-228.
\textsuperscript{17} Richards (1995) p. 632
\textsuperscript{18} Alexander et al. (2002), p. 71.
Against this background, in this thesis, the degree of financial integration in Europe is quantified and measured by the more dynamic cointegration framework. The understanding of the comovements between European stock markets, both short and long-term, can help identify how powerful the financial integration process has been in Europe. Is it possible to find tendencies towards a more financially integrated Europe and, if so, is it possible to determine if this process is related to formal agreements between the European states? Thus, the intention of this thesis is to investigate whether there are differences in the degree of integration. This is accomplished by comparing countries that have chosen not to participate in the European economic cooperation (Norway and Switzerland), with countries that are participating in both the EU and EMU (Austria, Belgium and Finland) and countries that have chosen to join the EU, but to remain outside of the monetary union (Sweden and the United Kingdom).

1.3 Purpose of the study

Applying a cointegration analysis, the purpose of this thesis is to examine the degree of financial integration in Europe. Research questions to be answered are therefore:

- Are the selected stock markets cointegrated in the long-run?
- To what extent has the increased European financial cooperation affected the degree of financial integration between the stock markets?
- What implications would an increased degree of financial integration imply?

1.4 Limitations

This thesis intends to move away from the somewhat abstract and controversial definition of European economic integration and instead focus solely on the financial integration in Europe. Specifically, the study will determine the degree of financial integration by measuring the cointegration between European stock markets. This thesis will not examine the degree of financial integration for all of Europe, but only the selected countries during the period 1989 to 2011.

1.5 Procedure

This thesis has a quantitative and econometric approach in order to measure the degree of financial integration between the selected European markets. This is applied on the indices of the chosen stock markets, using a cointegration analysis developed by Johansen (1988) and Johansen and Juselius (1990). Furthermore, the test for non-causality presented by Granger (1969) is applied in order to study the short-term causal relationships between the selected countries. The indices of the stock markets consist of monthly observations established by Morgan Stanley Capital International (MSCI) and are collected from Datastream International. The observations extend from the first month of 1989 until the last month of 2011.
The cointegration analysis will have a comparative perspective which requires the time period to be divided into two sub-periods. The first sub-period extends from the year of the fall of the Berlin Wall, until the introduction of the euro as a circulating currency in January 2002. The second sub-period extends from January 2002 to December 2011. These sub-periods were chosen to reflect the most influential events in the European economic collaboration for the sample countries during the time period analyzed.

**1.6 Justification of the study**

The degree of financial integration in Europe is vital for the working of the European cooperation. The European Central Bank (ECB) claims that:

i. The financial system is important for the conduct of monetary policy in the euro area, which is the basic task assigned to the Eurosystem. A well-integrated financial system facilitates the smooth implementation of monetary policy and the balanced transmission of its effects throughout the euro area.

ii. Financial integration contributes also to financial stability by creating larger, more liquid and competitive markets which offer increased possibilities for risk diversification.

iii. Financial integration is also fundamental to the Eurosystem's task of promoting the smooth operation of payment systems, which in turn plays a significant part in the safe and efficient functioning of securities clearing and settlement systems.”

A well-functioning financial system can thereby mobilize and channel savings into investments, reduce risks in the economy and provide a functional payment system. Financial integration also promotes economic growth, since the efficiency of financial markets will increase. The overall contribution of this thesis is therefore to provide a careful review and understanding of the comovements regarding the selected stock markets. This will offer valuable information for policymakers who adjust current policies or implement new policies in Europe. The subject is thus particularly relevant due to the ongoing debate among the member states of the EU concerning a new Euro Pact. Yet, this thesis is also of interest to investors looking to allocate portfolios in an efficient manner. This is particularly relevant as most financial actors base their investments on the basis of a long-term investment horizon and thus holding the same assets for a long time.

Ever since the late 1980s, when Engle and Granger (1987) developed a method for measuring cointegration, the international long-term comovements of stock markets have been studied extensively in the literature. The purpose of these studies has mostly been to establish the diversification opportunities for long-term investors and to identify the implications to investors on major financial markets. In recent years, the research on cointegration has partly changed direction and has focused on how opportunities for diversification have been affected in the developing markets. In Europe, the research is mainly centred on globalization and its impact on the stock markets of major economies such as Germany and the United Kingdom. Regarding the degree of

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19 The euro was formally introduced as an account currency on 1st of January 1999. However, euro notes and coins were not put into circulation before 1st of January 2002.

financial integration, cointegration has been used as a measurement, but other methods have also been used. The methodological approaches range from various pricing models to econometric techniques such as GARCH-models and correlation, but also cointegration. Despite these extensive studies, there is yet no consensus on the degree of integration between the European financial markets.

Worthington et al. (2003) and Soares da Fonseca (2008) have particularly investigated financial integration in Europe by employing the cointegration approach. These studies have dealt with the countries this thesis intends to examine. However, Soares da Fonseca has only used the period 2001 to 2005 and therefore cannot give a definite measurement on the degree of integration before the launch of the euro. Furthermore, Soares da Fonseca used the Engel and Granger’s two-step procedure which will not be applied in this study. This thesis will apply a similar approach used by Worthington et al. which also is one of the most recent studies concerning financial integration and its evolvement before and after the introduction of the euro. Worthington et al. uses weekly data and performs cointegration tests during the years 1988 to 2000. However, the time period used does not cover the introduction of the euro as a circulating currency and therefore neglects the impact the euro has had on the degree of financial integration. This is due to the fact that actors on the financial markets are likely to demonstrate an inherent inertia regarding the transition to a new currency. In addition, the introduction of the euro can be seen as an institutional regime change, which makes it more appropriate to test for cointegration with the year of the practical implementation as a starting point. This thesis intends to fill the vacuum left by previous research and to expand the understanding of the financial integration process in Europe.

1.7 Disposition

This thesis is structured as follows: chapter two contains a literature review of financial integration in Europe, chapter three focuses on the methodology and the econometric approach, chapter four displays the data set underlying the cointegration analysis and chapter five presents the empirical results. Finally, chapter six discusses the implications of the results, presents concluding remarks and recommendations for future research.

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22 Worthington et al. (2003), pp. 79-99.
Chapter 2 - Literature review

2.1 Definition of financial integration

In the literature there are different definitions for what is meant by financial integration. Baele et al. (2004) considers a market for a particular set of financial instruments or services to be fully integrated if all potential market participants have the same relevant characteristics.

i. They face the same rules when they decide to use these financial instruments or services.
ii. They have the same access to these financial instruments or services.
iii. They are treated equally when they are active in the market.23

Xing & Abbott (2007) is not as explicit in their definition and argue that the integration of financial markets represents the process of how a country’s financial markets become more interconnected with those in other countries. This implies indirectly an increase in foreign capital flow and a tendency for prices and returns on financial assets in different markets to converge.24

Accordingly, financial integration expresses the connection between financial markets and may specifically be divided into indirect, direct and total financial integration. Likewise, it is possible to divide the integration of a market based on a scale from perfect integration to perfect segmentation. Direct financial integration is measured by deviations from the law of one price for financial assets. Thus, an investor will have the same risk-adjusted returns for an asset no matter where the investor buys it. Indirect financial integration can be interpreted from a situation where the return on an investment in a country is indirectly linked to the return on an investment in a foreign country. Total financial integration includes both direct and indirect integration where real rates of return should be the same at different markets. If markets are not totally integrated, they can be claimed to be segmented. Consequently, segmentation is the result of a lack of integration and may be due to high transaction costs relating to arbitrage opportunities or even a measure of market inefficiency.25

2.2 The European financial integration process

Financial integration may occur in two different ways. One way is to formally integrate financial markets with specific trade partners, particularly those countries that share membership in a widespread regional agreement. Here the integration process includes the elimination of cross-border barriers facing companies and investors in the region and the harmonization of taxes and regulations between states. The European Union is an obvious example of this process and it is also generally expected that financial integration will transpire in the EU. Secondly, financial integration may occur less formally and instead act as a precursor to explicit regional agreements. Factors that contribute to this integration may be foreign financial actors having the opportunity to compete in

other markets, loan opportunities and financial agreements between states. Financial integration may thus arise even before a declared commitment to a partnership.26

Worthington et al. (2003) identifies four phases of structural and institutional change regarding the process of financial integration in Europe. The first phase was initiated in the early 1960s, when the European Commission set an overall target to reduce barriers on capital flows. The second phase began a decade later when the Bretton-Woods system collapsed, resulting in the creation of the European Monetary System. Subsequently, in 1979, the European Commission introduced an exchange rate mechanism in order to reduce currency fluctuations, thus providing a greater monetary stability between countries within Europe. Furthermore, several member states abolished their capitals control, hence accelerating the financial integration process.27

The third phase began in 1983 when the European Commission presented four stages on how to increase the degree of financial integration. The steps involved the deregulation of cross-border capital, increased regulation in order to achieve stable and efficient capital markets, harmonization of taxes across countries and guidelines for deposits and loans of financial institutions. The fourth and final phase covered the period from the signing of the Maastricht Treaty in 1992 until the introduction of the euro. In addition to further institutional adjustments, the treaty placed higher demands on the member states concerning an increase in economic adjustment and convergence. Measurements on these criteria were the participating countries' inflation rates, budget balance, exchange rate stability and interest rates.28

Moreover, the European Commission (1997) argues that the introduction of the euro will bring a significant impact on the degree of financial integration in Europe, not only for EU countries but also for countries outside the formal European cooperation. As for countries outside the EU it is assumed that a higher financial integration will be primarily identified in countries with a close link to the European Union.29 It is also within this institutional framework the empirical research on financial integration in Europe is framed.

2.3 Earlier empirical studies

For decades the literature has been debating the financial markets degree of integration from both a macroeconomic and a financial perspective. The focus of the macroeconomic research has often been to use the interest rate parity condition to test for integration between money and bond markets.30 Similarly, the macroeconomic literature has attempted to quantify the benefits arising due to a higher degree of integration between the international markets. The focus has been on countries' ability to spread risk, but also how trade and financial integration affects the relationship between growth and

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27 Worthington et al. (2003), pp. 4-5.
28 Ibid, p. 5.
volatility in consumption.\textsuperscript{31} Studies have shown that an increase in financial integration implies that countries are becoming more vulnerable to macroeconomic shocks and that these have a tendency to spread to other markets and sectors.\textsuperscript{32} Nyberg (2011) states that the financial crisis in 2007 partly was a result of what he calls \textit{Europe's trilemma}, which means that financial integration, financial stability and national sovereignty are incompatible. He believes that it is only possible to achieve two out of the three objectives. For example, if financial integration is to continue to increase while maintaining a stable financial system, national sovereignty must be sacrificed as extensive cross-border regulation becomes inevitable.\textsuperscript{33}

The research on financial economics has often focused on how international investors act from a portfolio optimization perspective. Financial integration has been studied by quantifying the flows of capital and, above all, measuring the proportion of foreign holdings of investors' portfolios.\textsuperscript{34} These studies have consistently found strong support of home bias, i.e. that investors are showing a tendency to invest more in domestic assets even if the risk is spread out more efficiently if they hold foreign assets. The two main reasons for this phenomenon are that investors tend to invest in assets in countries and companies that they have knowledge of and the high information and transaction costs associated with foreign capital.\textsuperscript{35} Alsén (2008) claims that the increased financial integration in Europe has made it easier regarding where in the world the raising of capital now takes place. He also points out that the euro area is one of the regions where ownership of domestic assets has declined most.\textsuperscript{36} However, Lane (2005) shows that there still is a clear euro-area bias, resulting in investors from countries within the EMU placing disproportionately large amounts of funds within other EMU countries vis-à-vis countries outside of Europe.\textsuperscript{37}

Financial integration has also been studied using different pricing models. Akdogan (1995) finds, employing a European \textit{capital asset pricing model} (CAPM), that the increase in political and economic integration in Europe has reduced the opportunities for portfolio diversification and that European stocks are priced based upon an integrated market and not on each country's domestic systematic risk factors. Akdogan argues that this result indicates that all the European markets have become more integrated.\textsuperscript{38}

Spiegel (2009) maintains that the introduction of the euro has contributed to a greater degree of integration of money markets and that this is due to the disappearance of the exchange risk in Europe. He believes that a membership in the monetary union means higher penalties if countries fail to comply with regulations, which will have a deterrent effect on member states and thus contribute

\begin{itemize}
\item \textsuperscript{31} Kose \textit{et al.} (2006), pp. 176–202.
\item \textsuperscript{32} Kaminsky \textit{et al.} (2003), pp. 51-74.
\item \textsuperscript{33} Nyberg (2011), p. 10.
\item \textsuperscript{35} Nofsinger (2011), pp. 80-83.
\item \textsuperscript{36} Alsén (2008), p. 12.
\item \textsuperscript{37} Lane (2005), pp. 1-45.
\item \textsuperscript{38} Akdogan (1995), pp. 161-173.
\end{itemize}
to greater degree of integration between countries.\footnote{Spiegel (2009), pp. 751-776.} Blanchard and Giavazzi (2002) argue that the euro will imply a natural increase in international integration since countries more easily can borrow on other capital markets than their own. They believe that the introduction of the euro and the growing integration of the money and bond markets will accelerate the process of financial integration in Europe.\footnote{See Santos & Tsatsaronis (2006), pp. 35-63 and Baele et al. (2004), pp. 509-530.}

However, it is more complicated to determine the degree of integration between the European stock markets rather than the degree of integration between bond markets. Hatemi \textit{et al.} (2008) believes that the results relating to the degree of financial integration are mixed and depends on the markets studied, the methodology applied and the time period used.\footnote{Hatemi \textit{et al.} (2008), pp. 665-685.} Although European stock markets have been investigated previously in the literature, there are relatively few studies that analyze financial integration from a European perspective.\footnote{See Gallagher (1995), pp. 131-147.} The most common approach is to see if segmented markets exhibit increased integration due to the increase of correlation between stock markets. Correlation has been used as a measurement because it is relatively easy to interpret the short-term comovements between stock markets. Studies have shown that European stock markets have become increasingly correlated and that they also suffer from common European shocks.\footnote{Baele \textit{et al.} (2004), pp. 509-530.}

Worthington \textit{et al.} (2003) is one of the few studies mainly examining long-run relationships between European stock markets and the impact of the EU and the monetary cooperation. Their analysis separates the countries in Europe that have adopted the euro with countries that are only included in the European Union and compares their short and long-run trends. The study identifies stationary long-run trends and significant short-run dependencies between countries within the monetary cooperation and between those countries that have opted out.\footnote{Worthington \textit{et al.} (2003), pp. 79-99.} Soares da Fonseca (2008) finds similar trends during 2001 to 2005 and points out that the introduction of the common currency does not affect the integration of stock markets in a significant way. Soares da Fonseca argues that it is the increased technological developments, the liberalization of stock markets and the development of emerging markets that affect the process of financial integration more than the stated political cooperation between countries.\footnote{Soares da Fonseca (2008), pp. 309-324.} Moreover, Worthington \textit{et al.} show that the major stock markets are the most influential, but that there still exists some diversification opportunities for investors within the European borders.

Subsequent studies, particularly Rousova (2009), inspect how countries in Central Europe have been affected by their entry into the EU. By applying the Johansen cointegration method she finds two long-run stochastic trends between the sample countries indicating that the degree of financial integration...
integration has increased after the onset as no common trend could be identified prior to entry. Rousova emphasizes that the common long-run trends indicate that the countries of Central Europe have become more intertwined with those of Western Europe, suggesting an increased comovement between the old and the new Europe.\footnote{Rousova (2009), pp. 1-30.}

Based on this literature review, a picture emerges of an increasingly financially integrated Europe where capital markets are showing signs of increased comovements. However, the results have been varied and depended on the method and the markets used in the studies. Regarding cointegration between European stock markets long-run trends have been identified, indicating that there has been an increased degree of financial integration in Europe. Reasons stated have been the EU's declared goals regarding an increased financial cooperation and the greater harmonization process. Others have instead argued that it rather is the globalization process and the liberalization of financial markets that has contributed to the degree of integration among European countries.
Chapter 3 - Methodology

3.1 Cointegration analysis

Financial integration is quantified by the comovements between the selected countries’ stock markets by applying an econometric cointegration analysis. Inspecting cointegration from the context of this study has two main purposes. Firstly, if two or more stock markets are cointegrated, they can be said to share a common stochastic trend in the long-run. Such a result would indicate that the stock markets have become or are becoming increasingly integrated and therefore would show a greater degree of financial integration. Otherwise, the stock markets tend to constantly move apart, which would suggest that the markets are independent and not influenced by, for example, the same macroeconomic trends. Secondly, an identified cointegration suggests that stock markets share a common long-run trend, but may in the short-run deviate from this trend. This implies that the benefits of portfolio diversification, based on a short-term correlation and geographic diversification strategy, may be lost for an investor.

Accordingly, the aim of a cointegration analysis is to determine if there are any common stochastic trends between the selected stock markets. Variables that follow a stochastic trend consist of $\sum_{t}^{i} \epsilon$, i.e. the variables are a sum of random shocks.\(^{47}\) If there is a common stochastic trend, the variables will also share a common long-run equilibrium.\(^{48}\) In the economic literature it is accepted that stock prices are driven by stochastic trends such as productivity or other innovation processes. Additionally, the cointegration analysis will also explain how short-term deviations from long-run equilibrium are corrected and how the causal relationships between the stock markets materialize.

3.1.1 Definition of cointegration

Alexander (2008) defines cointegration as:

"...a set of integrated series are cointegrated if there is a linear combination of these series that is stationary.\(^{49}\)"

Hence, in the case of only two integrated series $X$ and $Y$ are cointegrated if there is a $\beta$ so that:

$$Z = Y - \beta X$$  \hspace{1cm} (3.1)

is stationary. In (3.1) $Z$ is a temporary deviation from the long-run equilibrium. The expected value of $Z$ defines a long-run equilibrium relationship between $X$ and $Y$, where the observed value of $Z$ in periods of disequilibrium varies around its expected value.\(^{50}\)

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\(^{49}\) Ibid, p. 228.

\(^{50}\) Ibid, p. 228.
The cointegrating vector is the vector of constant coefficients in $Z$. In the case of two variables, the vector takes the form of $(1, -\beta)$. With only two integrated variables studied there can be no more than one cointegrating vector. If there were two vectors, the original processes would have to be stationary. More generally, cointegration exists between $n$ integrated variables if there is at least one cointegrating vector. Accordingly, there exists at least one linear combination of the integrated variables that is stationary. Each stationary linear combination acts like glue in the system and the more cointegrating vectors found the greater the long-run relationship between the variables. The maximum number of cointegrating vectors is $n - 1$.

3.1.2 Dickey-Fuller test

A prerequisite before implementing a cointegration analysis is that the non-stationary variables studied are integrated of the same order. If several variables integrated of order $I(d)$ are cointegrated, they show a common integration of order $I(d - 1)$. Variables integrated of order $I(0)$ are weakly stationary because they show constant mean and variance. This is essential in order to make any reliable statistical inference and thereby avoiding problems associated with spurious regression. Hence, in order to measure the degree of financial integration, applying a cointegration analysis, the order of integration of the selected stock markets must first be determined.

The most acknowledged test to measure the order of integration was published by Dickey & Fuller (1979). The test assumes a variable to be integrated of order $I(d)$ and therefore non-stationary. More specifically the null and alternative hypotheses are formulated as follows:

$$H_0: Y_t \sim I(1) \ vs \ H_a: Y_t \sim I(0). \quad (3.2)$$

If the calculated test values are above the critical range and thus rejecting the null hypothesis, the variable under investigation is considered stationary. If the null hypothesis cannot be rejected, the variable is assumed to be integrated of order $I(1)$. If a higher order of integration is suspected, one should proceed with the following hypothesis:

$$H_0: \Delta Y_t \sim I(1) \ vs \ H_a: \Delta Y_t \sim I(0) \quad (3.3)$$

where $\Delta$ is the expression of the first difference operator. If the null hypothesis in (3.3) is rejected, only then can one conclude that the variable is $I(1)$ and not integrated of a higher order. Thus, an important conclusion is that the first difference of an $I(1)$-variable renders it stationary and therefore enabling reliable statistical inference.

53 See Appendix E for a complete definition.
54 Engel & Newbold (1974) found that two independent $I(1)$ variables showed a statistically significant relationship, although being completely independent of each other. It was possible to find a relationship, but it was not because one variable caused the other or vice versa.
Theoretically, the least restrictive test of Dickey & Fuller emanates from the simple regression that contains a drift term and a time trend:\(^{55}\)

\[ \Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \epsilon_t. \] (3.4)

A major problem with this test is that the critical values used for hypothesis testing becomes distorted if autocorrelation is present in the residual. For this reason Dickey & Fuller’s (1981) augmented test (ADF) is applied in this thesis. The regression in (3.4) is augmented with previous values of the response variable in order for the residual to become a white noise process\(^{56}\). The test equation applied looks as follows:

\[ \Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} + \epsilon_t \] (3.5)

where \( Y_t \) represents the selected stock markets for time period \( t \), \( \Delta Y_t = Y_t - Y_{t-1} \), \( \alpha \) is a constant representing a possible drift term, \( \beta \) measures if any time trend is present, \( \sum_{i=1}^{k} \rho_i \Delta Y_{t-i} \) are lagged values of \( Y_t \) and \( \epsilon_t \) is a residual that should be a white noise process. The coefficient of particular interest is \( \gamma \) and the ADF test measures the \( t \)-value of \( \gamma \).\(^{57}\) The test is one-sided in which the hypotheses are shown by:

\[ H_0: \gamma = 0 \quad \text{vs} \quad H_a: \gamma < 0. \] (3.6)

If \( \gamma = 0 \), it is possible to conclude that a stock market is non-stationary. The critical values that are applicable are always negative and have been identified by Dickey & Fuller through a Monte Carlo simulation. The size of the critical values depends on the lag length and whether a constant or a trend component is included in the regression. In order for the test to not lose strength, it is important not to include too many lags in the final ADF equation.\(^{58}\) The number of lags is an empirical question and a common approach is to assume a large number of lags and then exclude the insignificant variables.\(^{59}\) Moreover, according to Pantula (1989), the test should be conducted using equation (3.5) and if the null hypothesis cannot be rejected, one should exclude the trend component. If the null hypothesis still cannot be rejected, the test is performed without both the trend component and the constant.\(^{60}\)

An additional test for stationarity has been presented by Phillips & Perron (1988) and is a generalization of the ADF test. This test has less strict requirements regarding the distribution of the residuals and can in conformity with the ADF test be performed including a constant or both a constant and a trend component. However, both tests have been criticized for demonstrating low

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\(^{56}\) See Appendix E for a complete definition.


\(^{58}\) Ibid, p. 219.

\(^{59}\) In this thesis the number of lags is decided using the Akaike information criteria.

\(^{60}\) Sjö (2011a), p. 8.
strength in the identification of variables that are nearly integrated and thus resulting in the null hypothesis of non-stationarity not being rejected, although the series is stationary. This problem is greater in small samples. Due to the fact that the tests share the same weaknesses and usually give similar results, the augmented test of Dickey & Fuller is used in this thesis.61

3.1.3 Johansen’s methodology

After the determination of the stock markets order of integration, Johansen’s methodology is applied to investigate the cointegration between the markets. Johansen (1988) identifies cointegration in a general multivariate system, where there are at least two integrated variables. The test is more powerful than other cointegration tests, for instance the Engel and Granger two-step procedure, which has difficulties in determining cointegration among several variables and therefore unsuitable in the study of several stock markets. Johansen’s test can be shown having $n$ variables ($Y_1 \ldots Y_n$) in a first-order vector autoregressive model, VAR(1), which in general can be written as:

$$Y_{t} = \alpha + \beta_1 Y_{t-1} + \ldots + \beta_n Y_{n,t-1} + \varepsilon_{t}$$

The VAR(1)-process can be written into the form of a matrix as:

$$Y_t = \alpha + BY_{t-1} + \varepsilon_t$$

where

$$Y_t = \begin{pmatrix} Y_{1t} \\ \vdots \\ Y_{nt} \end{pmatrix}, \quad \alpha = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_n \end{pmatrix}, \quad B = \begin{pmatrix} \beta_{11} & \ldots & \beta_{1n} \\ \vdots & \ddots & \vdots \\ \beta_{n1} & \ldots & \beta_{nn} \end{pmatrix}, \quad Y_{t-1} = \begin{pmatrix} Y_{1,t-1} \\ \vdots \\ Y_{n,t-1} \end{pmatrix}, \quad \varepsilon_t = \begin{pmatrix} \varepsilon_{1t} \\ \vdots \\ \varepsilon_{nt} \end{pmatrix}.$$ 

By subtracting with $Y_{t-1}$ on both sides, a vector error correction model (VECM) is obtained:

$$\Delta Y_t = \alpha + \Pi Y_{t-1} + \varepsilon_t$$

where $\Pi = B - I$ and $I$ is the $n \times n$ identity matrix. However, the selection of a VAR-model that best explains the underlying process is an empirical question. In line with the simple regression in (3.4), which was published by Dickey & Fuller, the critical values used for hypothesis testing becomes distorted if there is autocorrelation in the residual.62 For this reason, equation (3.9) is augmented with lagged values of the response variable:

$$\Delta Y_t = \alpha + \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t.$$  

62 The correct specification of the VAR-model is established before applying Johansen’s test and the lag length is determined using Schwarz (1978) information criteria. The criterion is not as sensitive to long lag lengths as the criteria identified by Alaike (1973). The intention is to achieve white noise residuals in order to avoid problems with an inconsistent model, which will be confirmed by the Lagrange Multiplier-test.
Since all variables \((Y_1 \ldots Y_n)\) are integrated of the same order \(I(1)\), all equations in (3.10) have a stationary response variable which means that the right hand side can be described as a stationary process. For this reason \(\Pi\mathbf{Y}_{t-1}\) must be stationary.\(^{63}\)

The condition that \(\Pi\mathbf{Y}_{t-1}\) is stationary implies nothing at all about the relationship between \((Y_1 \ldots Y_n)\) if the rank of the matrix appears to be 0. However, if the rank of the \(\Pi\) matrix is reduced, \(r\), where \(0 < r < n\), there will be \(r\) independent linear relations between \((Y_1 \ldots Y_n)\) that must be stationary. In other words, the variables will be cointegrated. Hence, the Johansen’s test for cointegration is a test that measures the rank of the matrix \(\Pi\) and the rank of the matrix is the number of cointegrating vectors. The relationship is shown by \(\Pi = \mathbf{a}\mathbf{\beta}'\) where \(\mathbf{a}\) and \(\mathbf{\beta}\) are \(n \times r\) matrices with the rank \(r\).\(^{64}\)

\[
\Pi = \begin{bmatrix}
\alpha_{11} & \cdots & \alpha_{1r} \\
\vdots & \ddots & \vdots \\
\alpha_{n1} & \cdots & \alpha_{nr}
\end{bmatrix}
\begin{bmatrix}
\beta_{11} & \cdots & \beta_{1n} \\
\vdots & \ddots & \vdots \\
\beta_{r1} & \cdots & \beta_{rn}
\end{bmatrix}
\]

where \(\mathbf{a}\) contains the speed-of-adjustment coefficients, i.e. the short-run adjustment to the long-run equilibrium between the stock markets and where the rows in \(\mathbf{\beta}'\) are the cointegrating vectors and implies the long-run relationships between the stock markets.

Johansen’s Trace test is used in order to determine the rank of the \(\Pi\)-matrix which is more appropriate than Johansen’s Max test since it is more robust against oversized skewness and kurtosis.\(^{65}\) The hypotheses are:

\[
H_0: r \leq R \quad \text{vs} \quad H_a: r > R. \tag{3.11}
\]

The test is performed step by step until the null hypothesis can no longer be discarded. Once the rank of the matrix \(\Pi\) is determined and inserted in the model it will consist of stationary variables, which enables statistical inference.\(^{66}\)

One weakness of Johansen’s test is that it is based on asymptotic theory and therefore sensitive to specification errors in limited samples.\(^{67}\) In addition, the test is based on the assumption of normally distributed residuals\(^{68}\) which is not always the case when financial time series are considered.

Despite its flaws, the test is the most employed in testing for cointegration and therefore applied in this thesis.

### 3.1.4 Granger test for non-causality

Engle and Granger (1987) show that if cointegration is identified a causal linkage between the variables in at least one direction must be present. However, the Johansen’s test is unable to discern

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\(^{64}\) Ibid, p. 235.

\(^{65}\) Sjö (2011a), s. 20.

\(^{66}\) Ibid, p. 19.

\(^{67}\) Ibid, p. 13.

\(^{68}\) The Jarque-Bera test is used in this thesis to confirm whether the residuals are normally distributed.
the direction of the linkage. Therefore, to further study the financial integration and how the stock markets affect each other, the test for Granger non-causality (GNC) is applied in this thesis.\(^6\) The test establishes whether past values of a variable should be included as explanatory variables in an equation of another variable.\(^7\) If this is the case, it is possible to say that one variable predicts the other variable. GNC is tested by estimating an equation with and without restrictions. Granger starts from a bivariate equation:

\[
Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i Y_{t-i} + \sum_{i=1}^{k} \beta_i X_{t-i} + \varepsilon_t
\]

where \(Y_t\), in this study, is a country's stock market and \(X_t\) represents another country's stock market, \(\alpha_0\) is a constant and \(\varepsilon_t\) is a residual that must exhibit white noise. Subsequently, a F-test is applied to determine whether \(\sum_{i=1}^{k} \beta_i\) is significantly different from zero. If this is the case, then \(X_t\) Granger-causes \(Y_t\). Then the same procedure is carried out with \(X_t\) as the dependent variable to determine if \(Y_t\) Granger-causes \(X_t\). In this thesis, the GNC is used in order to determine the short-term causal linkage between the stock markets in Europe.

Moreover, in order to determine the short-term GNC in a multivariate system, as the one in (3.8), different equations are used depending on whether the variables are cointegrated or not. When the stock markets in question are cointegrated, GNC is conducted through a VECM in order to avoid specification errors:

\[
\Delta Y_t = \delta_0 + \sum_{i=1}^{k} \omega_i \hat{e}_{i,t-1} + \sum_{i=1}^{k} \delta_i \Delta Y_{t-i} + \varepsilon_t
\]

where \(Y_t\) is a vector of the various stock markets, \(\delta_0\) is a vector of constants, \(Y_{t-i}\) is a vector with previous stock market returns, \(\omega_i\) is a coefficient and \(\delta_i\) is a matrix of estimated coefficients and \(\varepsilon_t\) is a vector containing the residuals. The long-run relationship, identified by Johansen's test, is shown by \(\hat{e}_{i,t-1}\), which is the lagged value of the residual from the equilibrium relationship. The equation in (3.13) can be augmented with additional explanatory variables to avoid specification errors.

However, if the short-term causal linkages are tested on variables that are not cointegrated, the following VAR-model is used to determine the GNC:

\[
\Delta Y_t = \delta_0 + \sum_{i=1}^{k} \delta_i \Delta Y_{t-i} + \varepsilon_t.
\]

The difference between (3.12) and (3.14) is that the latter comprises more than two variables expressed in first differences. When a variable is differentiated, the long-term component of the

\(^7\) Enders (2010), p. 318.
variables disappears and left is the short-term impact. Furthermore, the GNC test is sensitive to variables that are integrated or nearly integrated, which often requires differentiation. The variables are differentiated in this thesis in order to avoid problems with spurious regressions and to enable the estimation of the short-term causal relationships.
Chapter 4 - Data

The data set of this thesis consists of monthly closing prices of stock indices in seven European countries. Stock markets in Austria, Belgium, Finland, Norway, Sweden, Switzerland and the United Kingdom have been selected to represent the developments of financial integration in Europe during 1989 to 2011. The sample countries are strategically selected since the countries represent various institutional adjustments to the European cooperation. Belgium was one of the founding states and United Kingdom joined the European Community in 1973. Austria, Finland and Sweden joined the European Union in January 1995 and can consequently be considered to have similar institutional conditions in order to measure integration. Furthermore, Austria, Belgium and Finland introduced the euro as a circulating currency in January 2002, while Britain and Sweden have chosen to remain outside the monetary union. Hence, Sweden and the UK can be a good reference measure in order to capture the significance of the exchange risk to the financial integration process. Norway and Switzerland, who have chosen to remain outside the EU, can act as a measure of the aggregated integration process in Europe. Accordingly, these two countries will have a comparative perspective towards the other sample countries.

The time period is divided into two sub-periods where each period seeks to capture any deviations in the financial integration process in Europe. The division of the time period is justified by that the introduction of the euro can be seen as an institutional regime shift, which changed the conditions for market participants in Europe. The sub-periods are defined as:

- "The Euro Period" - January 2002 - December 2011

When testing for cointegration, it is important to study a period long enough to capture the long-run relationships. It is the length of the time period that is important and not the frequency of the observations. The time horizon of the sub-periods extends over a decade and is therefore anticipated to be long enough to implement a reliable cointegration analysis.

The stock market indices have been developed by Morgan Stanley Capital International (MSCI) and are downloaded from Datastream International. These indices are well accepted in the literature because of their comparability with each other. The data set consists of 275 monthly observations for each stock market where the use of monthly data is motivated on the grounds of that daily or weekly data tend to fluctuate and contain too much noise. All data has been converted into the Swedish currency to account for changes in the exchange rate and also to make the time series more comparable. Moreover, by converting the indices to the same currency the problems associated with different price movements due to changes in each country's inflation rate are accounted for. Additionally, in order to facilitate the graphical comparison the indices have been recalculated to the
same basis. This calculation does not affect the strength of the cointegration analysis because the relative values remain unchanged. In addition, logarithmic stock prices are used in order to reflect the theoretically more correct lognormal distribution for financial assets. Stock prices in logarithmic form are also used to avoid outliers and problems related to heteroscedasticity. Figure 1 shows an overview of the price movements of the seven countries’ stock markets.

Figure 1 - *Price movements of the countries’ stock markets, 1989-2011*

It is intuitive to see from Figure 1 that the stock markets have had relatively similar patterns of movement and that the comovement appears to have increased over time. To give an informative picture, correlations are presented between the logarithmic returns on the respective stock markets in Appendix A. During the two sub-periods, positive correlations between the returns were exhibited. The correlations throughout “The Comparison Period” are significantly lower than what is found during “The Euro Period”. This is consistent with previous research, including Becker (1999) and Baele *et al.* (2004), who find a general increase in correlations between European stock markets.

Descriptive data for the two sub-periods is shown in Appendix B where the first sub-period consists of 155 monthly observations, while the other includes 120 observations. The average return has been positive for all the selected countries throughout “The Comparison Period”, but has been negative for Austria, Belgium, Finland and the UK during “The Euro Period”. Moreover, the volatility has varied over the different sub-periods, where the largest negative monthly returns coincide with the three major recessions experienced by the countries during the time periods.
Chapter 5 - Results

5.1 Test for stationarity and order of integration

The first step of the cointegration analysis is to determine the order of integration of the seven stock markets. This is implemented via the augmented Dickey-Fuller test. The results of the initial testing of the two sub-periods in level can be seen in Table A, where the test values are shown for the cases including a drift and both a drift and a time trend.

Table A - Test for stationarity in levels

<table>
<thead>
<tr>
<th></th>
<th>&quot;The Comparison Period&quot;</th>
<th>&quot;The Euro Period&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α</td>
<td>α + βt</td>
</tr>
<tr>
<td>Austria</td>
<td>-4.32***</td>
<td>-4.26***</td>
</tr>
<tr>
<td>Belgium</td>
<td>-0.70</td>
<td>-2.16</td>
</tr>
<tr>
<td>Finland</td>
<td>-0.19</td>
<td>-2.36</td>
</tr>
<tr>
<td>Norway</td>
<td>-1.74</td>
<td>-2.56</td>
</tr>
<tr>
<td>Sweden</td>
<td>-0.65</td>
<td>-2.27</td>
</tr>
<tr>
<td>Switzerland</td>
<td>-0.96</td>
<td>-1.88</td>
</tr>
<tr>
<td>UK</td>
<td>-0.65</td>
<td>-2.76</td>
</tr>
</tbody>
</table>

Source: Own calculations.
Notes: Hypotheses $H_0: Y_t \sim I(1), H_a: Y_t \sim I(0)$; the lag length is determined using Akaike information criteria; $\alpha$ represents a constant and $\beta t$ a time trend; the asterisks shows the significance level at 1%***, 5%** and 10%*.

Table A indicates that it is possible to reject the null hypothesis of non-stationarity for Austria during "The Comparison Period" at the 1% level of significance. This is the case when both a drift and a time trend are incorporated in the ADF equation.\(^{71}\) Hence, Austria seems to be $I(0)$ and therefore stationary during the first sub-period which means that the country should be excluded from the cointegration analysis. By studying the graphs in Appendix D one can see that Austria has not had the same distinct growth in their stock prices as the other countries. This may be due to domestic factors affecting stock prices in Austria in a more cyclical way. However, it is not possible to reject the null hypothesis for the other six stock markets and they can therefore be said to be integrated of at least order one. The study of these time series graphically also indicates non-stationary processes (see Appendix D).

To be sure of the order of integration, the two sub-periods are again tested for stationarity, but now in first differences. The test results for the two cases are shown in Table B.

\(^{71}\) Only in a few cases were lagged values of the response variable included (maximum one lagged variable) in order to ensure that the residual will satisfy the white noise condition. Moreover, the result of the ADF test also turned out to be insensitive if additional lags were added to the test equation.
Table B - Test for stationarity in first differences

Augmented Dickey Fuller-test in first differences

<table>
<thead>
<tr>
<th></th>
<th>&quot;The Comparison Period&quot;</th>
<th>&quot;The Euro Period&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α</td>
<td>α + βt</td>
</tr>
<tr>
<td>Austria</td>
<td>-10.77***</td>
<td>-10.84***</td>
</tr>
<tr>
<td>Belgium</td>
<td>-11.51***</td>
<td>-11.47***</td>
</tr>
<tr>
<td>Norway</td>
<td>-12.04***</td>
<td>-12.00***</td>
</tr>
<tr>
<td>Sweden</td>
<td>-10.58***</td>
<td>-10.54***</td>
</tr>
<tr>
<td>Switzerland</td>
<td>-10.44***</td>
<td>-10.43***</td>
</tr>
<tr>
<td>UK</td>
<td>-8.61***</td>
<td>-8.58***</td>
</tr>
</tbody>
</table>

Source: Own calculations.

Notes: Hypotheses $H_0: \Delta Y_t \sim I(1), H_a: \Delta Y_t \sim I(0)$; the lag length is determined using Akaike information criteria; $\alpha$ represents a constant and $\beta t$ a time trend; the asterisks shows the significance level at 1%***, 5%** and 10%*.

From Table B it is possible to reject the null hypothesis of non-stationarity at the 5% significance level for all stock markets in the two sub-periods. Belgium and the UK are the only countries where it is not possible to reject the null hypothesis at the 1% level during "The Euro Period". In addition, a graphical interpretation of the stock markets in differences also implies a stationary process (see Appendix D). This result indicates that the remaining stock markets are integrated of order one, implying that the first difference of the series makes them stationary. These results correspond well with the theoretical notion that financial asset prices should be $I(1)$ and contain a stochastic trend. The result is further supported since previous research has identified similar orders of integration, when applying the ADF test on the selected countries examined in this thesis.72

5.2 Test for cointegration between the stock markets

Now that the order of integration is determined and only Austria is considered to be stationary, the second step in the cointegration analysis is to test the long-run relationships between the remaining six stock markets. This is tested using Johansen’s methodology in which initially an appropriate VAR-model is identified. The results of the identification process for the two sub-periods are presented in Appendix C including the choice of the lag length, the test for autocorrelation using Lagrange Multiplier and the Jarque-Bera test for normal distribution.

The overall result of "The Comparison Period" indicates the identification of a VAR(2)-model. It is worth noticing that the Schwartz information criterion suggests that a VAR(1) is the most appropriate model (see Table M), but since this model exhibit traces of autocorrelation (see Table N) a VAR(2) is selected instead. Unfortunately, the residuals are not normally distributed (see Table O), which may affect the strength of the cointegration analysis.

The identification process of the most appropriate VAR-model for "The Euro Period" identifies similar results as the previous sub-period and indicates that a VAR(2)-model is the most suitable. Yet again, the Schwartz information criterion prefers the most restrictive model (see Table P), i.e. a VAR-model with only one lag on the explanatory variables. However, the VAR(1)-model demonstrates autocorrelation which disappears when the model is extended with one additional lag (see Table Q). Finally, it is also possible to reject the null hypothesis regarding normal distribution for this sub-period (see Table R).

Johansen’s test for cointegration based on the identified VAR(2) during "The Comparison Period" is shown in Table C for the six stock markets. The test is performed in a multivariate system to capture all possible combinations between the markets, which is preferable to a bivariate system. This approach reflects the financial integration in Europe in a more explicit way than if pair wise combinations of stock markets are studied.

Table C - Test for cointegration, 1989-2001

<table>
<thead>
<tr>
<th>H0</th>
<th>H1</th>
<th>Trace value</th>
<th>Critical value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>r &gt; 0</td>
<td>75.72</td>
<td>95.75</td>
<td>0.520</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>r &gt; 1</td>
<td>48.50</td>
<td>69.82</td>
<td>0.700</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r &gt; 2</td>
<td>29.94</td>
<td>47.86</td>
<td>0.720</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>r &gt; 3</td>
<td>16.92</td>
<td>29.80</td>
<td>0.650</td>
</tr>
<tr>
<td>r ≤ 4</td>
<td>r &gt; 4</td>
<td>6.73</td>
<td>15.50</td>
<td>0.610</td>
</tr>
<tr>
<td>r ≤ 5</td>
<td>r = 6</td>
<td>2.46</td>
<td>3.84</td>
<td>0.120</td>
</tr>
</tbody>
</table>

Source: Own calculations.
Notes: The number of cointegrating vectors is shown by r, the critical values are obtained from Osterwald-Lenum (1992), the asterisks shows the significance level at 1%***, 5 %** and 10 %*.

Table C indicates that no cointegrating vector can be identified during "The Comparison Period" since the estimated values from the Trace test does not exceed the critical values for each hypothesis. This result implies that the six stock markets have not had a common long-run stochastic trend in the period up to the introduction of the euro as a circulating currency in January 2002.

The Johansen’s test for cointegration is subsequently applied on the identified VAR(2)-model for "The Euro-Period", which is shown in Table D.
Table D - Test for cointegration, 2002-2011

Johansen’s test for cointegration

<table>
<thead>
<tr>
<th>H₀</th>
<th>H₁</th>
<th>&quot;The Euro Period&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>r &gt; 0</td>
<td>Trace value</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>r &gt; 1</td>
<td>Critical value</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r &gt; 2</td>
<td>p-value</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>r &gt; 3</td>
<td></td>
</tr>
<tr>
<td>r ≤ 4</td>
<td>r &gt; 4</td>
<td></td>
</tr>
<tr>
<td>r ≤ 5</td>
<td>r = 6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₀</th>
<th>H₁</th>
<th>Trace value</th>
<th>Critical value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>r &gt; 0</td>
<td>117.13***</td>
<td>95.75</td>
<td>0.001</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>r &gt; 1</td>
<td>69.33*</td>
<td>69.82</td>
<td>0.055</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r &gt; 2</td>
<td>42.84</td>
<td>47.86</td>
<td>0.136</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>r &gt; 3</td>
<td>22.44</td>
<td>29.80</td>
<td>0.275</td>
</tr>
<tr>
<td>r ≤ 4</td>
<td>r &gt; 4</td>
<td>9.68</td>
<td>15.50</td>
<td>0.306</td>
</tr>
<tr>
<td>r ≤ 5</td>
<td>r = 6</td>
<td>2.01</td>
<td>3.84</td>
<td>0.157</td>
</tr>
</tbody>
</table>

Source: Own calculations.

Notes: The number of cointegrating vectors is shown by r, the critical values are obtained from Osterwald-Lenum (1992), the asterisks shows the significance level at 1%***, 5%** and 10%*.

In Table D, the estimated value of the Trace test is greater than the corresponding critical value when the null hypothesis $r = 0$ is tested. This result is significant at the 1 % level, suggesting that there is at least one cointegrating equation in the system. In order to pin down the exact rank of the matrix the null hypothesis that the rank of the matrix is lower than or equal to one is tested. In this case, the null hypothesis is rejected only at the 10 % level. Although the p-value is relatively low, this result does not demonstrate any statistically significant support for an additional cointegrating equation in the system.

In order to clarify the cointegrating relationship between the stock markets, an overview of the estimated parameter values of $\alpha$ and $\beta$ from the II-matrix is shown in Table E. Recall that $\alpha$ represents the short-term adjustment to the long-run equilibrium and that $\beta$ shows the long-run relationships between the stock markets. The estimated $\beta$-coefficients are normalized on the UK stock market due to its size and importance, in order to enable statistical inference.\(^{73}\)

Table E - Estimated $\alpha$- and $\beta$-coefficients of the cointegrating vector for "The Euro Period"

<table>
<thead>
<tr>
<th></th>
<th>$\alpha$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>-0.304</td>
<td>-0.434***</td>
</tr>
<tr>
<td>Finland</td>
<td>-0.560**</td>
<td>-0.025</td>
</tr>
<tr>
<td>Norway</td>
<td>-0.776***</td>
<td>0.220***</td>
</tr>
<tr>
<td>Sweden</td>
<td>-0.677***</td>
<td>-0.084</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.079</td>
<td>-0.502***</td>
</tr>
<tr>
<td>UK</td>
<td>-0.446***</td>
<td>1.000***</td>
</tr>
</tbody>
</table>

Source: Own calculations.

Notes: The $\beta$-coefficients are normalized on the British stock market, the asterisks shows the significance level at 1%***, 5%** and 10%*.

From Table E it is possible to deduce that the $\beta$-coefficients are significant at the 1 % level for the Belgian, Norwegian and the Swiss stock market. This result indicates that the countries, along with the UK, share a common stochastic trend and that they follow one another in the long-run. The

\(^{73}\) An example of normalization: \(\frac{\beta_{\text{UK}}}{\beta_{\text{UK}}} = \beta\), \(\frac{\beta_{\text{Sweden}}}{\beta_{\text{UK}}} = \beta\).
insignificant $\beta$-coefficients for Finland and Sweden suggests that it is possible to identify a long-run stationary equilibrium without these stock markets. This may be because these markets share similar trends with any of the other countries or simply not contributing to the stationary long-run equilibrium.

Moreover, Table E also displays the results from the estimation of the $\alpha$-coefficients for the six stock markets where a larger $\alpha$ indicates a stronger adjustment back to the long-run equilibrium. Judging from the result, the largest adjustment will take place in the Nordic countries while the British stock market has the smallest adjustment back to the equilibrium. The countries exhibiting an insignificant $\alpha$-coefficient can be considered as exogenous as they do not adjust to the equilibrium. The time frame of the adaptation is associated with the previously identified VAR-model, where a shorter lag length implies a quicker adjustment process. Additionally, the significant coefficients exhibit the economically and theoretically correct negative signs because they show how each stock market returns to the long-run trend.

5.2.1 Sensitivity testing of the cointegrating vector

A significant matrix rank of one and consequently a cointegrating vector indicates that there is a long-run stationary stochastic trend among the stock markets after the launch of the euro in January 2002. However, it is difficult to determine whether this result coincides with the introduction of the euro or whether it is the result of the increased cooperation between EU member states or even the globalization process. To test the sensitivity of the results identified by the cointegration analysis, restrictions are imposed on the cointegrating vector. Three tests are carried out to investigate the impact different countries have to the stationary relationship.

Initially, a test is carried out to identify whether countries that have adopted the euro should be included as explanatory factors in the cointegrating relationship. The countries using the euro are Finland and Belgium which means that restrictions are imposed on these countries to verify their importance to the equilibrium. Subsequently, a test is conducted to see if the exclusion of countries that are only within the EU entails a stationary vector. Finally, we test if Norway and Switzerland, who completely have opted out of the European cooperation, should be included in the cointegrating vector. The results of the stated restrictions are presented in Table F.

**Table F - Sensitivity testing of the cointegrating vector**

<table>
<thead>
<tr>
<th>Restrictions</th>
<th>Euro-countries</th>
<th>EU-countries</th>
<th>Non EU-countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi²-value</td>
<td>$\beta_{Belgium} = \beta_{Finland} = 0$</td>
<td>$\beta_{UK} = \beta_{Sweden} = 0$</td>
<td>$\beta_{Norway} = \beta_{Switzerland} = 0$</td>
</tr>
<tr>
<td>Chi²-value</td>
<td>25.540</td>
<td>22.770</td>
<td>16.200</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Source: Own calculations.
Notes: Hypotheses $H_0$: The vector is stationary, $H_a$: The vector is non-stationary.
Table F indicates that the null hypothesis of stationarity can be rejected for all three restrictions. This indicates that a long-run stationary relationship cannot be achieved if we exclude these pair wise countries from the vector. This result suggests that a combination of countries with different institutional adaptations generates the cointegrating vector.

### 5.3 Test for Granger non-causality

The final step in the cointegration analysis is to investigate the short-term relationships between the six stock markets in the two sub-periods, by applying Granger's test for non-causality. Since no cointegration was identified during "The Comparison Period", the relationship is estimated using the VAR-model in equation (3.14). In order to obtain the short-term effect, the variables are estimated in first differences which also represent the return of each stock market. The results are presented in Table G, in which the coefficients and the causality between the countries are reported.

#### Table G - Test for non-causality, 1989-2001

Granger's test for non-causality is conducted using Equation (3.14), the asterisks shows the significance level at 1%***, 5%** and 10%*.

<table>
<thead>
<tr>
<th>Belgium</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>UK</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>0.059</td>
<td>-0.166</td>
<td>-0.146</td>
<td>0.020</td>
<td>-0.099</td>
<td>0</td>
</tr>
<tr>
<td>-0.037</td>
<td>-</td>
<td>0.047</td>
<td>0.296***</td>
<td>0.058</td>
<td>0.029</td>
<td>1</td>
</tr>
<tr>
<td>-0.118</td>
<td>-0.155</td>
<td>-</td>
<td>-0.150</td>
<td>-0.117</td>
<td>-0.067</td>
<td>0</td>
</tr>
<tr>
<td>0.055</td>
<td>-0.409**</td>
<td>-0.014</td>
<td>-</td>
<td>0.067</td>
<td>0.010</td>
<td>1</td>
</tr>
<tr>
<td>0.316***</td>
<td>0.004</td>
<td>-0.090</td>
<td>0.142</td>
<td>-</td>
<td>0.222**</td>
<td>2</td>
</tr>
<tr>
<td>-0.135</td>
<td>0.503*</td>
<td>0.493**</td>
<td>0.262</td>
<td>-0.035</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Caused</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Own calculations.

Notes: Granger's test for non-causality is conducted using Equation (3.14), the asterisks shows the significance level at 1%***, 5%** and 10%*.

Table G establishes six causal relationships between the sample countries. Most noteworthy is that the major stock markets United Kingdom and Switzerland, are affecting most markets while the Belgian and Norwegian are not influencing the others in a significant way. The result also suggests that the Swiss market is not affected by any of the other countries and can thus be regarded as weakly exogenous. An overview of the causal relationships can be seen in Figure 2.

#### Figure 2 - Granger non-causality between countries during "The Comparison Period"

Switzerland

Source: Own figure.

Figure 2 shows the causal relationship identified from Table G. The mutual relationship can clearly be seen for Sweden and Finland, while the remaining causal relationships are unidirectional.
Moreover, the causal relationships between the selected countries during “The Euro Period” are established based on a VECM, as the one in equation (3.13), since cointegration was identified for this sub-period. The results of the GNC are presented in Table H, which shows the estimated coefficients of each stock market.

Table H - Test for non-causality, 2002-2011

<table>
<thead>
<tr>
<th>Grangers test for non-causality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“The Euro Period”</strong></td>
</tr>
<tr>
<td><strong>January 2002 - December 2011</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Belgium</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>0.041</td>
</tr>
<tr>
<td>0.122</td>
</tr>
<tr>
<td>0.123</td>
</tr>
<tr>
<td>-0.097</td>
</tr>
<tr>
<td>-0.151</td>
</tr>
<tr>
<td>Causes</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Source: Own calculations.
Notes: Grangers test for non-causality is conducted using equation (3.13), the asterisks shows the significance level at 1%***, 5 %** and 10 %*.

Table H establish three causal relationships during "The Euro period" which differs from the previously identified six causal directions for the "The Comparison Period". Switzerland is the market affected mostly by the other markets as both the British and the Norwegian market are significant. The causal relationship is illustrated in Figure 3.

Figure 3 - Granger non-causality between countries during "The Euro Period"
Chapter 6 - Discussion and conclusions

6.1 The implications of the result

The significant long-run relationship, identified by the cointegration analysis, shows that there is a stationary long-run equilibrium between the examined European stock markets after the introduction of euro as a circulating currency in January 2002. Hence, the most significant result found in this thesis is that the degree of financial integration in Europe has increased, since no cointegration was found prior to the introduction of the euro. This is due to the fact that cointegration, as a statistical measurement, captures the long-term trends that have influenced the countries throughout the two decades covered by this study. This result suggests that the short-term dynamics of the stock markets are affected by random shocks, but that the long-term deviations are restricted by a common equilibrium. Accordingly, an economic interpretation may be that mutual European macroeconomic trends will have far reaching effects on the cointegrated stock markets. However, the short-term country-specific shocks will affect each stock market to a lesser extent over a longer time frame. This implies that the cointegrated stock markets (Belgium, Norway, Switzerland and the UK) can be considered, in accordance with Akdogan (1995), as a regional financial market characterized by similar systematic risk factors. Consequently, the Belgian, Norwegian, Swiss and the British stock market show sign of a lesser degree of segmentation than both the Finnish and the Swedish stock market. This is due to the fact that financial assets in segmented markets are priced based on risk factors related to the domestic market. Conversely, financial assets of more integrated markets are priced based on more international risk factors.

There is no unequivocal answer whether the identification of an increased financial integration is the result of formal agreements in Europe, or a byproduct of a more general process of integration. The restrictions imposed on the cointegrating vector suggest that the importance of the euro for the integration process between stock markets is not as significant as for other financial markets. For example, Spiegel (2009) and Blanchard and Giavazzi (2002) identifies a strong connection between the euro and the money and bond markets. A reasonable explanation for this discrepancy may be that the money and bond markets are more affected by a common currency, due to the close link between interest rates and currencies. On the contrary, stock markets are driven by entirely different market forces, such as expectations of growth and future income flows. These factors do not have the same inherent relationship to the euro as bonds with both short and long maturities. The conducted sensitivity test indicates that it is rather a combination of institutional changes that stimulates the financial integration in Europe. In addition, this remark is emphasized by the necessity to include both Switzerland and Norway, who have chosen to remain outside the EU and EMU, in the cointegrating vector. However, it is not possible to entirely discard the importance of the euro since the long-run relationship is found to be non-stationary when restrictions are imposed on the euro
countries. This result is in accordance with the European Commission's (1997) expectation about the euro having a significant impact on the financial integration for countries outside, but with a close connection to the European Union.

Moreover, the results of the imposed restrictions are supporting Soares da Fonseca's (2008) findings that the enhanced integration in Europe mainly is due to factors other than the declared policy objectives. It is important to remember that financial integration may arise through positive spillover effects, where minor trade agreements between countries appear as a precursor to larger regional agreements. An explanation may be that it is not the European Union all by itself that contributes to the increased financial integration. Rather, it is the overall process of integration that develops the economic cooperation between states. However, the absence of cointegration prior to the introduction of the euro implies that it is more recent institutional factors like the euro, together with the overall integration process, that have contributed to the significant increase in integration. This reasoning is consistent with the conclusion by Worthington et al. (2003) that the euro has had an impact on the degree of financial integration in Europe.

Ever since the mid-20th century, which accelerated in 1992 when the Maastricht Treaty was signed, the political forces have been relentless in their work towards a greater harmonization and centralization of the European states. The Union has, among other things, set up common rules and has coordinated the national laws in order to prevent unfair competition in the European markets. Consequently, the identified cointegrating relationship between the six stock markets will place greater demands on the institutions in the European area in order to deal with more regional risk factors. In addition, an increase in the financial integration should also weaken the established national regulations, thereby reducing the impact of domestic policy decisions. The higher degree of integration is likely to require more effective central European stabilization and assessment mechanisms. Hence, it is important for policy-makers to consider the identified increase in financial integration. A first step has already been taken by the EU when the European Financial Stabilization Facility (EFSF) was created in 2010 to preserve financial stability in Europe. The result of this study indicates that this institutional adjustment at least should be upheld.

The significant cointegrating relationship also entails that it is possible to predict the long-term price movements of the other markets based on historical data. According to Granger (1986), such a result violates the definition of a weakly efficient market since they share the same stochastic trend and long-run equilibrium. The stock markets thus contain properties that force them to eventually return to their equilibrium. Consequently, there exist possible arbitrage opportunities for investors who can utilize the knowledge about the cointegrating relationship between the Belgian, Norwegian, Swiss and the British stock markets. However, no concrete conclusions can be drawn regarding whether this violates the formal definition of a weakly efficient market, since the results of this thesis are not
based on risk-adjusted returns. Richards (1995) claims that this is necessary in order to make a judgment concerning the degree of market efficiency of stock markets.

However, the efficiency of stock markets may be interpreted on the basis of the performed tests of Granger non-causality which identifies the short-term causal relationships between the stock returns. This test determines whether previous stock market returns can be used in order to predict returns of another market, thus providing a measure of the (in)effectiveness of these markets. The fact that the number of causal relationships have declined after the introduction of the euro, suggests that the selected stock markets have become more efficient. However, this should be interpreted with some caution due to the possible existence of a specific risk premium, which eliminates the predictability of the other markets, since risk-adjusted returns are not considered. For example, a stock market predicting lower returns in another market would imply that the lower yield is due to a decreased risk premium for the market participants.

Furthermore, the results of Granger's test for non-causality indicates that the Swiss stock market can be regarded as weakly exogenous in the first sub-period, since Switzerland is not affected by any of the other countries. An economic interpretation may be that information that arises outside the studied countries will affect the Swiss market first and then spread to other stock markets, preferentially the Belgian and British markets which Switzerland itself influences. This result may be due to the fact that the Swiss market is one of the world’s largest financial markets where new information constantly is scrutinized by investors. This reasoning is also made by Worthington et al. (2003) and is also emphasized by the fact that Switzerland and the UK is found to have the largest impact on the other stock markets. On the other hand, the GNC test for the second sub-period indicates that several smaller stock markets turn out to be exogenous. It is more difficult to provide a reasonable economic interpretation for this phenomenon.

The established increase in financial integration also implies obvious positive effects for actors on the financial markets. One example of this is that it has become easier to invest in foreign assets. For financial investors this may facilitate the short-run diversification opportunities and the spreading of risks. This is done by eliminating the idiosyncratic risk factors that characterize each market. However, an increase in financial integration also places higher demands on cross-border regulations, as the systematic risk tends to become greater in Europe. Nyberg (2011) argues that the 2007 financial crisis and its spillover effects were the result of the increased financial integration, where countries have become more interconnected. Consequently, macroeconomic trends will have a greater impact on regional areas and impede the economic recovery of these countries after a recession. A further example is the recent debt crisis that has been afflicting the European countries in the aftermath of the 2007 financial crisis. This reasoning is also supported by the increased correlations between the stock markets. This is important since correlation captures the
contemporary impact of macroeconomic shocks, i.e. identifies the short-run dependence structures between markets.

The identification of a common stochastic trend among the stock markets also has implications for portfolio diversification, since there are no long-term diversification opportunities. An investor holding a portfolio often strives to reduce the risk by considering the correlations between the constituent assets. If an investor chooses to invest in different stock indices in order to achieve a well-diversified portfolio, the risk reduction is lost if the stock indices are cointegrated. Consequently, an investor cannot spread risks geographically since the cointegrating markets will behave as a single market with similar risk factors. This result may have implications for a large proportion of investors on the European financial markets. This is because of many investors having a long investment horizon, where few changes are made regarding the composition of the portfolio. Thus, presence of cointegration places higher demands on both private and professional portfolio managers since an investor cannot solely rely on a geographical and a correlation-based risk-spreading strategy in order to create an efficient portfolio. These findings should in particular have consequences for investors in Europe, as Lane (2005) identifies that there is a clear euro-area bias in which disproportionately large amounts of financial assets are invested in other countries within the euro area.

However, long-term diversification opportunities still exist between combinations of countries that are not cointegrated. The result of the cointegration analysis thereby indicates that the Finnish and Swedish markets are more effective from a diversification perspective. On the other hand, an identified cointegration is not as important to investors with a shorter investment horizon. This is because of when cointegration exist there may still occur deviations in the short-run, which would enable an effective diversification. Nonetheless, the increased correlation identified after the millennium indicates that it also has become more difficult for an investor with a shorter investment horizon concerning portfolio diversification.

Finally, it is obvious that the increase in financial integration has implications for financial actors in Europe. Macroeconomic trends that previously only affected particular countries have now become more pervasive with lasting effects on larger regional areas. Hopefully, the results from the cointegration analysis can shed some light on the European dependence structures, at least in the countries studied in this thesis. The findings can thereby assist politicians and other policy-makers when implementing new policies in Europe. Furthermore, the results can also be interpreted from the perspective of an investor wanting to allocate a portfolio in an efficient manner. It is foremost the long-term diversification opportunities that are affected by the identified cointegrating relationship and thus placing greater demands on both private and professional investors assembling efficient portfolios.
6.2 The limitations of the study and suggestions for future research

The degree of integration between financial markets has for decades been a controversial topic in both the financial and macroeconomic literature. Despite extensive empirical research, there is yet no clear answer on how integrated the financial markets are. This thesis has sought to contribute to the research by applying the more dynamic cointegration approach in order to determine the degree of financial integration in Europe. However, the area is characterized by many complex relationships rendering it problematic to get an overall measure of how strong the integration process has been in Europe, even though strong support for an increase in financial integration has been found. Moreover, this thesis has been restricted to only consider stock markets, which only captures a part of the dynamics of the financial markets. The financial system consists of more capital markets and the validity of the study would increase if money and bond markets were also included. Consequently, it would be most welcomed if future research could regard these shortcomings and thereby extend the scope of the study.

Furthermore, the cointegration analysis comprises six stock markets with different institutional adaptations to the enhanced European cooperation. According to Hatemi et al. (2008), the degree of financial integration depends on the markets studied, the methodology applied and the time period used. If other sub-periods and more countries were analyzed, it may be possible to explicitly isolate the importance of the EU and the euro on the financial integration. In addition, an interesting aspect would be if future research could focus on why some countries’ stock markets exhibit cointegration, while others do not. Such a study would clarify the political and economic causal factors and thus facilitate a process of harmonization among the European states. Finally, it would also be interesting if future research took risk-adjusted returns into account by using time-varying Beta values in order to palpably determine the efficiency of stock markets.

6.3 Conclusions

This thesis has examined the short and long-term dependence structures between six European countries during the period 1989 to 2011. The main focus has been to measure the degree of financial integration in Europe through a cointegration analysis using Johansen's methodology and Granger's test for non-causality. This thesis finds statistical support for the existence of cointegration between the Belgian, Norwegian, Swiss and British stock market, indicating that the financial integration has increased between these countries.

It is more difficult to determine to what extent the increased European financial cooperation has affected the degree of integration between the cointegrated stock markets. This is because of the problems associated with isolating the importance of institutional agreements to the stationary long-run equilibrium. The sensitivity test on the cointegrating relationship indicates that a combination of institutional changes have contributed to the increased financial integration. Both the importance of
the EU and the euro may have affected the integration process, but this thesis finds that this is not the only explanation. It is more likely the liberalization of financial markets and the overall integration process that best explains the enhanced integration.

The cointegrating relationship has significant implications for actors on the financial markets in Europe. The most significant finding is that the cointegrated stock markets in the long-run can be regarded as a common regional market characterized by similar systematic risk factors. This has implications for both policy-makers about to adjust existing policies in Europe and investors looking to allocate portfolios in an efficient manner. Accordingly, this will especially require higher demand on risk management and the managing of macroeconomic events in order for these not to have far reaching effects on the domestic markets across the European states.
References


ECB, Financial integration in the Euro area,


SCB, *Aktieägarstatistik*,


SSB, *Aksjestatistik*,


- 36 -


### Appendix A - Correlation matrices

#### Table I - The correlation matrix of returns, 1989-2001

**"The Comparison Period"**

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Belgium</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>0.50</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>0.27</td>
<td>0.30</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
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<td>0.48</td>
<td>0.48</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>0.33</td>
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<td></td>
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</tr>
<tr>
<td>Switzerland</td>
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<td>0.38</td>
<td>0.49</td>
<td>0.51</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.47</td>
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<td>0.52</td>
<td>0.61</td>
<td>0.60</td>
<td>0.67</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Own calculations.

#### Table J - The correlation matrix of returns, 2002-2011

**"The Euro Period"**

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Belgium</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Finland</td>
<td>0.49</td>
<td>0.53</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>0.74</td>
<td>0.70</td>
<td>0.55</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sweden</td>
<td>0.63</td>
<td>0.72</td>
<td>0.70</td>
<td>0.73</td>
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</tr>
<tr>
<td>Switzerland</td>
<td>0.50</td>
<td>0.62</td>
<td>0.53</td>
<td>0.50</td>
<td>0.70</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>0.70</td>
<td>0.77</td>
<td>0.63</td>
<td>0.77</td>
<td>0.76</td>
<td>0.68</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Own calculations.
Appendix B - Descriptive statistics

Table K - Descriptive statistics of returns, 1989-2001

"The Comparison Period"

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Belgium</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average return</strong></td>
<td>0.005</td>
<td>0.007</td>
<td>0.013</td>
<td>0.006</td>
<td>0.011</td>
<td>0.013</td>
<td>0.009</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.004</td>
<td>0.005</td>
<td>0.009</td>
<td>0.01</td>
<td>0.013</td>
<td>0.014</td>
<td>0.011</td>
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<tr>
<td><strong>Standard deviation</strong></td>
<td>0.073</td>
<td>0.048</td>
<td>0.104</td>
<td>0.072</td>
<td>0.075</td>
<td>0.05</td>
<td>0.048</td>
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<tr>
<td><strong>Variance</strong></td>
<td>0.005</td>
<td>0.002</td>
<td>0.011</td>
<td>0.005</td>
<td>0.006</td>
<td>0.002</td>
<td>0.002</td>
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<tr>
<td><strong>Kurtosis</strong></td>
<td>1.445</td>
<td>1.512</td>
<td>1.048</td>
<td>3.657</td>
<td>0.932</td>
<td>1.645</td>
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<tr>
<td><strong>Skewness</strong></td>
<td>-0.359</td>
<td>-0.275</td>
<td>-0.083</td>
<td>-0.96</td>
<td>-0.074</td>
<td>-0.153</td>
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<tr>
<td><strong>Min return</strong></td>
<td>-0.256</td>
<td>-0.182</td>
<td>-0.328</td>
<td>-0.337</td>
<td>-0.186</td>
<td>-0.163</td>
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<td><strong>Max return</strong></td>
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<td>0.314</td>
<td>0.193</td>
<td>0.282</td>
<td>0.175</td>
<td>0.185</td>
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</table>

Source: Own calculations.

Table L - Descriptive statistics of returns, 2002-2011

"The Euro Period"

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<th>Belgium</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average return</strong></td>
<td>-0.001</td>
<td>-0.004</td>
<td>-0.007</td>
<td>0.005</td>
<td>0.002</td>
<td>0.001</td>
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<tr>
<td><strong>Median</strong></td>
<td>0.011</td>
<td>0.005</td>
<td>-0.004</td>
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<td>0.006</td>
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<td><strong>Standard deviation</strong></td>
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<td><strong>Variance</strong></td>
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<td>0.006</td>
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<td>0.004</td>
<td>0.002</td>
<td>0.002</td>
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<td><strong>Kurtosis</strong></td>
<td>3.772</td>
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<td>2.5</td>
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<td><strong>Skewness</strong></td>
<td>-1.395</td>
<td>-2.004</td>
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<td>-0.644</td>
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<td><strong>Min return</strong></td>
<td>-0.318</td>
<td>-0.333</td>
<td>-0.235</td>
<td>-0.301</td>
<td>-0.182</td>
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<td>-0.115</td>
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<tr>
<td><strong>Max return</strong></td>
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<td>0.133</td>
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Source: Own calculations.
Appendix C - Identification of VAR

"The Comparison Period"

Table M - Lag length criteria, 1989-2001

<table>
<thead>
<tr>
<th>Lags</th>
<th>Log L</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>313.0347</td>
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<td>-4.15613</td>
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<td>2127.130</td>
<td>2.22e-16*</td>
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<td>-18.15760*</td>
<td>-18.66715*</td>
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<tr>
<td>2</td>
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<td>61.24340*</td>
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</table>

Source: Own calculations.
Notes: * Indicates the chosen lag length.

Table N - Lagrange Multiplier test, 1989-2001

<table>
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<th>Lags</th>
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<th>VAR (2)</th>
</tr>
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<tbody>
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<td>p-value</td>
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<tr>
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<td>7</td>
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<td>9</td>
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</table>

Source: Own calculations.
Notes: $H_0$: No autocorrelation.

Table O - Jarque-Bera test, 1989-2001

<table>
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<th>Jarque-Bera</th>
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<th>p-value</th>
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<tbody>
<tr>
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<td>Finland</td>
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<td>Norway</td>
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<tr>
<td>Switzerland</td>
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<td>Sweden</td>
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Source: Own calculations.
Notes: $H_0$: The variable is normally distributed.
"The Euro Period"

Table P - Lag length criteria, 2002-2011

<table>
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<tr>
<th>Lags</th>
<th>Log L</th>
<th>LR</th>
<th>FPE</th>
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<th>SC</th>
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<td>4</td>
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</table>

Source: Own calculations.
Notes: * Indicates the chosen lag length.

Table Q - Lagrange Multiplier test, 2002-2011

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<th>VAR (1)</th>
<th>VAR (2)</th>
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</thead>
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<td>p-value</td>
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Source: Own calculations.
Notes: H0: No autocorrelation.

Table R - Jarque-Bera test, 2002-2011

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<th>p-value</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>0.0314</td>
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<tr>
<td>Norway</td>
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<td>0.6920</td>
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<tr>
<td>Switzerland</td>
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<td>Sweden</td>
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Source: Own calculations.
Notes: H0: The variable is normally distributed.
"The Comparison Period"

Figure 4 - Stock markets in level and first differences, 1989-2001

**Level**

<table>
<thead>
<tr>
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<th>Level 1989-01</th>
<th>First differences 1989-01</th>
</tr>
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<tbody>
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<td>Finland</td>
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<td>Norway</td>
<td>6.0</td>
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</table>

**Graphs**

- **Austria**: Level 1989-01 and first differences 1989-01
- **Belgium**: Level 1989-01 and first differences 1989-01
- **Finland**: Level 1989-01 and first differences 1989-01
- **Norway**: Level 1989-01 and first differences 1989-01
Figure 5 - Stock markets in level and first differences, 2002-2011

"The Euro Period"

<table>
<thead>
<tr>
<th>Level</th>
<th>Austria</th>
<th>First differences</th>
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<tbody>
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<td>Bel 02-11</td>
<td>Differenced Bel 02-11</td>
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<tr>
<td>Fin 02-11</td>
<td>Differenced Fin 02-11</td>
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</tr>
<tr>
<td>Nor 02-11</td>
<td>Differenced Nor 02-11</td>
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</table>
Appendix E - Definitions

White noise-process

A residual is a white noise-process if its mean is equal to zero, it has a constant variance and it doesn’t show any signs of autocorrelation.

\[ E[\varepsilon_t] = \mu = 0 \]  \hspace{1cm} (E.1)

\[ E[\varepsilon_t \varepsilon_s] = \sigma^2 \]  \hspace{1cm} (E.2)

\[ E[\varepsilon_t \varepsilon_s] = 0 \text{ given } t \neq s. \]  \hspace{1cm} (E.3)

This process does not have a memory implying that previous shocks have no impact on future values. An additional requirement is that, \( \varepsilon_t \sim \text{NID} (0, \sigma^2) \) which means that the residual follows a normal independence distribution. Random variables following this distribution are not possible to predict using historical values. 74

Stationarity

It is necessary for a time series to exhibit stationarity in order to perform reliable statistical inference. The conditions required for a time series to display weak stationarity are: 75

\[ E[Y] = Y_{t-s} = \mu \]  \hspace{1cm} (E.4)

\[ \text{Var}[Y] = \text{Var}[Y_{t-s}] = \sigma^2 \]  \hspace{1cm} (E.5)

\[ \text{Cov}[Y_t, Y_{t-s}] = \text{Cov}[Y_{t-j}, Y_{t-j-s}] = \gamma_s \]  \hspace{1cm} (E.6)

74 Sjö (2011b), p. 46.
75 Enders (2010), p. 54.