JYVÄSKYLÄ STUDIES IN BUSINESS AND ECONOMICS 17

Esa Mangeloja

Nordic Stock Market Integration

Esitetään Jyväskylän yliopiston taloustieteiden tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Agora-salissa (Ag. Alfa)
syyskuun 8. päivänä 2001 kello 12.

Academic dissertation to be publicly discussed, by permission of
the School of Business and Economics of the University of Jyväskylä,
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UNIVERSITY OF JYVÄSKYLÄ

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Publishing Unit, University Library of Jyväskylä

ISBN 951-39-1016-4 (nid.), 978-951-39-5120-7 (PDF)
ISSN 1457-1986

Jyväskylä University Printing House, Jyväskylä
and ER-Paino Ky, Lievestuore 2001

ABSTRACT

Mangeloja, Esa
Nordic Stock Market Integration
Jyväskylä: University of Jyväskylä, 2001. 164 p.
(Jyväskylä Studies in Business and Economics
ISSN 1457-1986; 17
ISBN 951-39-1016-4 (nid.), 978-951-39-5120-7 (PDF)
Finnish summary
Diss.

During the past ten years integration of the international financial market has been under intense scrutiny. Several empirical analyses on the interrelationships in the Scandinavian stock market and on the econometric vector autoregressive (VAR) system and cointegration modeling exist. The absence of debate on the structure and the validity of the process of aggregation of the national stock market indexes is seen as a clear problem in previous studies. In this study, Scandinavian stock market interdependencies are analysed by applying certain cointegration methods. Investigation is first conducted using monthly and daily Scandinavian aggregate stock price indexes over the period January 1990 - February 1998. Contrary to the previous analyses in the Nordic stock markets, the markets under investigation were found to be cointegrated, therefore sharing one cointegration vector, and thus having a long-run equilibrium attractor. The innovation accounting technique is applied, to derive the impulse response functions and perform the variance decomposition analysis. For the purposes of efficient analysis, the maximum impulse response index is presented to better compare the alternative decomposition orderings and to gain an economic interpretation of the impulse response function results. But, contrary to preceding studies, instead of using only aggregate national stock market indexes as proxies on the development of particular national stock market behaviour, also the industry-specific indexes are applied. This procedure is considered as a better way of capturing the national characteristics of the financial market behaviour, as the large structural differences in the national stock exchanges are eliminated and therefore do not cause biased results. Also the differences in the aggregation procedures of the stock indexes are avoided. The results from these estimations are clearly different compared to those previous results, which were obtained when aggregate stock market indexes were used. Finally industry-specific stock market indexes (bank and telecom industry) from the 1990s were applied and no significant cointegration was found. Estimations were repeated using both daily and monthly data (also using data series in common and local currencies) but no differences emerged in respect of the non-cointegration property found.

Keywords: VAR, Cointegration, Stock Markets, Telecommunications, Banks, Financial Integration, Scandinavia.

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ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Professor Jaakko Pehkonen for his valuable advice and support during my long years of study in University of Jyväskylä. I am very grateful to my reviewer Professor Matti Viren, who gave me very useful assistance and comments during the process of final revision of the manuscript. I am also grateful to my other reviewer, Doctor Kari Heimonen, for his suggestions and guidance during the past years. During my finance and economic studies in University of Alberta, Canada, I was fortunate to meet several enthusiastic professors, teachers and students who gave me ideas for my dissertation. I like to thank my current colleagues in Conventum Securities Ltd, especially PhD Aarni Pursiainen, Peter Grönlund and Hannu Nyman, who have also helped me in several ways. I also thank all my previous colleagues and fellow students in University of Jyväskylä for their companionship.

I gratefully acknowledge funding from the Yrjö Jahnsson Foundation and Helsingin Sanomat 100-vuotisjuhlarahasto. During my years as a PhD student, I have benefited from positions as a lecturer, assistant and researcher in the University of Jyväskylä.

Finally, I would like to express my thanks to all those who have supported me during this study. My foremost debt of gratitude goes to my wife Maria and to my parents, who have all supported me throughout the past years. With their patience, support and love, I was able to continue working on and complete my PhD.

S.D.G.

Helsinki, August 2001

Esa Mangeloja

1 INTRODUCTION

1.1 Purpose of this study

The integration of international financial markets has been a topic of increasing research interest in recent years. Integration has been also widely analysed in the context of the Scandinavian stock markets. The growing interest in international integration of capital markets is due to the changes in international market environments. Besides the advanced technology for worldwide information transmission and processing, the liberalization of capital movements and the securitisation of capital movements result in national market, that more rapidly adjust to new information from international sources. In particular, strong interrelationships have been reported since the October 1987 crash, and it appears that the co-movements have significantly changed since. The general trend seems to be that stock prices in different countries have been tending to move in the same way in the 1990s compared to previous decades.

Financial integration has been defined as a statistical relationship between the aggregate national equity market indexes. Nevertheless, no attention has been paid to the relevance of using economy-wide aggregate equity indexes as a proxy for national stock market development. National stock indexes have been taken as *de facto* representative of the whole equity market. In this study, that approach is considered questionable. Alternative aggregate stock indexes contain very different mixes of industries, which means, that the indexes will represent the financial market development of various industries rather than national equity markets. This problem is apparent in Scandinavia, where Finland and Sweden have strong high-technology companies, while Norway and Denmark rely more on traditional industries. Nevertheless, numerous previous studies, which analyse the interrelationship and cointegration properties between these four Scandinavian stock exchanges, do not take this disparity into account. Therefore, the results obtained previously, say more about the relationships between industries (such as telecommunications versus traditional industries in Scandinavia), rather than countries. Technical procedures of index construction generate some country indexes that are large and well diversified, while others are not. Broad differences in the industrial composition of the aggregate indexes make them poor tools for international financial integration analysis.

In this study, cointegration of the Scandinavian stock markets is analysed, firstly, by using the aggregate stock market indexes (following the previous studies, but using a different time period). Cointegration has been found during the period of 1990-1998 (existing studies have not found cointegration during earlier periods), but the parameters obtained are pretty inaccurate. Rather few significant coefficients have been found in VAR model estimations and some signs are dubious. When estimations were repeated for two industry-specific equity index data series (telecom and banking industries are used), no cointegration is found. This means, that the Scandinavian equity markets respond differently to shocks and do not share significant common trends. Results obtained using aggregate stock indexes are biased because of different industry structures. Aggregate indexes do also respond more easily to macroeconomic shocks.

1.2 Theoretical background

Several attempts have been made to explain the traditional empirical perception that the national stock market indexes have low correlations. *Brooks and Catao (2000)* note the following main explanations:

- Home bias. Investors have historically strongly over-weighted domestic equities in their portfolios.
- Economic shocks may affect companies differently across countries. This may be because shocks are regional in nature, such as a policy change that is specific to one country, or it may be that national markets respond differently to global shocks because of differences in the institutions that influence the transmission of global shocks to equity markets. This leads to country-specific variations in stock returns.
- National indexes differ in terms of sector composition.

Earlier studies note that the historically low correlations between national equity indexes are primarily a result of large differences in country-specific sources of return variation. *Heston and Rouwenhorst (1994)* and *Rouwenhorst (1999)* note that these differences in country-specific sources of return variation are dominant even in geographically concentrated and economically integrated regions. Nevertheless, globalization and the new economy are raising the importance of global industry effects in explaining return variation, at the expense of country-specific factors. Several studies find that during the late 1990s the industry factors outweigh the country-specific sources of return variation. This has been due to the growing importance of high-tech companies, cross-border mergers and acquisitions and more efficient information gathering techniques (Internet).

In this study, the stock market returns are assumed to depend on four components (following Heston and Rouwenhorst (1994) and Brooks and Catao (2000)): a global market factor (α) which is shared among all securities, global industry factors (β), a country factor (γ) and a firm-specific disturbance (e). Therefore, the return on a stock, i, that belongs to industry j and country k in period of time t is given by:

$$r_{it} = \alpha + \beta_{jt} + \gamma_{kt} + e_{it}$$

As the stock market indexes are capitalization-weighted sums of individual equities, stock market index returns (R) have three components: the global factor, the weighted sum of industry effects and a country effect.

$$R_k = \alpha + \sum \beta_j w_{jk} + \gamma_k$$

This equation implies, that there exist two reasons for variation in country indexes. The first is the different industrial composition across countries, which means that weights w_{jk} differ across countries with the effect depending on these industrial compositions, countries are subject to different industry effects. w_{jk} is the share of industry j in the total market capitalization of country k. The second is the country effect, which accounts for differences in the return on stocks in country k relative to stocks in the same industry but located in another country.

Co-integration testing searches for common trends in index series, deriving them from either of these variation factors. Preceding studies on Scandinavian stock market integration have assumed that differences in industry weights (w) require no additional consideration. This has been somewhat understandable, as industry effects (β) have historically been minor. Cointegration testing in that setting can been seen as analysing whether common global economic factors (α) or country-specific characteristics dominate the national stock markets. Previous studies on the 1980s have found (several studies are reviewed in detail in chapter two), that the country factors, (γ), are the most important components in Scandinavian equity indexes, an observation which is supported by the non-existence of cointegration.

In this study, cointegration is found to be present between the Scandinavian stock markets during the 1990s. Two interpretations are possible for this finding:

- The period 1990-1998 has been different from that of the 1980s in several ways. Emerging high-technology investing, globalisation, liberalization of capital transactions and contagion effects during the crisis period (beginning of 1990s) have increased the amount of integration between the Scandinavian stock markets and they have shown similar reactions to economic shocks. To put it in another way, α has been the dominant factor in Scandinavia with macroeconomic factors (such as monetary and fiscal policies, movements in interest rates, budget deficits, national growth rates) providing similar shocks to the Scandinavian economies and eliciting a uniform reaction. Therefore, the common economic factors, (α), have been a source of common trends in Scandinavia.
- Results obtained using aggregate Scandinavian stock market indexes (in

earlier, and as well in this study) are biased and disturbed, due to index construction problems. Scandinavian aggregate indexes have very different industry weights, (w), and this leads to result, which reflect the relations between the development of industries, rather than countries. Another critical argument against aggregate indexes is the fact that industry weights are not stable in time, but change when the market capitalization of industries change. For example, Nokia's weight in the Finnish stock index (HEX) was close to 70% in the end of our period of analysis, but well below 10% at the beginning of the 1990s. This variance may have disturbed the estimations significantly.

When the cointegration testing is repeated for the industry-specific data at the end of this study, no common trends are found. This can be interpreted as the dominance of company (e) or industry-specific factors (β) in Nordic equity market movements. Even during the period of increasing globalisation and booming high-tech investment, very different industry structures in the Scandinavian countries have led national exchanges to adjust differently to economic shocks.

1.3 Motivation

The global financial markets have become more closely related in recent years because controls on capital have been removed. The resulting integration may have improved efficiency in the international allocation of capital and in the worldwide processing of news. On the other hand, national stock markets may simply be reacting increasingly to each other. In that event changes first reflected in any of the major national stock price indexes may immediately be passed on to other major stock markets around the world, even if there are no important news developments of global economic significance that could account for such comovement. Often substantial co-movements in national stock prices are related to geographical proximity, institutional currency relationships, partnership in trade, cultural similarity, or similarity of the economic bases of the countries combined. Interpretations of the strong positive correlations and relationships are in any case quite difficult, because it is difficult to analyze whether these strong relationships between stock market series imply that markets are integrated across countries or rather that markets are segmented and responding to common international shocks.

The Scandinavian, as well as global, financial environment has gone through several revolutionary changes since the late 1980s and especially during the 1990s. First, market information flows more rapidly, efficiently and freely across the national borders than ever before. The development in computer and network technology and improvements in the international processing of news and financial data have made global financial transactions easier and less expensive. There has been a huge boom in the quantity of international capital transactions.

Second, since 1970s the liberalization of capital movements has been taking place in all the most important markets with greatest emphasis at the beginning of the 1990s. For example in Finland, from the beginning of 1993, there no longer exists any regulation on foreign ownership of Finnish stocks. Finally, the securitization of national stock markets has changed the capital market environment. New financial innovations have improved the possibilities of national stock markets to react rapidly to new information from global markets.

During the 1990s, the emergence of European monetary integration has brought with it increased attention to the international stock markets. Both investors and academic scholars have examined the implications of these profound changes to the international equity markets. The recent studies on international stock markets have found that the main international stock markets really seem to be cointegrated and sharing common trends. Several studies have been conducted on the degree of stock market integration, for example *Ammer and Mei (1992)* have used variance decomposition methods to analyse international stock market linkages, while *Malkamäki (1993)* and *Kasa (1992)* have applied VAR-system estimation and Johansen's cointegration techniques to test for the number of common stochastic trends. The results obtained by Malkamäki suggest that the Scandinavian stock markets too are integrated. European financial market convergence is examined by e.g. *Serletis and King (1997)* and *Hall, Robertson and Wickens (1992)*.

Stock price movements derive their motivation either from changes in expected cash flows or from changes in discount rates. The discount rate used in stock valuations can change because of interest rates or the risk premium. The risk premium is determined globally, which builds a particular link which connects open international stock markets together. This study tests the common links between the Scandinavian stock markets, whether these markets are so connected that international investment diversification is no longer justified. The existence of a common feature among those particular markets would lead them to be cointegrated. Cointegration testing will be used to analyse the common ties between these markets, which most importantly has implication for the efficiency of the Scandinavian markets. Several respectable studies have demonstrated that stock market cointegration implies collective inefficiency (e.g. Chan, Gup, Pan, p. 804). If Scandinavian stock markets are collectively efficient in the long run, then their stock prices cannot be cointegrated.

According to the capital asset pricing model (CAPM) of Sharpe (1964), Lintner (1965) and Mossin (1966), the rational Scandinavian investor would hold a well-diversified portfolio. In CAPM, the quantity of risk is measured with β^d (domestic beta), which is defined as the covariance between the return on a market portfolio in one country and the individual asset, i, divided by the variance of the market portfolio, m, which consists of all assets weighted according to their market values:

$$\beta^d = \frac{COV(R_i, R_m)}{VAR(R_m)} = \frac{\sigma_{im}}{\sigma_m^2}$$

In CAPM, investors can always diversify away all risk except that brought by the covariance of an asset with the market portfolio. The maximum diversification benefits would be attained through investing in all assets in the world portfolio (or Scandinavian portfolio, in this study with restricted geographic reach). In cases where assets are priced in internationally integrated capital markets, the expected returns compensate for the systematic risk of those assets. If an investor does not diversify internationally, he will bear unsystematic risk without being compensated for this higher risk. If a domestic investor can circumvent the barriers to diversify internationally, additional benefits from international diversification can be found because an investor can then combine assets in a way which exceeds the expected return and risk level on the domestic market. The results of cointegration would imply that the CAPM assumptions of market efficiency in Scandinavia are not valid and that the benefits of diversification would be smaller.

In contrast to the previous studies I investigate the time period January 1990 - February 1998 using monthly aggregate Scandinavian stock price indexes. This reveals the interesting tendency towards stronger interrelationships between the markets, compared to previous studies which have mainly concentrated on the data of the 1980s. The causal relations revealed in this paper also vary from those of previous analyses, giving less strong proof of Sweden as a leading market with the strongest effects on the other Nordic markets. I am suspicious of the justification of using aggregate national stock indexes in studies concerning international financial linkages, as different stock indexes contain very different mixtures of industries.

This paper extends previous research on Scandinavian stock market integration during the 1990s. A four-variable vector autoregressive (VAR) system is estimated to analyse the dynamics of the Nordic stock market interrelationships. This study contributes to the growing body of studies about convergence in Europe during the 1990s. The stock market behaviour of four Scandinavian stock markets is examined by applying Johansen's (1988) maximum likelihood technique to test for the number of cointegrating vectors (i.e. the number of common trends) and to estimate both short- and long-term stock behaviour simultaneously. It should also be noted that the ARCH or GARCH types of heteroschedastic volatility modeling is not applied in this study, as the focus of this analysis concentrates strictly on market integration, not on market return modeling. While the ARCH and GARCH models have enjoyed considerable success in practical applications, a limitation of these models is that they are simply extrapolation techniques, which can not anticipate the real-world events that cause markets to be efficient or not.

In contrast to the previous analyses in the Nordic stock markets, I found the markets under investigation to be cointegrated and sharing one cointegration vector, and thus to have a long-run equilibrium attractor. The long-term equilibrium relation concerns only Sweden, Norway and Denmark, while Finland does not seem to be integrated with the other Scandinavian stock markets. Sweden seems to be the main market in the cointegration vector.

The convergence within the Scandinavian stock markets is considered by analysing the recursive cointegrating eigenvectors. If the eigenvectors present no apparent change (increase for convergence) during the estimation period, we are able to conclude that the Scandinavian stock markets have not been converged during the 1990s.

Innovation accounting techniques allow one to examine of the dynamic relationships between the variables of the econometric system and to trace the time paths of the unexpected impulses and their effects in the other variables of the system. Innovation accounting is applied to examine the effects and the lag structure of the impulses occurring in one Nordic market and how those effects change the time paths of the other Scandinavian stock markets. No other study has yet analyzed the Nordic stock market relationships using the innovation accounting technique over the time period January 1990 - February 1998, as done here.

This study examines next the international linkages of the Nordic stock markets by considering the effects of the stock markets of the United States, the United Kingdom and Germany. Respectively, these linkages can be interpreted, at least to some degree, to represent the global, European and European Monetary Union (EMU) linkages of the Scandinavian stock markets. The US is the largest and the most influential financial market in the world, the UK is the largest European financial market and Germany, while the second largest European market, is also the main economic and political factor in the European Union and in the European Monetary Union.

No similar study has previously been done, which includes all four Nordic stock exchanges in the same comprehensive VAR model and examines the model responses of the outward impulses to the model. *Malkamäki M.J.(1993)* has examined the stock market linkages of Finland, Sweden, Germany, the UK and the US in a single VAR system using the Johansen cointegration methodology. He found the markets to be cointegrated (it should be noted that if stock markets are found to be cointegrated, it does not necessarily indicate that those markets are inefficient, as some have interpreted this in the past). Malkamäki also found significant linkages from Germany and the UK to Finland and from the UK to Sweden, using the monthly stock market data (valued both in local and in US currency) during the period 1974-1989. My study also includes Denmark and Norway in the VAR system, while the non-Scandinavian markets are treated as exogenous. The estimation period under consideration here is also different, while similar methods are applied.

Several papers have analysed previously US stock market linkages to the Nordic markets, for example *Malkamäki, Martikainen, Perttunen, Puttonen (1993), Mathur and Subrahmanyam (1990)* and *Bos et al.(1995)*, but these studies do not include any European stock market variables, as done in this paper. Contrariwise to the findings of Malkamäki M.J.(1993), the paper by Malkamäki, Martikainen, Perttunen, Puttonen (1993) suggests that the Swedish stock market is Granger-caused by the US market instead of the UK market. In all those papers the estimation period is the 1980s, while this paper concentrates on the stock market behaviour during the 1990s, which has seen tremendous changes in the financial markets unknown during the previous decade.

I also consider the effects of using both monthly and daily market data. International linkages are assumed to remain quite stable despite the different frequencies used. Monthly data reveal more easily the long-term integration between the various stock exchanges, while these linkages may remain unnoticed in daily stock price variation. No previous studies exist on the Scandinavian stock market linkages using different data frequencies, but the estimated model coefficients for international linkages to Scandinavian markets are assumed to be larger in quantity when monthly data is applied.

The problem of using aggregate national stock indexes as the proxies on the development of national stock markets was already mentioned above. The main problem with that practice (which is *de facto* standard in most studies on international financial integration) is that the industry structures vary significantly between the different national economies and therefore also between the national stock exchanges. This leads to biased results, as analysis on international linkages actually end up analysing the interrelationships between the different industries rather than between the particular stock markets.

All the earlier studies on the Scandinavian stock market interdependencies apply aggregate national stock market indexes as a representative of the development on the particular national stock exchange, without any discussion on the differences in the weightings of the various industries listed in the financial market. There exists a controversy on whether indexes should be denoted in local or in common currency (usually USD). Studies also vary in respect to the data frequencies applied, as some use daily market index data, while most prefer monthly values, which better gather the long-term movements in VAR modeling. Nevertheless, no space is devoted to consideration of the validity of using economy-wide aggregate stock market indexes, while all stock exchanges have very different kinds of industry structures implied in their aggregate indexes. No discussion is found on handling the problem of different industry structures between the international stock exchanges.

Therefore, in this study industry-specific stock market indexes are applied in the analysis of the interrelationships between the Nordic stock markets. I shall examine the cointegration properties of the four (Finland, Sweden, Norway, Denmark) national stock markets by using the indexes on the banking and telecommunications industries as proxies for the characteristic behaviour of the national stock markets. I continue to use *S. Johansen's (1988, 1992)* cointegration testing method for analysing the eigenvectors of the multivariate VAR-systems for industry-specific Nordic stock market data.

1.4 Using Scandinavia as the focus area

Scandinavia has been chosen for the target area of this study, because it forms unique geographic entity which also shares quite similar financial market properties. As a foundation for this study I first examined using monthly data the correlation properties of the most important stock markets in the whole world, consisting of 37 stock exchange indexes from all continents. The period taken was Jan 90 - Feb 99, meaning 110 observations from 37 national stock exchanges. After the correlation coefficients between 37 stock indexes were estimated, the indexes were factorized according to the five continents (including Scandinavia) and summarized. Table 1 presents the correlation coefficients after the analysis.

TABLE 1 Correlation coefficients of the stock exchanges in 5 major geographical areas

Correlation	*SC*	*WE*	*NA*	*LA*	*AS*
Scandinavia	0.93				
Western Europe	0.90	0.89			
North America	0.94	0.90	0.98		
Latin America	0.65	0.59	0.70	0.62	
Asia, Oceania	0.23	0.18	0.24	0.35	0.40

When the correlation coefficients of the above geographical factors are examined, we see that Scandinavia forms a clearly distinct area, which can be analysed as a separate geographical and financial entity. The factors "North America" and "Scandinavia" attained clearly the highest intrinsic correlation coefficients inside the chosen factor, meaning that all the Northern American stock indexes (namely, Dow Jones Industrial Average, Standard & Poors 500, Nasdaq, NYSE Composite, Toronto 300) and all the Scandinavian stock exchange indexes (Finland, Sweden, Norway, Denmark) have a higher correlation with each another (0.93 for Scandinavia and 0.98 for North America) than with any other stock indexes.

The strong correlation between the North American indexes is obviously not surprising, as the chosen indexes even include the same stocks and are known to present very similar patterns. The Scandinavian stock exchanges also seem to be strongly correlated with North American indexes (0.94), more than with any other continent factor. These correlations are clearly higher than any of the other correlations; consequently, we consider Scandinavian stock indexes as an interesting financial group, as they seem to present a rather distinct area, with several unique properties.

In Scandinavia differences between industrial structures, policies and economic behaviour have traditionally been small. There have even been serious negotiations among the Scandinavian exchanges to establish a joint Scandinavian stock market to meet the challenge of increasing competition from the international securities markets. The reason for this suggestion is to improve competitiveness and make the market more attractive to foreign traders and investors. Such a joint Scandinavian market would form the third largest securities market in Europe.

The Scandinavian countries offer a stable basis for cointegration analysis because these nations are economically quite similar. Cooperation between Finland, Sweden, Norway and Denmark is currently strong, in terms of harmonizing the regulations in the different marketplaces and developing the joint distribution of price screens on Scandinavian exchanges. The trading and the stock markets exist in a roughly similar time zone. The geographical location is close, as the countries are neighbours. The automated trading mechanisms in these markets are also very similar to each other.

Major deregulation of stock market in the Scandinavian countries began in the middle of the 1980s. Nonetheless, the market value of listed stocks compared to GDP has remained relatively low. The increased foreign ownership of Nordic stocks has been an important factor during the 1990s. While foreign ownership in the past was typically limited to a minority interest in most Scandinavian companies, the abolition of foreign ownership restrictions has increased foreign ownership considerably in Nordic countries (Booth, Martikainen, Tse 1995, p. 6). Stockholm is the largest of those four Scandinavian equity markets.

Actions in the region have been taken to harmonize the regulations governing stock market activities and securities trading. This harmonizing process has been strengthened, as the Scandinavian countries have gradually implemented EU regulations in a number of fields (including securities trading). In November 1998 the stock exchange in Helsinki (Finland) nevertheless decided to abstain from cooperation with the other Nordic stock exchanges and decided instead to cooperate with the exchanges in Germany, namely with the Deutsche Börse, operating in stock markets, and with Eurex, handling derivatives markets, both based in Frankfurt, Germany.

The EU policies of the Scandinavian nations have interesting differences, which also affect their stock markets. In January 1995 Sweden and Finland became new members of the EU, which Denmark had already joined back in the 1970s. Norway has not joined the EU. The European Monetary Union (EMU) has also met with different receptions in the Scandinavian countries. Finland is the only Nordic economy in the EMU, joining in 1999, while Denmark (with the UK) only acquinted the privilege to enter later. Sweden has made an individual decision not to enter the EMU, owing to internal political resistance.

The interrelations between the Scandinavian stock markets have been under quite intense scrutiny, but the results obtained in this area differ quite strongly. Causality analysis reveals spillover effects between the markets. Some results vary, depending on the currency transformation on the data, implying that this exchange rate behaviour affects the Nordic stock markets and that the exchange risk is not fully hedged. One important emphasis in this study will be to compare the results obtained by using the different data frequencies. Estimations will be conducted by using both monthly and daily stock exchange data, and the differences in the estimation results will be analysed. Cointegration properties are usually more easily found when lower frequency data is applied (quarterly and monthly) than with daily data. We will analyse the differences in Scandinavian stock market integration by testing causality and cointegration properties using both monthly and daily data.

1.5 Analysis of convergence

The concept of convergence is used in various contexts in economics, but its basic meaning is that the difference between two or more series should become arbitrarily small (or converge to some constant c) as time elapses. In stochastic convergence (for random series as most economic series) the probability that the two series differ by a specified amount is required to become arbitrarily small, which also means weak convergence. Weak convergence may be widened to include integrated processes. If the series are I(1), then it may be unreasonable to expect the absolute difference between them to become arbitrarily small. We may define convergence in terms of the difference between them being of a lower order of integration than the series under consideration. When we extend the notion of convergence to systems, it can be divided as:

- Strong system convergence. Every pair of variables in a system or subsystem has converged.
- Weak system convergence. Some elements of the system have converged without the others showing any tendency to change behaviour.

There are various approaches to performing convergence implementation (this summary on the various alternative methods is based on the paper by *Hall G., Robertson D., Wickens M. (1992), pp. 99-104)*:

1. Calculating measures of dispersion for the series across countries and plotting these over time. The problems in this technique are that some series are available only in index number form, implying that at the arbitrarily chosen base period dispersion will be zero. The degree of dispersion may also be affected by an external factor which is so strong that it obscures the underlying processes at work on covergence.

2. Looking for convergence in the parameters of key econometric relations. Similar coefficients suggest economic convergence. Various tests can be done for structural change in existing relations.

3. Testing for mean reversion. The literature on the convergence of growth rates argues that high output per capita countries must grow slower than low output per capita countries if convergence is to be achieved. This is tested on a time series of cross-sections of international levels of output per capita by regressing the change in output per capita of a country on its previous level. The regression coefficient will be negative if convergence is occurring. This test is closely related to the Dickey-Fuller test of the stationarity of a time series, since a finding of convergence would also imply stationarity. However, stationarity on its own is neither necessary nor sufficient for convergence.

4. Cointegration of variables. For convergence, the first thing which must be established is that the differences between the series (defined in some way) do not have infinite variances, i.e. they do not drift infinitely far apart. If two non-stationary time series are not cointegrated then they cannot converge. Thus, testing for the cointegration of the series is a necessary (but not sufficient under all definitions of convergence) condition for convergence. Having determined that the differences do not have infinite variances, it then becomes appropriate to seek to establish whether their means tend to zero or a suitable finite number, which might be stochastic. This is, in effect, equivalent to testing for mean reversion.

5. Testing on cointegrating vectors. Once cointegration is established, tests may be carried out on the cointegrating vectors to see if certain restrictions are satisfied. For example convergence of stock returns implies that there exists n-1 cointegrating vectors among the n stock return series consisting of the pairs of exchange rates. For convergence, the non-zero coefficients in the cointegrating vectors should be [1,-1]. It should be stressed that convergence is a gradual and

on-going process. Testing for cointegration is a powerful way of assessing whether convergence has occurred before the period of the data sample being used. But if we believe that convergence is in the process of taking place over the sample period we are examining, then any tests which assume structural stability will almost certainly reject convergence for the whole period. If we test for convergence using data from the whole of the 1980s and two countries had not converged at the beginning of the 80s but had converged by the end, we would almost certainly reject the null of cointegration. We see the dynamic process of convergence as still continuing and we need a measure of convergence which allows for this dynamic structural change.

6. Time-varying parameters (Kalman filter). This method is illustrated by *Haldane and Hall (1991)*. The Kalman filter estimation method means considering differentials between any two countries and the differential between one of the countries and a third country (or a world index). We may estimate the equation to test for convergence of a series X (the log of the series), which is typically used to estimate regression-type models where the coefficients follow a random process over time. As such, Kalman filter estimation is very useful in investigating structural changes in parameters and hence in describing the process of structural change in terms of both degree and timing.

In *Serletis and King (1997)* the evidence based on the time-varying parameter technique proposed by Haldane and Hall (1991) suggests that the link between the EU stock markets has been strengthening but that convergence is still in the process of being achieved, which is consistent with the view that convergence is not forcibly imposed but attained through emulation and competitive behaviour that enhance efficiency and strengthen equality of opportunities. The Haldane and Hall (1991) technique is currently one of the most promising methods available for measuring convergence according to Serletis and King. The method is based on the use of time-varying parameter (Kalman filter) analysis.

Most current papers applying VAR estimation seem to prefer the Johansen's maximum likelihood technique (1988) in analysing the cointegration properties of the statistical system. The alternative empirical methods for stock market integration estimations are discussed in the second chapter of this study, as well as the stock return modeling problems. From each study the specific modeling problems and the remedies for those problems are discussed. The main implications and the solutions suggested by the results of these studies are also presented.

The second chapter concentrates on the recent research papers analysing in particular Scandinavian stock market integration and the lead structures of these markets. The most important conclusions from these research papers regarding Scandinavian stock market integration are presented in table 4, in chapter two. The existing papers seem to reach quite different conclusions concerning the cointegration and causality properties of both the Scandinavian and the international stock markets.

The various methods applied in this study offers the possibility to test several hypotheses derived from the theory of international finance. The market segmentation hypothesis suggests that the reduced degree of market segmentation tends to integrate one stock market to others. Liberalization of the financial markets, the faster flow of information and the increased internationalization of the investment environment have all decreased the segmentation of the Nordic stock market. According to the market segmentation hypothesis, we should see a gradual increase in the degree of cointegration in the Nordic markets over time.

According to the financial theory, and especially the common feature market hypothesis, the stronger the economic ties among countries that are in the same continent or within the same time zone the more those countries are expected to exhibit a higher degree of integration. This implies that the existence of a common feature among stock markets should lead them towards cointegration (*Chan, Gup, Pan 1997, p.804*).

The study of cointegration has implications for the traditional stock market efficiency framework. According to the cointegration literature (*Granger 1986;* Chan, Gup and Pan 1997) if two stock markets are collectively efficient in the long run, then their stock prices cannot be cointegrated. This cross-country market efficiency hypothesis means, that if two markets are cointegrated, then possible arbitrage profits can be made.

One interesting pragmatic question arises from the viewpoint of an international investor considering international portfolio diversification in Scandinavia. Cointegrated Nordic markets imply that there exists a common trend which would make Nordic portfolio diversification ineffective, because the long-run systematic risk (often referred as market risk) cannot be removed by simple portfolio diversification. In Finland, since the beginning of 1993, there has no longer existed any regulation on the foreign ownership of stocks quoted on the markets. Nevertheless, the fact that markets have been restricted does not necessary mean that their economies cannot react to the same piece of information in a similar manner and hence produce common long memory return characteristics in the equity market.

Several studies investigating the transmission of prices between stock markets suggest that international co-movements between markets have increased in recent years. These observed relationships are nevertheless often lower than might be expected on the basis of recent trends in those financial markets. These low relationships between different stock markets may exist because of technical differences in constructing aggregate stock market indexes and because of different industrial structures in different countries. These low relationships may also be caused by different exchange rate behaviour and policies (*Booth, Martikainen, Tse 1995*).

A number of macroeconomic and technical factors may have contributed to the increased interdependence that has taken place among national stock exchanges. A trend toward growing international cooperation in macroeconomic policymaking in Scandinavia has been due to the building of European union. The growth in international activity in stock transactions, such as cross-border investment and 24-hour global trading, along with the technological advantages in communications and trading operations on a global basis, also seem to have contributed to the increasing interdependence among national stock markets. These growing linkages in macroeconomic policy and European monetary integration among the Scandinavian national markets have increased the speed of the international transmission of financial disturbances across nations.

The growing interdependence among the major world stock exchanges suggests that barriers to the international transmission of financial, as well as real, disturbances have declined. Furthermore, the rationale for international portfolio diversification must be re-examined in the light of the greater national co-movements in stock prices. Finance theory predicts that there are potential gains from international portfolio diversification if returns from investment in different nations are not perfectly correlated and the correlation structure is stable.

2 REVIEW OF THE LITERATURE

This chapter surveys the methods and the specific aims of several recent research papers on the international financial market integration. Various problems arising from the use of these methods are discussed and the remedies suggested in the papers are presented. Much of the literature in stock market modeling has concentrated on measuring international stock market integration. The most direct methods apply the law of one price to financial assets. For example, *Ammer and Mei (1996)* investigates the international economic linkages and the degrees of integration among different economies, while *Turtle and Abeysekera (1996)* use five international parity conditions as determinants of international capital flows. *Kleidon and Werner (1993)*, in turn, look for arbitrage opportunities associated with cross-listed stocks. These strategies are nevertheless limited by their dependence on the existence of assets with the same risk in different countries.

Other studies focus on one-period returns and the conditional means and variances of one-period returns in characterizing international financial integration. Ammer and Mei refer to papers using methods of this kind, including *Wheatley (1988), Gultekin, Gultekin and Penati (1989), Campbell and Hamao (1992), Bakaert and Hodrick (1992), Chan, Karolyi and Stulz (1992), King, Sentana and Wadhwani (1994)* and *Heston and Rouwenhorst (1994)*. One weakness of this sort of approach is that one may overlook persistent co-movements in long-term expected returns that could be of considerable importance in asset pricing.

2.1 Modeling international linkages

Ammer and Mei (1996) analyse covariation between the components of returns on national stock markets. By examining the co-movement of future returns aggregated over a long horizon instead of the co-movement of one-period expected returns, they try to detect small but persistent co-movements in expected returns and more accurately measure the degree of financial integration. Their paper also departs from the other literature in its simultaneous treatment of real and financial linkages. This enables them to treat aspects of the stock market, the money market, the goods market, and the foreign exchange market in the context of a single unified system, making it possible to study their interactions without many ad hoc assumptions.

By relying more on financial market data than on macroeconomic data, there also emerge fewer problems with measurement errors. By using the *Campbell and Shiller (1988)* approximate present value model, they decompose excess stock return innovations for different countries into news about future excess returns, divident growth rates, interest rates and exchange rates. By studying the co-movements of these different excess return components among various countries, they assess the relative importance of different types of international linkages among the world's economies. Specifically they measure real economic integration by calculating the correlations of dividend innovations between different countries and measure the degree of financial integration of two national economies by calculating the correlation between innovations in future expected stock returns in those countries.

As noted by Campbell and Hamao (1992), if asset returns in different countries are generated by an international multivariate linear factor model, the conditional means of these excess returns must move in tandem, as linear combinations of a set of common risk premiums. If national financial markets are highly integrated, high correlations between future expected return innovations in different countries should be found.

Ammer and Mei (1996) measure real integration between two countries by the correlation between the long-run real components of the two stock returns, namely future domestic dividend innovations and future foreign dividend innovations. They also measure financial integration by using the correlation between future domestic expected return innovations and future foreign expected return innovations. To compute the required expectations of the variables, they assume that expectations are generated by a vector autoregression (VAR). The generalized method of moments (GMM) of Hansen is used to jointly estimate the VAR coefficients and the elements of the variance-covariance matrix of the VAR innovations. Previous studies have found that dividend yields and nominal interest rates have significant forecasting power for stock returns; see for example, *Ferson and Harwey (1991), Fama and French (1988, 1989)*, and *Keim and Stambaugh (1986)*.

It also seems that the innovations in long-term dividend growth are much more highly correlated between the two countries than are their measures of contemporaneous output growth. Ammer and Mei suggest two explanations for this result. First, output growth may be much more highly correlated than suggested by the macroeconomic data, owing to possible measurement errors.

Second, although output in the two countries may be affected in the short run by transitory country-specific factors or by common factors but with different lags, long-term dividend growth in the two countries is driven by common influences. Using contemporaneous output correlations alone may understate the magnitude of international real integration. The decomposition results seem to be quite robust to changes in model specification.

As an additional robustness check, Ammer and Mei have tried adding a term spread (the difference in yields between 10-year government bonds and the 1-month bill) to the VAR process. The additional variable did not change the character of the decomposition results. Adding a market volatility variable (the standard deviation of daily returns) was also tried. The results are quite robust to these different specifications of their forecasting model. *Goetzman and Jorion (1993)* point out that the predictive power of the dividend yield for returns may be spurious due to the fact that the changes in the dividend yield are highly (negatively) correlated with returns.

Inter-temporal stability in the long-run and short-term co-movements of international stock markets have been an important area of research. *Meric I., Meric G. 1996, (p. 73-75)* provide a conclusive analysis on various studies done lately in this area. They also determine that international stock market relationships are relatively unstable in the short-run but stable in the long-run. Low correlations among national stock markets have been often presented as evidence in support of the portfolio gains to investors from international diversification, but this method is hardly adequate as the only procedure, while for example the cointegration approach offers a much firmer basis for the long-run analysis.

Clare, Priestley, Thomas (1997) analyse the predictable component of excess returns in German, Japanese, UK and US aggregate stock indexes, finding evidence to suggest that the frequently documented predictable component in excess returns is predominantly due to a failure in previous research to consider risk. They estimate a conditional CAPM model for the four international markets.

If the ex ante variables really are tracking changes in risk and expected returns, then it should be possible to make the return on the market index conditional upon the forecasting instruments. They also use instrumental variables where the forecasting variables are used as instruments, thus treating the market return as an endogenous variable.

Clare, Priestley, Thomas (1997) find only very weak evidence to suggest that excess German equity market returns can be forecasted, and when they consider an unconditional CAPM for the German equity market they find no evidence of predictability. When they consider a conditional CAPM for the Japanese market, they find that the variables are not able to forecast excess Japanese equity returns, but instead are valid as instruments for the market.

Keim and Stambaugh (1986) and *Campbell (1987)* find that a measure of the term structure of interest rates and changes in the risk-free rate of interest can predict future stock returns. According to the Campbell and Shiller (1988) paper, lagged dividend yields can also help to forecast stock returns. *Clare and Thomas (1992)* use the stock and bond returns in the US, UK, Japan and Germany and find that it is possible to build ex ante models of excess stock and bond returns across these four capital markets. Evidence of well-specified, intertemporally stable forecasting models might lead to rejection of a constant expected returns version in the efficient market hypothesis (as formulated in Fama 1991). Fama (1991) argues that if expected returns do time-vary then the forecasting variables such as the equity market dividend yield may form an integral part of a conditional asset pricing model.

2.1.1 Cointegration modeling with VAR

The implicit motivation behind all attempts to decompose economic time series into trends and other components is the belief that different underlying economic forces govern the evolution of the components and therefore something can be gained by studying each component in isolation. Applied to international stock markets, a trend or stationary decomposition of stock prices might be based on the belief that the unit root, or stochastic trend, components derive from common underlying stochastic growth components driving earnings and dividends. Such components presumably depend in turn on underlying trends in national economies or industries. The stationary components of national equity markets then have the interpretation of being an amalgam of the stationary components in earnings or dividends and of transitory deviations from the price-dividend link arising from time variation in discount rates and "the national risk premium". (Kasa 1992, p.96).

Kasa (1992) notes that one must be careful when choosing the number of lags in the VAR model. For the data sets studied in his paper, he finds that low-order VARs reveal little evidence of cointegration, while higher-order VARs (those including over a year's worth of lags) provide much stronger evidence in favour of cointegration. He argues on the basis of the usual normality and autocorrelation error-term diagnostics that higher-order models are probably more appropriate specifications. Kasa (1992) stresses at the outset that he does not attempt to address the question of international equity market integration.

Another reason to note is that if stock markets share a common trend then there are no long-term gains to international diversification. Most discussions of the potential gains to international portfolio diversification are based on simple cross-country correlations computed over relatively short return horizons. These types of computations can be misleading if investors have long holding periods and national equity markets share a common trend. Of course, the economic relevance of any long-term co-movement hinges on the speed of adjustment towards the common trend. (Kasa 1992, p.97).

Almost all studies of international equity markets have focused on equity returns rather than on equity prices. *Engle and Granger (1987)* demonstrate, however, that if a vector of a time series shares a common trend, then models which ignore this trend by only incorporating first differences suffer at a minimum a loss of efficiency, and perhaps are subject to more serious specification biases as well.

As noted by *Lucas (1982)*, and others, the most important implication for integrated capital markets is the equalization among countries of marginal rates of substitution in consumption, both intertemporally and across states of nature. Therefore a better yardstick against which to judge the degree of capital market integration might be, for example, the degree of coherence among consumption growth rates across countries.

It could also be interesting to test the point made by *Shiller and Perron (1985)*, also, that the power of unit root and cointegration tests is primarily a function of the length of the time period, not the number of observations. Kasa (1992), also, finds much stronger evidence of cointegration when using quarterly data than when using monthly data. Such strong findings are surprising in a data set consisting of less than seventeen years of data. *Fama (1991)* points out that stock returns can be predictable in an efficient market. *Dwyer and Wallace (1992)* argue that there is no general equivalence between the existence of arbitrage opportunities and cointegration or a lack of it. One should, then, be careful when drawing conclusions regarding market efficiency, which are done on the basis of cointegration analysis.

If the variables in levels are non-stationary we can test for the presence of co-integration among those variables. *Chaudhuri (1997b)* uses the *Engle-Granger (1987)* cointegration test, which is based on testing the stationarity of the estimated residual series from the static long-run equation for the levels of variables. Chaudhuri notes the large finite sample bias problems that emerge with the static regression framework. While such estimates are superconsistent (T-consistent), Monte Carlo experiments (*Banerjee et al. 1993*) nonetheless suggests that a large number of observations are needed to reduce the bias in the estimates.

The effect of using static regressions to estimate the cointegrating vector is to allow the residual to capture all the dynamic adjustment terms. According to the super-consistency theorem, this is certainly permissible asymptotically. However, in a finite sample the omitted dynamics can matter considerably. Chaudhuri (1997b) suggests using the reparametrized estimation equation with the bias adjusted for the cointegrating coefficient.

Chaudhuri (1997a) investigates the common trends in stock returns in seven Asian emerging markets. Conventional approaches usually model stock prices or returns as a random walk, though Chaudhuri refers to some recent studies (*Fama, French 1988; Fama 1991; Lo 1991; Cheug et al. 1993; Cheung, Lai 1995*) which provide some evidence in favour of mean reversion in stock returns using either time-domain analysis or frequency-domain analysis. Chaudhuri (1997a) uses the multivariate technique of *Johansen (1988)* to determine the number of common trends and finds evidence of a single stochastic trend. Then, following Kasa (1992), a non-unique identification of the non-stationary common trend as a weighted average of each series is obtained and Chaudhuri shows its use as a market interdependency measure.

Chaudhuri (1997a) estimated the number of common trends contained in the logarithms of nominal stock returns of seven countries. The number of lags in the autoregression was chosen on the basis of the *Sims (1980)* likelihood ratio test. A model with six lags was chosen. The model is estimated under the hypothesis that the linear trend is fully contained in the intercepts of the cointegrating regressions, and this hypothesis was then tested and accepted. Critical values for the trace statistics are from *Osterwald-Lenum (1992)*. The diagnostics of the model revealed non-normality. The Jarque-Bera statistic for normality was high for one country, but Monte Carlo studies have noted that moderate kurtosis does not pose a substantial problem for Johansen's approach *(Gonzalo 1994)*. The estimations confirm the presence of six cointegrating vectors and a single common trend. Weak exogeneity is also tested and Taiwan turns out to be weakly exogenous. This restriction is imposed and the restricted model is estimated. The restricted model offers evidence of no common trend, which implies that the unrestricted model has a single common trend.

Chaudhuri (1997a) applies a procedure used by Kasa (1992) to obtain a non-unique identification of the common trend. Kasa (1992) obtains a non-unique identification of the single trend by decomposing the vector X such that

$$X_t = \beta(\beta'\beta)^{-1}X_t + \beta_0(\beta_0'\beta_0)^{-1}\beta_0'X_t$$

where the first part is the stationary component and the second term is the common trend. β_0 is the orthogonal element of β such that $\beta'\beta_0 = 0$. The elements of the vector β_0 are normalized such that the elements of $(\beta'_0\beta_0)^{-1}\beta'_0$ sum to 1 in absolute value. The common trend is defined as $(\beta'_0\beta_0)^{-1}\beta'_0X_t$. Using this, the common trend can be expressed as a linear combination of the nominal stock returns for each country. In order to use the weighted common trend, the intercept for each trend is chosen such that the mean of the differences between the common trend and the actual series is zero. Chaudhuri obtained a measure of the common trend and uses this as graphic evidence of the interdependence of stock returns in emerging markets. The graphic evidence shows that nominal stock returns for these countries have considerable linkages, in particular that their long-run movement is governed by a single non-stationary trend. The long-run behaviour of nominal stock returns seems to be governed by global, not idiosyncratic shocks.

If cointegration exists between two variables, then causality must be present in both or at least one direction. Hence, Chaudhuri uses the Granger causality test in a bivariate framework. Chaudhuri (1997b) builds up an error correction mechanism (ECM) from the Granger representation theorem (Engle, Granger, 1987). The test of Granger causality boils down to the significance of the lagged coefficient of the residual from the static regression for the levels of variables. The quantity of that coefficient also indicates the speed of adjustment, which differs among the countries in his study.

Although the cross-correlation coefficients provide valuable information concerning the relationship between the two time series, they do not test for direct causality. They do not answer the question of whether some market returns lead the returns on certain other markets or vice versa. The Granger causality test has received the most attention. According to the Granger causality test procedure the hypothesis that $\{Y_t\}$ causes $\{X_t\}$ can be examined by regressing $\{X_t\}$ on lagged $\{X_t\}$ and lagged $\{Y_t\}$, and testing the joint hypothesis of the lagged values of $\{Y_t\}$.

This analogously means that the series $\{X_t\}$ fails to Granger cause $\{Y_t\}$ if in a regression of $\{Y_t\}$ on lagged $\{Y_t\}$'s and lagged $\{X_t\}$'s, the coefficients of the latter are zero. The standard Granger causality test includes only differenced series, i.e. stock returns, because the Granger causality tests assume stationary time-series. However, it does not indicate whether the level series, i.e. logarithmic stock price indexes, show any common trend. If the level series are cointegrated, an error correction term should be included as an additional regressor to the causality tests. This error-correction term is the residual term from the co-integration equation $P1_t = \lambda P2_t + \lambda_t + \epsilon_t$, where P1 and P2 are level series. This is because the causality between markets may otherwise be underestimated by ignoring the common trend in price series.

All the studies analysed here work with the natural logarithm of the aggregate stock price indexes, but no discussion is found on the aggregation process and its effects on the integration results obtained. We consider the evidence of significant causal relationships, which are found in several cases, as doubtful, as the process of aggregation can affect the results.

2.1.2 ECM and time-varying parameter estimation

Francis and Leachman (1998) come to conclusion that agents participating in financial markets are forward looking. The error correction mechanism (invented by Granger) has traditionally been interpreted as a backward looking adjustment process characterized by Granger causal relationships. However, researchers have recently questioned this interpretation and point out that an error correction representation among a set of variables may result from a forward looking optimization strategy on the part of economic agents (*Engle et al. 1983; Campbell and Shiller 1988; Engle and Hendry 1993*). Granger causality may or may not characterize such a system. Given that a broad class of international asset pricing models is expectationally based, this interpretation holds theoretical relevance. (Francis B., Leachman L. 1998, p. 477). Campbell and Shiller (1988) point out that the finding of cointegration and therefore the existence of an ECM between a set of economic variables does not necessarily arise from the adjustment to past disequilibria but may be due to economic agents forecasts of future changes.

Several financial market variables have been found to have forecasting power for broad equity and stock market indexes. Dividend yields have been related to future stock returns through the present value model (Campbell and Shiller 1988) and also though a noise trader model (Shiller 1984). Fama and French (1989) relate stock returns to the term structure of interest rates. Clare and Thomas (1992) find that foreign equity market indexes can help to predict domestic returns and they relate this phenomenon to the extent of the integration that exists between international equity markets.

Serletis and King (1997) present evidence on the number of common stochastic trends in ten European Union stock markets. They also measure the degree of convergence of these stock markets using the time-varying parameter (Kalman filter) methodology suggested by *Haldane and Hall (1991)*. Johansen's (1988) maximum likelihood procedure is applied to test for the number of cointegrating vectors (i.e. the number of common trends). If international stock markets share common trends, this would imply that there are no gains to be made from international portfolio diversification. Thus, full stock market integration would imply that risk-adjusted stock returns denominated in a common currency are equal in all countries.

Several studies have examined the degree of stock market integration by variance decomposition methods (f.e. Ammer and Mei 1992, Campbell and Hamao 1992, Wheatley 1988). Kasa (1992) and *Malkamäki (1993)* consider this issue by applying Johansen's cointegration methodology to test for the number of common stochastic trends across international stock markets (while denominating stock returns in terms of USD).

Serletis and King (1997) explore the degree of shared stock market trends among EU countries utilizing Johansen's (1988) maximum likelihood (ML) extension of the Engle and Granger (1987) cointegration framework. They also attempt to measure the degree of convergence using the time-varying parameter technique proposed by Haldane and Hall (1991). In Europe some nominal convergence is found. Inflation rate differentials among European Monetary System (EMS) members have declined, as have short-term interest rates and primary budget deficits. The move towards European monetary union seems to be enhancing the intra-EU mobility products, labour and financial and physical capital, both directly as a result of the elimination of barriers to such movements and indirectly as a result of trade integration.

In the study by Serletis and King (1997) all series have been converted to a common currency (as in Kasa (1992) and Malkamäki (1993)), which is real DEM, using spot exchange rates and Germany's consumer price index. The stock market series are also converted to natural logarithms and set equal to unity in the first observation. The skewness numbers point to significant deviations from normality for most series. They also calculate the standardized spectral density function (i.e. S(0) -value) at zero frequency on the basis of the Bartlett window with the window size taken to be twice the square root of the number of observations. This gives consistent estimates of *Cochrane (1988)*'s measure of persistence, providing a useful diagnostic on the relative importance of permanent and transitory components. Large S(0) values indicate mean persistence, while small S(0) values suggest mean reversion (used also in Kasa 1992). Mean reversion and mean aversion properties of the series are also analysed and the values of contemporaneous correlation are calculated.

The objective of Serletis A. and King M.(1997) is to determine whether the close proximity and integration of the financial markets results in significantly different stock market performance. If so, this would constitute evidence that financial market integration and convergence in the EU may not be occurring. They used cointegration analysis by performing Johansen tests on quarterly vector autoregressions (VARs) of various lag lengths and stopped at the smallest lag number for which the normality and autocorrelation diagnostics appeared to be roughly consistent with the independent and identically distributed Gaussian assumption. In the trace test, the null hypothesis that there are at most r cointegrating vectors is tested against a general alternative whereas in the maximum eigenvalue test the alternative is explicit, i.e. the null hypothesis $r=0$ is tested against the alternative $r=1$, i.e. $r=1$ against $r=2$ etc. The 95 per cent critical values of the trace and the maximum eigenvalue test statistics are taken from Osterwald-Lenum (1992). The two test statistics yield different results. However, since the trace test takes account of all (p-r) of the smallest eigenvalues it tends to have more power than the maximum eigenvalue test when the eigenvalues are evenly distributed.

On the basis of the estimated tests, Serletis A. and King M. assume that there are two shared stochastic trends in the ten dimensional system, implying that the ten stock market series are linked together by eight cointegrating relationships. The evidence presented can also be used to address the question of whether financial market convergence is occurring within Europe. *Bernard (1991)*, in developing stochastic definitions of convergence and common trends based on cointegration analysis, argues that a necessary (but not sufficient) condition for

TABLE 2 Summary of the methodological problems and remedies presented in the selected international stock market studies

Author(s)	*Problems*	*Suggested solutions*
Ammer J., Mei J. (1996)	Persistent long-run co-movements may be overlooked. How to measure financial linkages and "openness" of the markets.	Examines the long-term co-movements of future returns, not one-period expected returns. Simultaneous analyse of real and financial linkages. Financial data yield fewer measurement errors than macroeconomic data.
Meric I., Meric G. (1996)	How to measure inter-temporal stability in the co-movements of international stock markets.	Analyses the long-term stability of the correlation matrix. Uses monthly, rather than daily, data.
Engle R.F., Granger C.W. (1987)	How to develope estimation procedures for co-integration and error correction models.	Cointegration and common trends must be considered in empirical modeling. Cointegrated series can be represented by error correction models. Several cointegration test procedures suggested.
Kasa K. (1992)	Portfolio diversification decisions are too often based on simple correlation analysis. Does cointegration imply economic integration ?	Applies long-term cointegration analysis and concentrates on the statistical analysis of cointegration. Lag selection and the length of the time period covered by the data are critical in VAR modeling.
Chaudhuri K. (1997a)	How to measure and present stock market inter-dependence.	Obtains a non-unique identification of the common trend by decomposing the series, using similar techniques as Kasa, and then uses graphical analysis and evidence.
Chaudhuri K. (1997b)	Large finite sample biases in the static regression framework.	Large number of observations are required. Reparametrizes the estimated equation using bias-adjusted cointegrating coefficients. Builds up an error correction mechanism from the Granger representation.
Francis B.B., Leachman L.L. (1998)	Should the error correction mechanism in stock market modeling be interpreted as a backward or forward looking adjustment process ?	Rejects superexogeneity, which is consistent with the hypothesis that the error correction mechanism, which corresponds with cointegration testing, is forward looking.
Clare A., Priestley R., Thomas S. (1997)	Stock return predictability and modeling.	International stock market integration is related to the predictability of the domestic stock returns by the foreign equity market indexes in conditional CAP models.
Serletis A., King M. (1997)	How to measure convergence of international stock markets.	Time-varying parameter technique is applied, because cointegration analysis cannot detect a move from non-convergence to convergence.

multi-country convergence is that there are p-1 cointegrating vectors for p countries.

Cointegration analysis, however, cannot in principle detect convergence, because it fails to take into account the fact that convergence is a gradual and ongoing process, which implies that statistical tests should lead to rejection of the null hypothesis of no-cointegration only when convergence has already taken place; for more on this, see Bernard (1991). So, cointegration tests are tests for convergence over the whole period under consideration, but these tests are not tests of a move from non-convergence to convergence. Similarly, cointegration techniques are inappropriate for investigating whether the degree of convergence has been stronger lately than earlier.

It should be noted that the cointegration of a series is a necessary condition for convergence (see also *Hall et al(1992)*). But cointegration tests are not tests of a move from non-convergence to convergence but rather tests for convergence over the whole period under consideration. Definition of convergence assumes that long-run forecasts of price differentials tend to zero as the forecasting horizon tends to infinity. Therefore, in order for countries i and j to converge, their prices must cointegrate with the cointegrating vector [1,-1].

Also, if we are testing for the number of cointegrating vectors which exist within the f.e. 4 currencies, and if all the currencies have converged, we would expect to find 3 cointegrating vectors. If the α coefficients are consistently non-time-varying, implying that the specific alternative is always sufficient to capture any non-convergence over the period, we may be focusing the analysis on the β coefficients. The α coefficients are potentially important as they allow for the possibility that our specific alternative explanation is inadequate or irrelevant.

2.2 International financial integration

Empirical research regarding common long-run relationships and the short-run dynamics of integrating capital markets has been very productive during the last few years. Most papers usually suggest that stock markets are in many cases less than fully integrated, which implies that shocks are transferred from one market to another. The fact that the rapid changes in international financial markets during the 1980s and 1990s feature a lesser degree of market segmentation, such as foreign ownership and cross-country stock-investing restrictions, may tend to have an integrating effect on the international stock markets. Several studies also point to the October 1987 stock market crash as a structural change and note the increasing (not unanimously) cointegration behaviour after that event. This chapter examines the results obtained from several stock market studies on international financial integration. A table summmarizing the main results is presented at the end of this chapter.

Kasa (1992) finds that five big international stock markets (the US, Japan, the UK, Germany and Canada) move together in the long run, and that there is a single common stochastic trend driving these stock markets (when quarterly data is applied). This is equal to finding four cointegrating vectors among the five stock markets under examination (Kasa found only one cointegrating vector with monthly data). This result means that to international investor with long holding periods the gains from international portfolio diversification are minor. He also raises the interesting question as to what the sources of this trend are. He suggests that a stochastic world economic growth factor could be the underlying force driving national earnings and dividends. Similar results are obtained from the study by Francis B.B. and Leachman L.L. (1998), which covers the same period (monthly data from January 1974 to August 1990) as Kasa (1992), but excludes Canada from the VAR-system. Similarly to Kasa, the stock markets are found to be cointegrated with one cointegrating vector (in this study only monthly data is applied), and also superexogeneity of the stock market indexis rejected.

Jeon and von Furstenberg (1990) investigate the interrelationships among stock prices in Japan, Germany, the UK and the US They note that the strong leadership of the US market seems to have been reduced since the October 1987 crash, especially with respect to Japan. One of the most important studies suggesting that the US was the most influential and leading market in the world during the first half of the 1980s was *Eun and Shin (1989)*. Jeon and von Furstenberg apply the vector autoregressive (VAR) approach to daily stock price indexes and find evidence of a significant structural change, with regard to the correlation structure and leadership. Their impulse response function analysis showed that the degree of international co-movements in stock price indexes has increased significantly since the crash.

They first examine the contemporaneous correlations among the disturbances arising in every market. In every pair of markets, correlation coefficients increased substantially from the range 0.02-0.23 to the range 0.19-0.56 after the crash, indicating that on a daily basis an innovation in one market has been transmitted to other markets more quickly and to a greater extent since the crash. Secondly they examine the impulse response functions. The variables are ordered in accordance with the sequence of the closing times of the four markets. The contemporaneous effects of innovations in a certain market on other markets are allowed to occur only in the markets that close later on the same day, not the other way around. The estimations were performed by applying the triangular orthogonalization procedure to innovations. When they reordered and re-dated the sequence of the markets, however, the patterns of cumulative responses after several periods were not significantly different from their original results. This means that the patterns of impulse response functions in the major world stock exchanges were generally not very sensitive to the ordering of the markets in the sample period (Jan 7, 1986 - Nov 25, 1988).

Several implications were derived. First, innovations in all of the major stock markets had more significant effects on other markets after the crash. During the pre-crash period, on average 10.9% of the initial impulse in a specific market was transmitted to foreign markets within a 24-hour period. The size of the innovation transmission increased more than threefold to an average of 33.1% after the crash. This increased sensitivity of national stock prices to innovations in foreign markets is especially conspicuous between adjacent markets.

Similar results were also obtained by *Masih and Masih (1997)*, who concluded that, in general, the October 1987 crash has brought about a greater interaction amongst the international stock markets, with a greater role for fluctuations in explaining shocks across markets (including the US). Greater psychological contagion effect appears to have developed between the markets since the stock market crash.

The average proportion of innovations passed from one market to the next has risen from 14.0% of initial innovations before the crash to 45.1% since the crash, according to the study by Jeon and von Furstenberg (1990). Second, the influence of the Tokyo Stock Exchange on the New York Stock Exchange seems to have become stronger since the crash, while the influence of the New York market on the Tokyo market has been reduced. Third, the persistence of initial innovations in countries' own markets have become smaller since the crash in all markets except in London. Volatility was reduced in the Japanese market after the crash, while other markets have experienced greater volatility in their stock price indexes. The Tokyo market is increasingly charting its own course.

Chan, Gup and Pan (1997) examine altogether the integration properties of 18 stock market, including three Scandinavian markets (Finland, Sweden and Norway). They found no significant cointegration for the full sample, which contains aggregate monthly price indexes from the years 1961-1992, or from most estimated subperiods during that time range. Four European markets (the UK, Germany, France and Italy) share one cointegration vector during the period 1970-79 and two cointegration vectors during the period 1980-87, but no cointegration can be observed after the 1987 stock market crash. Thus, in Europe there was increasing cointegration behaviour during the 1980s , but this trend seemed to break up after the October 1987.

Their empirical results have several implications to the hypothesis offered to explain cointegration relationships. First, countries with common economic ties (e.g. European Community countries) may not cointegrate to each other. That means that common economic and geographic ties do not necessarily lead national stock markets to follow the same stochastic trend. The lack of significant cointegration in the overall sample and various subsamples seems not to support this hypothesis.

Second, under the market segmentation argument for integration, the number of significant cointegrating vectors among world stock markets should increase over time because of less market segmentation (e.g. fewer restrictions on cross-country investing, foreign ownership and foreign exchange control) over the last three decades.

The findings of Chan, Gup and Pan (1997) show that some cointegrated markets existed in the world in the 1980s before the 1987 stock market crash. Thus, their evidence seems supportive of the hypothesis that less market segmentation leads to cointegration relationships among international stock markets. Their results also show no increase in the number of significant cointegration relationships after the October 1987 stock market crash, indicating that the contagion effect is not very strong either, which seems to contradict the findings by Jeon and von Furstenberg (1990).

Ammer and Mei (1996) examine interactions between the US and UK markets. For all subperiods the correlation between the two country's stock returns is substantially greater than the correlation of measures of their real output growth. In addition, the contemporaneous correlations between equity returns and output growth are negligible. A comparison of the two subsamples of 1957-1972 and 1973-1989 shows a significant rise in the covariance of US and UK stock returns after fixed exchange rates were abandoned in 1973. The decomposition leads Ammer and Mei to attribute most of the increase in return covariance to greater financial integration in the later period. A similar comparison of the two sub-samples of 1957-1972 and 1979-1989 also shows a significant rise in the covariance of US and UK stock returns after relaxation of capital controls in October 1979. Results suggest that monetary shocks may not be an important source of variation in the real economy. A move to floating exchange rates reduces the obligation of the two central banks to coordinate monetary policy, whereas monetary shocks tend to be common to all countries under fixed rates.

The US and UK markets do not seem to be unusual in having a higher current correlation between their equity returns than between their output growth rates. Ammer and Mei present the correlation matrices for industrial production growth in 15 industrialized economies and for excess dollar returns on their national stock markets. They find evidence that real linkages are much stronger from a long-run perspective than from a short-run perspective. Economies that are geographically proximate are connected quite closely (Switzerland and Germany). There seems to be a high degree of financial integration between Canada and the US, but hardly any real integration.

Japan and the US are among the few pairs for which Ammer and Mei measure negative long-run financial integration. On a mechanical level, this derives from the fact that in the estimated VAR system for these two countries, most of the long-run predictability of stock returns is due to information in dividend-price ratios. Consistent with Campbell and Hamao (1992), they find that for both countries, long-run returns tend to be higher when the own-market dividend-price ration is higher and when the other country's dividend-price ration is lower. Ammer and Mei also find that while the short-term expected returns of the two countries are positively correlated, the long-term expected returns are negatively correlated. This negatively correlation may be partly attributable to the pattern of depreciation of the dollar against the yen.

Ammer and Mei try to develop a new framework in which one could measure both financial and real economic integration by characterizing co-variation between components of returns on national stock markets. They also find that while the variations in equity risk premiums are the principal source of stock return variance in the US, they appear to apply to the UK as well. Second, they find substantial degrees of both real and financial integration between the US and UK economies. Both real and financial linkages are found to be greater after the Bretton Woods arrangement was abandoned in the early 1970s. They also discover that news about future dividend growth in the two countries are more highly correlated than contemporaneous output measures, which is also confirmed by a 15-country application of the methodology. The results imply that contemporaneous output correlations may in general understate the magnitude of real international integration.

Meric and Meric (1996) investigate inter-temporal stability in the long-term co-movement patterns of the world's 18 largest stock markets and conclude that the index return for the 18 stock markets in the 1987-1993 period is significantly different from the index return correlation matrix in the 1980-1986 period. Exchange rate-adjusted logarithms of the monthly index returns (1973-1993, divided into three subperiods) are used for principal components analysis to examine the co-movements of the international stock markets. Box's M statistic is used to test the hypothesis that the index return correlation matrices of the consecutive 7-year sub-periods are significantly different. Box's M is a standard test statistic used in the multiple discriminant analysis (MDA) and multivariate analysis of variance (MANOVA) computer programs to test the equality of the variance-covariance or correlation matrices of different groups of observations. (Meric and Meric 1996, p. 77). Since speculative leads or lags lasting several days in the co-movements of international stock markets can obscure long-term structural relationships, monthly data is more suitable for testing the long-term intertemporal stability of international stock market relationships.

The study by Meric and Meric (1996) suggests that the world's 18 largest stock markets were more closely tied to one another and their co-movements were much more harmonious after the October 1987 stock market crash. Again their study contradicts the results obtained by Chan, Gup and Pan (1997) and points to the importance of the contagion effect after October 1987, as in the same way for example Jeon and von Furstenberg (1990).

Other papers examining international stock market interdependences are for example, Eun and Shim (1989), Hamao et al.(1990) and King and Wadhwani (1990). The papers presented above mainly focus on large financial markets (such as the US, the UK, Japan and Germany). Similar methods can of course be applied to other stock markets, for example, the Latin American, Scandinavian or to the Asian emerging markets. One example is *Chaudhuri (1997a)*, who applies Johansen's cointegration technique to seven Asian emerging markets and finds one common stochastic trend in these markets.

Chaudhuri (1997b) investigates the presence of a long run relationship in stock market prices in six Latin American Markets. In the Latin American Markets supernormal yields, autocorrelated returns and high volatility of prices are typical. These suggest that these markets are not fully integrated into the global financial market and that they are inefficient. First the order of integration of the variables is determined by using the Dickey-Fuller (DF) and the augmented Dickey-Fuller (ADF) tests. In these tests the time trend is also used, because Evans and Savin (1984) highlight the importance of including the time trend even if its estimated coefficient differs insignificantly from zero. Its absence makes the distribution of the unit root test estimate dependent on the characteristics of the unknown constant parameter. The ADF test is estimated with zero, two and with four lags. Critical values are from *McKinnon (1991)*.

Mean reversion is also found. Chaudhuri (1997b) finds evidence of a long run relationship among the stock market prices of six Latin American emerging markets in a bi-variate framework. Granger causality tests indicate bi-directional relationships rather than unidirectional causality, which suggest the absence of weak exogeneity among the stock prices in these markets. This indicates that the

TABLE 3 Summary of the previous studies on international stock market interdependencies

Author(s)	*Countries*	*Data*	*Methods*	*Results*
Eun C.S., Shim S. (1989)	US, UK, GE, JA, CA, AU, FR, HK, SU	1980 - 1985 ; daily	VAR, innovation accounting	The US leads the other markets. The national markets are interdependent.
Jeon B.N., Furstenberg G. (1990)	US, UK, GE, JA	1986 - 1988 ; daily	VAR, innovation acounting (Impulse response function anal.)	Oct 1987 was a structural change. International co-movements increased since Oct 87. Leadership of the US reduced.
Masih A.M., Masih R. (1997)	US, UK, GE, JA, CA, FR	1979 - 1994 ; monthly	VAR, cointegration (Johansen)	One cointegrating vector. International interdependence increased since Oct 87.
Chan K.C., Gup B.E., Pan M-S. (1997)	UK, GE, FR, IT	1961 -19 92 ; monthly	VAR, cointegration (Johansen)	Cointegration increased during 1961 - 1987 no cointegration after Oct 1987
Kasa K. (1992)	US, UK, GE, JA, CA	1974 - 1990 ; monthly, quarterly	VAR, cointegration (Johansen)	Four cointegrating vectors, i.e. one common trend with quarterly data. One cointegrating vector with monthly data.
Ammer J., Mei J. (1996)	US, UK, + 13 other countries	1957 - 1989 ; monthly	VAR, variance decomposition, GMM	Increasing integration between the US and the UKafter the 1973 (end of Bretton Woods) and 1979 (relaxation of capital controls).
Meric I., Meric G. (1996)	18 countries	1973 - 1993 ; monthly	principal components analysis, Box M-test for correlation matrices	International co-movements increased after Oct 1987.
Francis B.B., Leachman L.L. (1998)	US, UK, GE, JA	1974 - 1990 ; monthly	VAR, cointegration (Johansen), exogeneity testing	One cointegrating vector, i.e. three common trends, superexogeneity rejected for all countries.
Chaudhuri K. (1997a)	seven Asian markets	1985 - 1993 ; monthly	Cointegration (Johansen),	Cointegration, six cointegrating vectors, i.e. one common trend.
Chaudhuri K. (1997b)	six Latin American markets	1985 - 1993 ; monthly	Cointegration (Engle-Granger), Granger causality	Cointegration, bidirectional causality.

The following symbols are used: GE=Germany, UK=United Kingdom, US=USA, JA=Japan,CA=Canada, FR=France, IT=Italy, AU=Australia, HK=Hong Kong, SU= Switzerland, W=World index markets are inter-related with each other in long run. Presence of bi-directional causality indicates the presence of a short run relationship but absence of any weakly exogenous variable as the driving force of stock prices in these economies.

It should also be noted that all the research papers presented above (summarized in table 3) use aggregate national stock market indexes to proxy the behaviour of the national stock market behaviour, without practically any discussion on the aggregation process and the effects of this aggregation on estimation results concerning the interdependence modelled. We suspect that the wide aggregate indexes contain very different kinds of industries, as the weightings of industries vary strongly between the national stock exchanges. This leads to results which end up analysing the interrelationships of different industrial sectors (such as the forestry industry in Scandinavia and the strong manufacturing industry in Germany) instead of the international linkages between particular nations.

2.3 Scandinavian stock market integration

Booth, Martikainen, Tse (1995) examine Scandinavian daily stock price indexes and find that the data distributions are not normal. They performed an analysis of the dependencies between the Nordic stock markets based upon daily data for the period from May 1988 to June 1994. They found that the Swedish market appeared to be leading, whereas both Finland and Denmark did not show price or volatility spill-over to the other Nordic markets. They also reported that the markets did not share the same volatility process and were not cointegrated in the long run. This final result partly contradicts the results of *Pynnönen et al.(1995)* who found that the volatility spill-over between the Finnish and Swedish stock markets was highly dependent on the particular time period studied. In their research on Finland's financial market liberalization, *Kallunki and Martikainen (1997)* also point out the tremendous effects of liberalization during the 1990s on the behaviour of the Finnish stock market.

Using a vector autoregression approach, *Bos et al.(1995)* provide empirical evidence on the international co-movements of Finnish stocks based upon monthly returns for 37 stocks for the period 1983-89. Their results indicated that, in particular, the Swedish market leads the Finnish stock market by approximately one or two months. The excess kurtosis and skewness of all the return series indicate that the indexes strongly depend on their past values and exhibit strong ARCH effects. These findings are consistent with the several other papers (e.g. *Frennberg, Hansson (1993); Booth, Chowdhury, Martikainen (1994)*). The correlation coefficients between the markets are all different from zero. The highest correlations are reported between the Swedish and the other markets. It seems that Denmark has economically differed from the three other countries because it has been a member of the EU since the 1970s. Booth et al. (1995) and *Knif et al.(1995)* study the Scandinavian stock markets and Bos et al.(1995) the international co-movements of Finnish stocks.

The first study to suggest that foreign (Swedish) stock returns predict

Finnish returns was that by *Virtanen and Yli-Olli (1987)*. *Yli-Olli et al.(1990)* later used the arbitrage pricing model to investigate the common factors in Finnish and Swedish stock markets, and were able to identify two or three stable factors generating stock returns in these two neighbouring countries. *Pynnönen and Knif (1998)* study the stock markets of Finland and Sweden over the period 1920-1994. Their results indicate that no evident cointegration or even fractional cointegration between the markets exists. An analysis of short-term dynamics indicates that virtually all shock impulses are absorbed in both markets within one month. Sub-period analyses reveal increasing instantaneous causality between the markets over the passage of time, whereas no meaningful Granger-causality is found.

According the study by Booth, Martikainen, Tse (1995) the Scandinavian stock markets are not cointegrated, and while price changes in Sweden and Norway spill-over to other markets, those in Finland do not. It appears that the four markets are not very strongly related to each other informationally in terms of price spill-over. Not a single pair of markets indicate a two-way price spillover. It seems that despite the ongoing increase in the globalization of financial transactions all over the world, financial markets may not be informally as integrated as one might think (Booth, Martikainen, Tse 1995, p. 21).

Malkamäki (1993) consists in fact of four different papers, the third of which is the most important in relation to my study. This essay: "Cointegration and causality of stock markets in two small open economies and their major trading partners", was also published in the Bank of Finland research department series of discussion papers, as no. 16/1992. This essay examines the time-series predictability of Finnish stock market returns. Cointegration and Granger causality analysis is done for the stock markets of the US, UK, Germany, Sweden and Finland. Standard VAR modeling using the Johansen (1988) procedure for testing cointegration is used. The data used in Malkamäki (1993) are end-of-month stock market logarithmic aggregate price indexes in local currencies which are constructed by Morgan Stanley Capital International. Analyses are conducted using the indexes in local currencies, US dollars and Finnish markkas, and the foreign exchange risk is not hedged.

Malkamäki (1993) applies Johansen's (1988) multivariate cointegration and Granger causality analysis to stock markets in the US, the UK, Germany, Sweden and Finland. As usual in international interdependence studies, aggregate stock market indexes are used, without any discussion on the differences concerning the various industries and segments of the national economies and the validity of using aggregate equity indexes in representing the whole national economy.

He finds that the stock markets are cointegrated, having one common vector when prices are measured in local currencies or in Finnish markkas, and two common vectors when prices are in US dollars, and that the Finnish market may deviate from an equilibrium path without having a significant impact on the other markets, which indicates that the causality is from the other markets to Finland. The Finnish stock market is also found to be predicted by the German market, instead of the Swedish market, as previously suggested, and also by the UK market when returns are in local currencies or in Finnish markkas. The Swedish stock market is Granger caused by the UK market instead of the US market. These results are not sensitive to inflation differences, since all the analyses were performed on nominal and real stock market indexes. All the tests are computed over the returns denominated in local currencies, US dollars and Finnish markkas, in both nominal and excess forms.

The results from the Granger causality analysis of returns in all three currencies contradicts the prior results of *Mathur and Subrahmanyam (1990, 1991)*. They emphasized that Sweden's stock market index leads Finland's. In contrast, Malkamäki (1993) finds that the Finnish stock market is in all cases led by the German market, as well as by the UK market (when returns are measured in local currencies or in Finnish markkas). This dilemma may be due to the fact that the construction of the data differs in these two studies. Malkamäki (1993) used end-of-month returns for all the countries, and a lower number of lags, while Mathur and Subrahmanyam (1990, 1991) used somewhat mixed data. (Malkamäki 1993, p.109).

Hietala (1989), Mathur and Subrahmanyam (1990, 1991) and *Malkamäki, Martikainen, Perttunen, Puttonen (1993)* have emphasized that the Nordic stock markets are less than fully integrated. Hietala (1989) investigated the international betas for Finnish stocks by regressing the returns of Finnish stocks to a global market portfolio, estimated in terms of the return on the value-weighted world index. The results revealed very low correlations between the returns on Finnish stocks and those of the world market portfolio. Hietala saw the legal restrictions in force in Finland in the mid-1980s as the main reason for this.

Mathur and Subrahmanyam (1990, 1991) employed the Granger causality procedure to analyse interdependencies among Danish, Finnish, Norwegian and Swedish stock market indexes. They used monthly (average, mid-month or end-of-month) data provided in IMF statistics for 1974-1985. The first (1990) paper used a VAR model and the 1991 paper the seemingly unrelated (SUR) procedure and found that the Swedish market index led the indexes in Finland, Denmark (not in 1990 paper !) and Norway. The Norwegian market influenced the Danish and Swedish markets in the 1991 paper (but not in 1990), whereas the Danish and Finnish markets did not influence any other markets. However cointegration was not tested and the quality of their data was mixed.

Contradictionary to the findings of Malkamäki, Martikainen, Perttunen, Puttonen (1991), Malkamäki (1993) suggests that the Swedish stock market is Granger-caused by the UK market instead of the US market. This may be due to data differences, since Malkamäki, Martikainen, Perttunen, Puttonen (1993) used daily data from 1988-1990. According the paper from Malkamäki (1993) the US stock market is always able to predict the German market. The German stock market was also led by the Swedish stock market in all currencies. Some evidence was also found that the German index was able to predict the UK stock market. (Malkamäki 1993, p.109).

Malkamäki, Martikainen, Perttunen, Puttonen (1993) used daily stock returns measured in US dollars for February 1988 - April 1990 and also included the world stock index in the analysis. Their preliminary analysis produced rather similar results regarding the correlation structure of market returns, regardless of whether local currencies or dollar values were used.

TABLE 4 Summary of the previous studies on Scandinavian stock market interdependencies

Author(s)	*Countries*	*Data*	*Methods*	*Results*
Mathur I., Subrahmanyam V. (1990)	FI, SW, NO, DE, US	1974 - 85 ; monthly	VAR, Granger causality	Sweden leads Finland and Norway USA leads Denmark
Mathur I., Subrahmanyam V. (1991)	FI, SW, NO, DE	1974 - 85 ; monthly	SUR, Granger caus.	Sweden leads Finland, Norway and Denmark Norway leads Sweden and Denmark
Malkamäki M.J., Martikainen T., Perttunen J., Puttonen V. (1993)	FI, SW, NO, DE, W	1988 (Feb) - 1990 (Apr) ; daily	Granger caus., cointegration (Engle-Granger 1987)	Sweden leads Finland, Norway and Denmark no cointegration
Malkamäki M.J. (1993)	FI, SW, GE, UK, US	1974 - 89 ; monthly, (in $ and local currencies)	VAR, cointegration (Johansen 1988)	Germany and UK lead Finland UK leads Sweden Sweden and US lead Germany Germany leads UK markets cointegrated
Booth G.G., Martikainen T., Tse Y. (1995)	FI, SW, NO, DE	1988 - 94 ; daily	VAR, cointegration (Johansen)	Sweden leads Finland Norway leads Sweden and Denmark no cointegration
Bos T., Fetherston T.A., Martikainen T., Perttunen J. (1995)	FI, SW, US	1983 - 1989 ; monthly	VAR, cointegration (Johansen), innovation accounting	Sweden leads Finland no cointegration
Chan K.C., Gup B.E., Pan M-S. (1997)	FI, SW, NO	1961 - 92 ; monthly	VAR, cointegration (Johansen)	no cointegration
Pynnönen S., Knif J. (1998)	FI, SW	1920 - 94 ; monthly	VAR, cointegration (Johansen), innovation accounting	no Granger causality no cointegration increasing instantaneous causality

The following symbols for the stock index series are used: FI= Finland, SW= Sweden, NO= Norway, DE= Denmark, GE=Germany, UK=United Kingdom, US=USA, W=World index

This also supports the work of Mathur and Subrahmanyam (1991), which found no significant influence on the empirical results in this respect. They employed the single equation approach and tested for cointegration by using the Engle-Granger (1987) two-step procedure. They found no cointegration among the indexes but again found that the Swedish stock market led the other Scandinavian markets. However, the other Scandinavian markets did not significantly influence any other markets. The worldwide returns were found to have leading causality for Scandinavian stock market returns.

Malkamäki (1993) notes that from the paper by Kasa (1992) one would expect the stock markets of all industrialized western countries to move together in the long run, i.e. that the indexes studied here are cointegrated and cannot drift too far from the equilibrium path. If the stock markets are cointegrated and share a common stochastic trend, long-term gains to international diversification among them are smaller than they would otherwise be, assuming that transitory deviations from a trend do not persist too long and that investors have a finite horizon. Full stock market integration would imply that risk-adjusted stock returns denominated in the numeraire currency are equal in all countries.

Malkamäki (1993) suggests that, one would expect that at least the stock markets of the US and UK to be fully integrated since both markets are of reasonable size and there have not been any significant restrictions on capital movements between them. Regulations have prevented foreign investors from having free access to the Finnish and Swedish stock markets. Furthermore, these markets, as well as the German stock market, have been marked by low capitalization and illiquidity. Such markets are typically characterized by non-synchronous trading. Therefore, one would not necessarily expect the Finnish and Swedish stock markets in particular to be fully integrated with the US and UK stock markets. If the stock markets of Finland and Sweden are not fully integrated, we would expect them to be Granger-caused by the stock markets of their major trading partners, namely Germany, the US and the UK (Malkamäki 1993, p.108-109).

3 METHODOLOGY AND DATA

3.1 Granger causality

If cointegration exists between two variables, then causality must be present in both or at least one direction. *Chaudhuri (1997b)*, for example, uses the Granger causality test. The series x fails to Granger-cause y if in a regression of y on lagged y's and lagged x's, the coefficients of the latter are zero. Chaudhuri (1997b) builds up an error-correction mechanism (ECM) from the Granger representation theorem (*Engle, Granger, 1987*). The test of Granger causality boils down to the significance of the lagged coefficient of the residual from the static regression for the levels of variables. The quantity of that coefficient also gives information about the speed of adjustment, which differs among the countries in this study.

Although the cross-correlation coefficients provide valuable information concerning the relationship between the two time series, they do not test for direct causality. They do not answer the question of whether some market returns lead the returns on certain other markets or vice versa. The Granger causality test has received the most attention. According to the Granger causality test procedure the hypothesis that {Yt} causes {Xt} can be examined by regressing {Xt} on lagged {Xt} and lagged {Yt}, and testing the joint hypothesis of the lagged values of {Yt}.

The standard Granger causality test includes differenced series only, i.e. stock returns, because the Granger causality tests assume stationary time-series. However, it does not indicate whether the level series, i.e. logarithmic stock price indexes, show any common trend. If the level series are cointegrated, an error correction term should be included as an additional regressor to the causality tests. This error-correction term is the residual term from the co-integration equation $P1_t = \lambda P2_t + \lambda t + \epsilon_t$, where P1 and P2 are level series. This is because the causality between markets may otherwise be underestimated, by ignoring the common trend in price series.

Time series used in Granger causality analysis should be stationary in order to apply standard inference techniques. Differencing the logarithmic stock prices once usually produces stationarity. *Granger (1981)* showed that even in the case when all the variables in a vector are stationary only after differencing, there may be linear combinations of those variables which are stationary without differencing, i.e. the variables may be cointegtrated. Cointegration of a vector of variables implies that the number of unit roots in the system is less than the number of unit roots in the corresponding univariate series. This implies that the variables share at least one common (stochastic) trend. Engle and Granger (1987) showed that a cointegrated system can be represented in an error-correction structure that incorporates both changes and levels of variables such that all the elements are stationary. The levels of variables contain long-term information, which is lost when differencing the data, except in the unlikely event that short-term effects are identical to long-term effects.

Error-correction models (ECM) allow for testing the possibility of differences in short-run and long-run dynamics. If a set of variables is cointegrated, the ECM term should be included in the dynamic model, otherwise the model is mis-specified since relevant information is omitted. Cointegration tests can be done using e.g. the Engle-Granger (1987) two-step procedure or Johansen's (1988) efficient autoregressive formulation of the multivariate ECM (later refined in *Johansen and Juselius (1990), Johansen (1991)* and *Johansen (1992)*). His multivariate cointegration approach allows for the simultaneous analysis of hypothetical long-run relations and short-term dynamics, using a maximum likelihood estimation procedure. This approach relaxes the assumption that the cointegrating vector is unique and takes into account the error structure of the underlying process. It also allows for several tests regarding the cointegrating vectors and for tests of weak exogeneity among the variables. Other methods for cointegration testing, however, also exist.

3.2 Johansen cointegration methodology

A good informal discussion of Johansen's maximum likelihood approach to testing for integration is presented by *Kasa (1992)*. The full details are in *Johansen (1988, 1990, 1995)*. In the analysis all the long-run information in the X_t process is summarized by the long-run impact matrix, Π, and it is the rank of this matrix that determines the number of cointegrating vectors. Johansen's (1988) procedure for testing the number of cointegrating relationships is equal to determining the number of non-stationary common trends. Let the vector of variables under examination be X_t, which is a p x 1 vector of I(1) variables, and we assume that the data can be described by a k-dimensional vector autoregressive process with possibly non-zero drift.

In order to distinguish between stationarity by linear combinations (cointegration) and by differencing, we express the model as

$$\Delta X_t = -u + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} - \Pi X_{t-k} + \epsilon_t$$

The cases to be considered are

1. Rank(Π) = p, which implies that vector X is stationary
2. Rank(Π) = 0, which implies the absence of any stationary long-run relations among the elements of X.
3. Rank(Π) = r < p, where r determines the number of cointegrating relationships.

The value of p - r denotes the number of non-stationary common trends in the variables. When r < p, the equation also has an error correction representation where $\Pi = \alpha\beta'$ (Engle, Granger, 1987).

Johansen's test procedure for determining the number of cointegrating relationships is equivalent to estimation of the rank of Π. Johansen derives two tests of the hypothesis that there are at most r cointegrating relationships: trace and maximum eigenvalue tests. It is also possible to test for the absence of the deterministic trend. In the estimations of this study, restrictions on system variables (constant and possible trend) are considered each time, but most times the constant enters the system as an unrestricted variable and the trend is restricted if required. The test for weak exogeneity of the *n*th variable ($n \leq p$) is a test on the coefficients of the *n*th row of the α matrix. If r linearly independent cointegrating vectors in a group of n stock markets is found, then we can define n - r common stochastic trends from the linear combinations of the markets lying in the orthogonal complement of the cointegration space.

In the method by Johansen (1988) the estimated eigenvalues essentially measure how strongly the linear combination vX_{t-k} is correlated with the stationary part of the process. If vX_{t-k} is nonstationary, this correlation tends to zero. The columns of β are eigenvectors. The trace test takes account of all n - q of the smallest eigenvalues, it will tend to have greater power than a maximum eigenvalue test when eigenvalues λ are evenly distributed. On the other hand, a maximum eigenvalue test will tend to give better results when the λ are either large or small. In practice, the value of r is best chosen by a judicious consideration of both statistics, along with an inspection of the eigenvalues themselves.

3.3 Innovation accounting

This paper also makes uses of the impulse response function analysis technique.This technique allows the tracing out of the time path of the various shocks on the variables contained in the vector autoregressive (VAR) system. Impulse response analysis uses the fact that a VAR model can also have a vector moving average representation. The moving average representation of a VAR system can be written in terms of the pure innovations (ϵ_t) in the structural (primitive) system variables. Hence, for a VAR system of variables y_t and z_t , the moving average representation can be written in terms of the ϵ_{yt} and ϵ_{zt} sequences and the vector x_t, containing the variables y_t and z_t:

$$x_t = \mu + \sum \phi_i \epsilon_{t-i}$$

The moving average representation is an especially useful tool in examining the interaction between the y_t and z_t sequences. The coefficients of ϕ can be used to generate the effects of ϵ_{yt} and ϵ_{zt} shocks on the entire time paths of the $\{y_t\}$ and $\{z_t\}$ sequences. The elements of ϕ are impact multipliers. The sets of coefficients ϕ are called the impulse response functions. Plotting the impulse response functions (i.e., plotting the coefficients of $\phi(i)$ against i) is a practical way to visually represent the behaviour of the $\{y_t\}$ and $\{z_t\}$ series in response to the various shocks. The important restraint is that a structural VAR is under-identified, otherwise it would be possible to trace out the time paths of the effects of pure ϵ_{yt} and ϵ_{zt} shocks. An additional restriction on the two variable VAR-system must be imposed.

One possible identification restriction is to use the Choleski decomposition, which constrains the system such that an ϵ_{yt} shock has no direct effect on z_t, which means that there is an indirect effect, in that lagged values of y_t affect the contemporaneous value of z_t. The key point is that the decomposition forces a potentially important asymmetry on the system since an ϵ_{zt} shock has contemporaneous effects on both y_t and z_t (of course decomposition can also be done other way around).

The importance of the ordering depends on the magnitude of the correlation coefficient between the residuals. The simple rule of thumb is that if $|\rho| > 0.2$, the usual procedure is to obtain the impulse response function using a particular ordering and then compare the results to the impulse response function obtained by reversing the ordering. If the implications are quite different, additional investigation into the relationships between the variables is necessary.

Another useful tool can be developed if we want to forecast the various values of x_{t+i} conditional on the observed value of x_t and then to write the associated forecast errors in terms of the ϵ_{yt} and ϵ_{zt} shocks. The forecast error variance decomposition tells us the proportion of the movements in a sequence due to its own shocks versus shocks to the other variable. If ϵ_{zt} shocks explain none of the forecast error variance of y_t at all forecast horizons, we can say that the y_t sequence is exogenous. In such a circumstance, the y_t sequence would evolve independently of the ϵ_{zt} shocks and of the y_t sequence. At the other extreme, ϵ_{zt} shocks could explain all of the forecast error variance in the y_t sequence at all forecast horizons so that y_t would be entirely endogenous.

Quite often a variable explains almost all of its forecast error variance over short horizons and smaller proportions over longer horizons. Again we face the problem of estimating an under-identified VAR system. The alternative Cholesky decomposition orderings have large effects over a short period, but these effects are reduced over longer forecasting horizons. It is useful to examine the variance decomposition over various forecast horizons. As the length of the forecast horizon increases, the variance decompositions should converge. If the correlation coefficient is significantly different from zero, it is useful to obtain the variance decompositions under various orderings. The analysis of impulse response functions and variance decompositions is called innovation accounting.

3.4 Various decomposition methods

Even though the contemporaneous values of all the variables do not appear on the right-hand side of the VAR model, contemporaneous correlations between the variables in the system are captured in the covariance matrix of the disturbance terms. The contemporaneous correlation matrix needs to be decomposed to allow for OLS-estimation and economic interpretation. One device for dealing with this difficulty is the triangular orthogonalization of the innovation matrix, also better known as Cholesky decomposition. Different orders of variables in the system produce different results. A causal chain is, therefore, implicitly assumed to have a specific ordering of variables.

One advantage of VAR analysis is that it is suited to studying the dynamic response of a system to shocks. Analysis of the pattern of innovations and responses in different markets can be precisely performed by the impulse response function (IRF) analysis and variance decomposition available in the VAR model. The IRF's show the current and subsequent effects of innovation in a given variable on all variables in the system. The orthogonalized impulses are in this study equal to one standard deviation of the variable that is shocked. The size of contemporaneous shocks to other markets is determined by the size of the contemporaneous correlation coefficients of innovations.

The Cholesky decomposition leads always to an exactly identified system of innovations. Estimating the system of four Scandinavian stock market indexes, using the Cholesky decomposition ordering implied by the β restriction tests (table 63), we assume the correct way to model the contemporaneous relationships between the forecast errors and the structural innovations to be

$$e_{sw\,t} = \epsilon_{sw\,t}$$
$$e_{no\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t}$$
$$e_{de\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t} + \epsilon_{de\,t}$$
$$e_{fi\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t} + \epsilon_{de\,t} + \epsilon_{fi\,t}$$

where the e_t-terms are the errors from the vector autoregressive model estimated in standard form (which can be identified and estimated). These reduced-form shocks are the composites of the pure innovations, ϵ_t, of the structural VAR (primitive system).

The 4x4-matrix requires a total of $(n^2\text{-}n)/2$ restrictions, which means here exactly 6 restrictions attained by Cholesky decomposition, but the Cholesky decomposition is only one possible type of identification restriction. With a system of four independent equations any other six linearly independent restrictions will allow for the identification of the structural model. One alternative method is to form an over-identified Sims-Bernanke system, which also allows performance of the likelihood ratio tests of the restrictions applied (a good review of the method is in *Enders (1995), pp.305-343)*. The estimation results for the contemporary interrelationships in the VAR system may be used to assume the correct economic model for the decomposition restriction ordering. According to the estimation results (see table 26), the most often suggested alternative way of modeling the relations between the structural innovations and the forecast errors would be a Sims-Bernanke decomposition of the form

$e_{sw\,t} = \epsilon_{sw\,t}$
$e_{no\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t}$
$e_{de\,t} = \epsilon_{de\,t}$
$e_{fi\,t} = \epsilon_{de\,t} + \epsilon_{fi\,t}$

This is referred to below as S-Bα decomposition. This over-identifying decomposition ordering implies a similar ordering to that of the Cholesky decomposition, but the contemporary effects are allowed to exist only from Sweden to Norway and from Denmark to Finland. This assumption is supported by table 26. Alternative, but less promising, are the following options, denoted as S-Bβ and S-Bγ, respectively

$e_{sw\,t} = \epsilon_{sw\,t}$
$e_{no\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t}$
$e_{de\,t} = \epsilon_{de\,t}$
$e_{fi\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t} + \epsilon_{de\,t} + \epsilon_{fi\,t}$

where Sweden affects contemporaneously Norway and Finland, and both Norway and Denmark affect Finland. This S-Bβ ordering includes less over-identifying restrictions than the S-Bα option.

S-Bγ is formulated as
$e_{sw\,t} = \epsilon_{sw\,t}$
$e_{no\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t}$
$e_{de\,t} = \epsilon_{sw\,t} + \epsilon_{de\,t}$
$e_{fi\,t} = \epsilon_{sw\,t} + \epsilon_{no\,t} + \epsilon_{de\,t} + \epsilon_{fi\,t}$

where the contemporary effect from Sweden to Denmark is also included, compared to previous S-Bβ ordering.

To compare the alternative ordering procedures and their impulse response effects and results, the innovation response functions are estimated. A special maximum impulse response index is used to quantify the maximum responses attained after the initial shock. A time period that can be observed after the maximum response, is denoted as a subindex.

Thus the maximum impulse response index (denoted here as I_λ) can be defined as

$$I_\lambda = 100 * [\ \mathrm{Max}\ \{\phi_{jk}(i)\}_{\max t}\ / \phi_o\ ]$$

where the subindex "max t" refers to the period after the maximum response was attained and o refers to the specific variable in which the original shock occurs. The index developed here is useful for filtering out the final largest effect that the initial shock caused from the massive output of the statistical software results. It can thus be used to conclude the impulse effects of a single innovation in one defined market to the other markets using a single quantitative measure. This measure can be also used to analyze the effects of various decomposition orderings; the value of I_λ index, however, should remain quite stable even when the orderings change definitely. Large variability in the value of I_λ 's, calculated by using very different orderings, imply that the effects are not strong but can only be observed when particular orderings are used. Such results should be regarded with caution.

On the other hand, if the calculated values of I_λ -index remain rather similar, even when very different decomposition orderings are used, we can define the strong innovation effects as valid and significant. Similar reasoning applies to the "max t" value. The period after which the maximum effect can be observed should be quite stable unless the ordering differences have a strong effect to the results, implying an unsignificant relationship between the market innovations. The I_λ index value has a definite economic interpretation, while the value of I_λ gives the percentage maximum observed after the initial shock in the particular market.

3.5 Aggregate data applied

Interdependences among the Scandinavian stock markets are examined using the vector autoregressive modeling (VAR) technique. Of the Scandinavian countries I use market indexes of Finland, Sweden, Norway and Denmark. Iceland's stock markets are too thinly traded and still under the process of being established to be included in this study. These indexes are combined in a multivariate econometric system and the VAR models attained are analysed using the multivariate cointegration approach by *Johansen (1988, 1991, 1995)* and *Johansen and Juselius (1990, 1992)*, which allows for the analysis of hypothetical long-run relations and short-term dynamics simultaneously.

Monthly prices for the aggregate stock indexes for the period January 1990 - February 1998 were obtained from the ETLA data bank and the daily data from Bloomberg. Following the rationale provided by Fama, log differences of the stock prices rather than the first differences of the stock prices were utilized in the study to assure the Gaussian error process. Logarithmic first differences of the stock index series are interpreted as stock market returns. This data formation procedure is in line with the preceding studies on Scandinavian stock market integration and therefore also in this study the stock market data is in market model form, not in excess return structure. While the excess return form (where the nominal risk-free rate of interest is subtracted from the return on securities series) is popular in financial analysis, a simpler market model is applied here, to be able to contrast the estimation results obtained with the preceding analyses. The excess return form is more useful when analysing single securities and not indexes as in this study. The analyses with the monthly data are conducted using both indexes in local currencies and in US dollars. I also examine the models also from the dollar investor's point of view to consider foreign exchange risk hedging.

To be able to examine the effects of the global and European financial markets on the Scandinavian stock markets, the monthly and daily stock market indexes of Germany, the United Kingdom (UK) and the United States (US) are applied. These three variables are treated as exogenous variables in the Scandinavian VAR system. This assumption of the exogeneity of the German, UK and US stock markets in relation to the Scandinavian markets is probably best supported by common sense, as the Scandinavian stock markets are so small and peripheral, that possible causal effects most probably come from the large markets to Scandinavia and not other way around.

While the estimation period used is relatively short (consisting of 98 periods for the monthly data) the application of a seven-variable VAR system would not be appropriate. This is the reason why a four-variable VAR system with the stock market index variables of Germany, the UK and the US, entering the system as exogenous variables is applied in this study. The appropriate lag structure for the exogenous variables is selected according the LR-and t-tests. All the estimations are done by using the stock market index variables in logarithmic form and denominated in both local and US currencies.

The US stock market index (Dow-Jones Industrial Average index) is used as a proxy for the global stock market, because the US is the largest stock market in the world, and the degree of integration of a particular Scandinavian stock market with that proxy can be seen as a sign of globalization of that particular market, meaning that the national stock market is open to global effects and impulses. The largest stock exchange in Europe is in London, so the quantity of an integration with the UK stock index series is here assumed to be a sign of openness to aggregate European stock market impulses. The German stock market index is also included in this study, as Germany forms the largest stock market in the European Monetary Union (EMU) and is the second largest (after the UK) in the whole of Europe. The differences in the relationships between the effects coming from Germany versus the effects from the UK can give hints of the degree of importance of European monetary integration to the particular Scandinavian stock market.

The following symbols for the national aggregate stock index series are used: FI= Finland, SW= Sweden, NO= Norway, DE= Denmark. The series applied are also graphed in figures 2 and 3, (in appendix). It should also be noted that the index series applied in this study are similar to the data used in preceding studies on international stock market linkages, in the sense that only aggregate national stock market indexes are used. Nevertheless, these national stock exchanges in Scandinavia have very different industry structures, which could lead to results which rather than reveal accurate information on Scandinavian financial integration more likely reflect the process of index series aggregation and the differences in industry structures.

3.6 Problems with using aggregate data

Previous studies have used aggregate stock market indexes to present the behaviour of the single countries stock markets in a single data set. This has been an extremely convenient way to compare the stock market behaviour in different geographical areas, but this aggregation also has apparent drawbacks. Different stock indexes contain very different mixes of industries and economic segments, leading to results which present the behaviour of different industries rather than the stock market of a particular country.

Firstly, in this study, the characteristics of the national aggregate stock indexes are presented to reveal the underlying differences with respect to industry weightings in the Scandinavian stock markets. It seems that each Scandinavian stock market has its own character, as the core industries of each national economy are reflected in the main company lists of the stock exchanges. Secondly, we summarize these properties to enable comparison between the Scandinavian stock markets. The utilisation of wide aggregate stock market indexes clearly appears to be a dubious method for analysing Scandinavian stock market integration, as the economies (and therefore also the stock exchanges) differ to a large extent.

3.6.1 The Finnish aggregate stock index, HEX

The most widely used Finnish stock market index is the HEX general index, which was started with a base level of 1000 as of December 28, 1990. The HEX also practically replaced the UNITAS index, which previously was the most widely used. The HEX-index is a capitalization-weighted index consisting of all the securities traded on the Finnish stock exchange. It is a broad-based index, which is broken down into seven industry groups and has 124 members.

The following table presents the 10 largest members of the index with their weightings (these weightings represent the weights as of the late 1990s):

TABLE 5 Members of the Finnish HEX index

Equity	Industry	Weight
Nokia	Telecom	67,7 %
Sonera	Telecom	8,5 %
UPM-Kymmene	Forestry	2,4 %
Stora Enso	Forestry	2,4 %
Helsinki Telephone Comp.	Telecom	1,7 %
Merita (Nordic Baltic Holding)	Bank and Finance	1,4 %
Fortum	Energy	1,0 %
Sampo Insurance	Insurance	0,8 %
Sanoma-WSOY	Media and Publishing	0,8 %
Tietoenator	IT-Consulting	0,8 %

As seen from the table above, the telecommunications industry is clearly over-represented in the HEX index, accounting for 78.8 % of the whole index. The forestry industry accounts for 5.9 % and banking sector 1.8 %.

3.6.2 The Swedish aggregate stock index, OMX

The Stockholm Options Market Index is a capitalization-weighted index of the 30 stocks that have the largest trading volume on the Stockholm Stock Exchange. The index was started with base level of 125 as of September 30, 1986. The index has no sub-groups.

TABLE 6 Members of the Swedish OMX index

Equity	Industry	Weight
Ericsson	Telecom	40,3 %
Telia	Telecom	6,4 %
AstraZeneca Plc	Pharmacy	6,4 %
Nordbanken	Bank and Finance	6,2 %
Skandia Forsakring	Insurance	5,4 %
Hennes & Mauritz	Retail	3,9 %
Svenska Handelsbanken	Bank and Finance	2,8 %
Nokia	Telecom	2,8 %
ABB Ltd.	Engineering and machinery	2,6 %
Foreningssparbanken	Bank and Finance	2,4 %

The Swedish aggregate stock index is also very loaded with telecom sector companies, as 51.6 % of index is weighted by telecom stocks. Banking sector accounts for 15.1% of the aggregate index, while conventional manufacturing industry (including auto-industry) has a weighting of 9.9%, pharmaceutical companies 7.7% and forestry 2.1%.

3.6.3 The Norwegian aggregate stock index, OBX

The OBX Index is a capitalization-weighted index of the largest companies traded on the Oslo Stock Exchange. The index was started with a base value of 200 as of January 1, 1987. It has no industry groups or sub-division. The Norwegian aggregate stock index is much more diversified and balanced than either the Finnish and Swedish indexes. The most weighted industry is energy (including Norsk Hydro), which accounts for 21.1% of total index. Banking and Finance sector account for 15.9%, transportation 13.5% and the food industry 11.6%. The telecom sector (Tandberg) accounts for only 3.4%, the forestry industry 2.9%, pharmaceuticals 4.2% and insurance 5.1%.

TABLE 7 Members of the Norwegian OBX index

Equity	Industry	Weight
Norsk Hydro	Multi-industry	15,5 %
Orkla	Food	9,4 %
Den Danske Bank Holding	Bank and Finance	8,6 %
Christiania Bank	Bank and Finance	7,3 %
Tomra Systems	Recycling	6,4 %
Opticom	Optical equipment	5,9 %
Storebrand	Insurance	5,1 %
PetroleumGeo	Energy	4,7 %
Royal Caribbean	Transportation	4,3 %
Nycomed Amersham	Pharma	4,2 %

3.6.4 The Danish aggregate stock index, KFX

The KFX Index is a capitalization-weighted index of the most liquid stocks traded on the Copenhagen Stock Exchange. The components are picked from a basic portfolio of 20 stocks. The index was started with a base value of 100 as of July 3, 1989. KFX index is not divided into subgroups.

TABLE 8 Members of the Danish KFX index

Equity	Industry	Weight
Novo-Nordisk A/S	Pharma	17,1 %
Tele Danmark A/S	Telecom	15,8 %
D/S 1912	Transportation	8,2 %
Den Danske Bank	Bank and Finance	8,2 %
Dampskibsselkabe	Transportation	7,9 %
Unidanmark A/S	Bank and Finance	7,8 %
GN Store Nord	Telecom	5,5 %
Vestas Wind System	Energy	5,2 %
H.Lundbeck A/S	Pharma	4,3 %
ISS A/S	Commercial Services	3,3 %

Most important industry in the KFX is the pharmaceutical industry, with an index weighting of 25.7%. The telecom industry is weighted at 21.3%, the banking and finance sector 18.2% and the transport industry 16.1%. The energy sector has a weighting of 6.3% and the food industry 2.5%.

3.6.5 The importance of index structure

Each Nordic aggregate stock index seems to have unique properties concerning the industry weighting structures. Finland's HEX index is clearly highly loaded with telecommunications equities, while Norway's OBX index is not (telecom accounts for only 3.4%). Banking equities have weightings of over 15% in all the Nordic aggregate stock indexes, except in Finland. The pharmaceutical industry is the most important segment in Denmark, but quite minor in all other Nordic regions. Similarly, the energy and food sectors are typical of the Norwegian stock market, while practically non-existent in the other Nordic aggregate stock indexes. Transportation seems to be important for both Norway and Denmark, but is practically non-existent in Sweden and Finland. The table below summarises the industry weightings of the aggregate Nordic stock indexes:

TABLE 9 Industry structures of the aggregate Nordic indexes

Industry / %-weights	FI	SW	NO	DE
Telecom	78.8	51.6	3.4	21.3
Banking & Finance	1.8	15.1	15.9	18.2
Forestry	5.9	2.1	2.9	-
Pharmaceutical	0.5	7.7	4.2	25.7
Energy	1.2	-	21.1	6.3
Transportation	0.4	-	13.5	16.1
Food	0.5	-	11.6	2.5

These large variations in the weightings of the Nordic aggregate stock indexes imply very different index behaviour processes. If the similarities in Nordic stock market behaviours are to be analysed, this must apparently be done at industry level, not aggregate level, as the aggregate indexes vary greatly in respect of industry weightings. Any possible co-integration or convergence behaviours found in the Nordic aggregate stock index data imply less the actual co-integration of the Nordic stock markets, but rather the process of aggregating and engineering the index itself.

Nevertheless, aggregate stock indexes are still very commonly used when international stock market linkages are analysed. My findings suggest that researchers must pay more attention to the similarities and dissimilarities in the structure of the indexes and use industry-specific stock market indexes rather than aggregate indexes, which contain all the industries in a single data set. Due to this aggregation, information on industry-specific stock market behaviour is lost, and this information is in fact the only essential information with regard to the co-integration properties of international stock markets.

To demonstrate the importance of the aggregate index weighting structure for the analysis of the interrelationship between international stock market indexes, we have performed a simple Monte Carlo type of simulation for the alternative aggregate Helsinki Stock Exchange index (HEX) weightings. As the HEX index is strongly loaded with technology equities (e.g. Nokia), that weighting structure determines the correlation results. If the weighting structure were different, the correlation coefficients would also apparently change. In this example, I relate the HEX index to the most commonly used US aggregate stock index, the Dow Jones Industrial Average. Randomly generated weightings were assigned to all the HEX index member stocks (estimation period 7:1991-2:1998) to generate 10 000 simulated HEX indexes. Correlation coefficients between the simulated HEX indexes and actual Dow Jones index were calculated. Results are presented below:

TABLE 10 Simulation results

Simulated correlation distribution	
Mean	0,937312783
Standard Error	0,000123642
Median	0,939302707
Standard Deviation	0,012364199
Sample Variance	0,000152873
Kurtosis	2,152765388
Skewness	-1,129271096
Range	0,112625388
Minimum	0,851212702
Maximum	0,963838089
Sum	9373,127833
Count	10000

The actual correlation coefficient between the real HEX and Dow Jones index is 0.93. Stock market behaviour during the 1990s in all the HEX member stocks and Dow Jones is quite similar (presenting an upward sloping trend), but the range of the calculated correlation coefficients in randomly simulated series is very wide (from 0.85 to 0.96). This indicates that the different equity weights in aggregate indexes generate clearly different series. Therefore, correlation coefficients between the indexes tell us more about the industry weights than about the development of national equities.

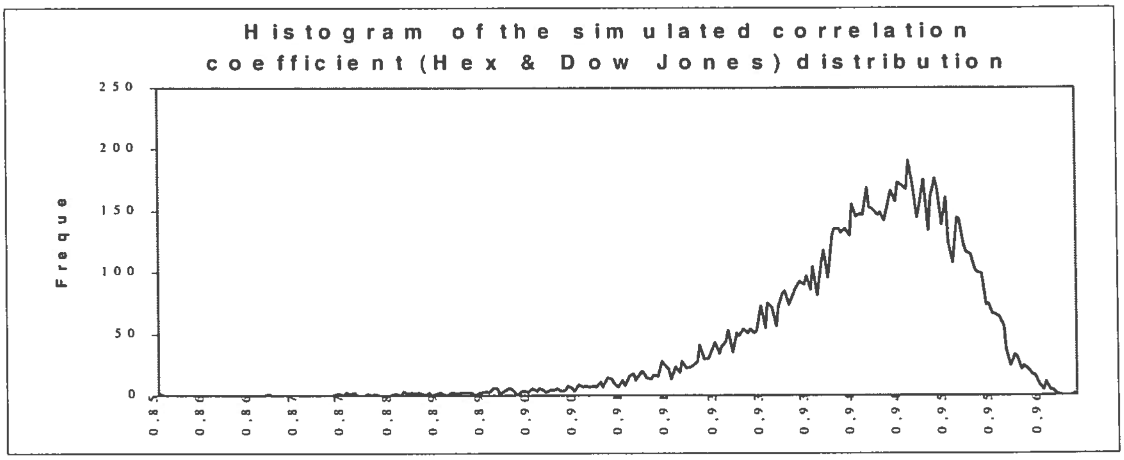

FIGURE 1 Simulated correlation coefficient

3.7 Data sets on Banking and Telecom industries applied

Because we consider the use of aggregate national stock indexes inadequate to capture the required nation-specific stock market behaviours for cointegration analysis, we will analyse the Nordic stock market interrelationships by using industry-specific data. As we have already mentioned, Nordic stock markets have very different kinds of industry structures and therefore we need to analyse the interrelationships between specific industries if we wish to analyse the possible co-integration or convergence properties of the Nordic stock markets.

Therefore, in this study we have analysed the interrelationships of two specific industries, which are of some importance to all the Nordic countries as well as in the global sense. Banking (also including the overall finance sector) and telecommunications are chosen in our study to represent two large and important industries, firstly because every Nordic stock exchange has equities which can be considered to belong to these industries (actually these were the only two industries possible, because all the other industries lagged at least one Nordic exchange for the required period, and could not therefore be used), and secondly because these industries have very important implications to the global economy as well. These industries are also typically very important among the Nordic countries (telecom for Finland and Sweden, and banking for Denmark and Norway).

We have used similarly composed Nordic industry data in our study, which means capitalization weighted indexes. All the index values are transformed to natural logarithm and indexed to start from an equal base value (100). These subindexes include all the Nordic banking and telecom equities which are also included in the aggregate Nordic stock market indexes. In this study, we use data denominated both in common currencies and in local currencies. We use also data which is transformed to a common currency (USD), because this is the most important currency as seen from the perspective of the international investor. Nevertheless, as seen also in our previous studies, no apparent differences concerning the interrelation properties of the Nordic stock markets are found as a result of using these different currency bases. Figures to all the data used in this study are shown graphically at the beginning of the appendix section.

For the Nordic banking sector, our monthly data cover the period from October 1992 to February 1998 (n=66) and daily data the period from 1993:25 to 1998:45 (n=1322). The Finnish bank data include all the main Finnish banks during the 1990s, namely KOP/SYP (now Merita), Okobank, SKOP and Ålandsbanken, all weighted according to their capitalization. The Swedish bank data form also a wide bank index, with 8 members: Foreningsbanken, Handelsbanken (Hypothek), Nordbanken, S-E Banken, Skandia Forsakringsbank and Svenska Handelsbanken. The Norwegian bank index consists of all the six listed Norwegian banks, namely Christiania Bank, DnB Holding ASA, Bolig OG Naering, Industrifinans, Nordlandsbanken and Storebrand. Denmark's banking index consists of three large Danish banks, namely Den Danske Bank, Unidanmark A/S and Real Danmark A/S.

For the Nordic telecommunications industry, our monthly data consists of the period from July 1991 to February 1998 (n=81) and the daily data the period of 1991:142 to 1998:41 (n=1728). The data series applied are shown in figures 10 to 17, in the appendix. As can be seen, the data periods applied are somewhat different between the bank and telecom industries, but we believe that this is not a significant problem. Composing these telecom indexes was not as easy as for the banking industry, because the Nordic stock exchanges do not contain many different (and old enough) telecom equities, which could be used for the whole period of the 1990s. Most of the IPO's of the Nordic telecom equities were done during the late 1990s and thus could not be included in the data sets used in this study. Nevertheless, all the Nordic exchanges include telecom stocks for the whole period, so the task was not impossible, but the indexes are obviously thinner than those in the banking data. The Finnish telecom industry consists of two telecom equities, Nokia and Instrumentarium (although the weight of the latter is apparently very small, only 0.3%). The Swedish telecom index has Ericsson as its most important equity, the Norwegian telecom index has Tandberg ASA and the Danish index GN Store Nord A/S as the companies with the heaviest weightings.

4 EMPIRICAL RESULTS

4.1 Preliminary analysis

Figures 2 and 3 in the appendix graph the Nordic stock index series both in local currencies and in a common currency (USD). Series are in logarithmic form and indexed (base value 1990:1 = 100). All the tables, which are referred in the following text, but not shown here, are presented in the appendix.

Tables 38 (monthly data) and 39 (daily data), summarize the descriptive statistics for the Nordic stock returns (all the tables are found in the appendix). The means of all the stock returns are positive with Sweden showing the largest monthly return, Finland the largest daily returns, and Denmark the lowest returns during the period. The standard deviation of the returns implies a measure of volatility, which is largest in Finland (on a monthly basis) and in Sweden (daily volatility), and smallest in Denmark. Sweden and Finland seem to offer the best returns during the 1990s for investors, but these markets also include greater risk (larger volatility and minimum values), while Denmark and Norway are more suitable for risk-aversive investors. Tables 38 and 39 also include three non-Scandinavian countries (Germany, the UK and the US) as they will also be applied later in this analysis.

The largest average stock returns during the 1990s seem to be gained from the US and the smallest from Germany. The reason for the small returns in Germany is probably due to the massive economic difficulties after German unification. The largest individual monthly stock returns were in Finland and in Sweden, but also were the largest drawbacks. This is due to the exceptionally deep recession during the first years of the 1990s both in Sweden and in Finland. The largest daily stock returns are also found in Finland and in Sweden, whose exchanges have both the largest and the smallest changes in daily stock prices. This is a clear sign of the exceptionally large volatility of the Finnish and Swedish stock markets. The stock returns are usually found to be non-normal, and this notion is also supported by the descriptive statistics. The stock returns of Sweden, Germany and the US are clearly non-normal. Several stock return series have autocorrelation properties, at least the returns of Norway, Finland, Germany and the US.

Non-normality is typically found in stock return series and at least Sweden's stock returns are clearly non-normal. The returns include an autocorrelation property. Strong one-month autocorrelation seems to exist in the returns of Finland and Norway. The Scandinavian stock returns are strongly correlated, as table 44 suggests. The largest monthly correlation coefficients are between Norway and Finland and also between Sweden and Denmark. The smallest coefficient exists between Finland and Denmark, which is not very surprising. The largest daily correlations (in table 45) are between Sweden and Norway, and between Finland and Sweden.

Tables 44 and 45 present the correlation coefficients between the stock returns. The correlations are quite strong, especially the relation between Norway and Finland and between Sweden and Denmark. When the 3 non-Scandinavian local currency denoted stock returns are analysed, the correlation between the US and the UK is strong (0.600) and the another strong correlation exists between the UK and Germany (0.547) when US dollar-valued stock returns are applied. Most correlation coefficients seem to be smaller when return series in USD are used. Table 45 presents the correlation coefficients of the daily stock returns. The largest positive correlation seems to be between Germany and the UK. Strong correlations also exist between Germany and Finland and Norway, Sweden and Norway and between Finland and Sweden.

Before modeling the system a test for unit roots is conducted. Tables 50 and 51 conclude the stationary testing results. The Dickey-Fuller methodology is used to test for unit roots. Augmentation of the test estimation is used when necessary. General-to-specific modeling was used to derive the proper models for the DF and ADF tests. All the Nordic stock return series are found to be stationary, i.e. the first differencing of the stock index series is enough to assure stationarity. In Finland's stock returns (in dollar terms) the stationarity was also clearly found when more efficient Dickey-Pantula procedure was applied. The weak power of the Dickey-Fuller test in the case of Finland is due the deep recession at the end of 1992, which forms a structural change, as can be seen in figure 3.

Before the cointegration methods are applied, the stock index series must be tested for unit roots. All the stock index series (also the 3 non-Scandinavian countries, results are presented in table 52) are found to be integrated of order one, meaning that all the stock return series are stationary[1]. The VAR system with seven variables would not be a statistically relevant model in this analysis due the rather restricted amount of data applied (98 periods in the monthly data) and the long-term structure required for a non-autocorrelated VAR system producing random error residuals. Several methodological guides also strongly recommend not using VAR systems with more than four endogenous variables. Therefore, the four-variable VAR system, including the four Nordic stock market index variables is calculated.

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1 The unit root tests are presented in the appendix, and the cointegration test results (not presented here) can be obtained from the author.

When testing the stock index series for possible cointegration, the Scandinavian stock market index variables (both monthly and daily data) are found to be cointegrated of order (1), implying that the error-correction form should be used in the estimation and that the level index variables should also be included in the model to attain the long-term stationary relations between the stock markets.

To compare the results of the previous studies to the stock returns in the 1990s in this study, VAR estimations for the stock returns are done and tables 57 and 58 summarize the Granger causality test results. The lag lengths for all the VAR estimations in this study are decided by using the general-to-specific procedure (by Hendry) by choosing the shortest possible lag length, which produces residuals with Gaussian white noise properties. Model reduction tests used include Akaike's and Schwartz-Bayesian information criterions and LR tests.

The LR test is applied for Granger causality testing, and the test results vary depending on the currency used in the stock returns. When the returns are expressed in a common currency (US dollars) the causality results seem to be much weaker than in the case of local currencies. Highly significant causalities seem to exist only from Norway to Finland (Finland also causes itself). When the stock returns are expressed in local currencies, Finland is affected by all the other returns except Sweden. Norway seems to be influenced by all the Scandinavian markets, while Denmark and Sweden do not.

More interestingly, Sweden seems to have lost its leading role in Scandinavia. Nevertheless, a more relevant explanation is the indistinct nature of the testing procedures when aggregate index series are applied. The unstable and various industry weightings implied in the country indexes make causality testing inaccurate. All the previous studies which draw conclusions about causality or "leading"countries with aggregate index data should be considered as suspect. Previous studies (e.g. *Mathur, Subrahmanyan 1990, 1991; Malkamäki, Martikainen, Perttunen, Puttonen 1993*) usually report Sweden having a strong influence on other stock markets during the 1980s, but Sweden seems to "have lost" this leading ability in the 1990s. This finding is supported by *Malkamäki (1993)* who also did not find any causality between Finland and Sweden. The strongest interrelationship seems to exist between Norway and Finland. Both the local and US dollar return expressions support causality between Finland and Norway in both directions.

In these VAR models stock return series are used. These models can be interpreted as short-term relations, in which important and valuable long-run information is possibly destroyed by differencing. Next the cointegration tests are conducted. If the series are found to be co-integrated, then there exists an error-correction representation for these models whereby both short- and long-term relations can be estimated simultaneously. The models discussed above are in that sense misspecified.

4.2 Cointegration analysis

Tables 11 and 12 presents the Johansen (1988) cointegration analysis results for the Nordic monthly stock market data. Both the maximum eigenvalue and trace-test values indicate the existence of one cointegration vector between the Nordic stock index series. It also implies the existence of common trends (three altogether) between the Scandinavian markets. The first eigenvalue is clearly non-zero (0.44 and 0.40 for local and US dollar series respectively) and much larger than the other eigenvalues. An appropriate lag structure constructing vector autoregressive models with Gaussian errors was found with lag lengths 2 and 8 for the local currencies and US dollars, respectively. These uniform results suggest that an error correction model should be used, because when Nordic stock index series are not stationary, they are cointegrated.

TABLE 11 Cointegration analysis for VAR(2) model for Nordic stock market indexes. Local currencies

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	*99 %*	*Critical values* [a], λ_{trace} 95 %	*99 %*
$r = 0$	56.28	90.44	31.46	36.65	62.99	70.05
$r \leq 1$	16.52	34.16	25.54	30.34	42.44	48.45
$r \leq 2$	10.52	17.64	18.96	23.65	25.32	30.45
$r \leq 3$	7.13	7.13	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.4436, 0.1581, 0.1038, 0.0715, 3.5265^{-017}

TABLE 12 Cointegration analysis for VAR(8)-model for Nordic stock market indexes. US dollars

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	*99 %*	*Critical values* [a], λ_{trace} 95 %	*99 %*
$r = 0$	45.99	81.63	31.46	36.65	62.99	70.05
$r \leq 1$	20.00	35.64	25.54	30.34	42.44	48.45
$r \leq 2$	12.23	15.64	18.96	23.65	25.32	30.45
$r \leq 3$	3.41	3.41	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.4001, 0.1993, 0.1271, 0.0371, -1.1206^{-016}

Table 59 (in the appendix) summarizes the model diagnostics and misspecification tests of the VAR model for the Nordic stock index data (in local currencies). The resultant error terms include no autocorrelation and are clearly normal. The reported diagnostics include the most widely used vector Portmonteau- and vector error autocorrelation test statistics, as well as vector normality test statistics. Other possible statistics (such as tests for vector heteroscedasticity and functional form tests) are not reported, but were checked during the estimation process and did not present problems for the validity of the model. The correlations of the system residuals are quite strong, which fits into typical VAR modeling assumptions, where a column vector of random errors are usually contemporaneously correlated but not autocorrelated.

Autocorrelation in VAR estimation can be very serious in that it may lead to inconsistent estimates of parameters. An essential, but sometimes overlooked feature of a VAR model is that the multivariate error term contains nonzero elements as in table 59. But it is just this error series property that allows for the formulation of structural alternatives to Cowles Commission-type models, consistent with a particular economic theory and applicable to economic policy analysis (for a discussion, see *Charemza, Deadman, 1997, pp. 157-161*). Later a more profound analysis will be done to transform the model into one having orthogonal innovations and make interpretation of the investment behaviour analysis of these VAR analyses more straightforward by innovation accounting methods.

Tables 60 and 61 (in appendix) give similar diagnostic statistics and misspecification test results for a VAR model with the series in US dollars and with daily market data. In these tables the residuals are again normal and contain no autocorrelation as required. Contemporaneous correlation is present as before, but the correlations are smaller. Again we can conclude that transforming the series into common currency seems to make the series less integrated.

Next we analyse the cointegration results using daily data instead of the monthly indexes. The VAR(5) model with daily data is estimated and presented in table 13 below. The correct lag structure was done using a lag length of 5, which presents non-autocorrelated error series. Again, exactly one cointegration vector and three common trends were found (using both the maximum eigenvalue and trace tests). Therefore, we found no difference between using monthly or daily stock market data, as cointegration is present even with the higher frequency data. Cointegration is usually more easily found to be present with lower frequency data (quarterly, monthly) than with daily data. But in our case, we are able to found the Scandinavian indexes to be cointegrated even with the daily data.

TABLE 13 Cointegration analysis for VAR(5)-model for Nordic stock market indexes. Daily data

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	42.20	68.62	31.46	36.65	62.99	70.05
$r \leq 1$	16.67	26.43	25.54	30.34	42.44	48.45
$r \leq 2$	6.91	9.76	18.96	23.65	25.32	30.45
$r \leq 3$	2.86	2.86	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.0193, 0.0077, 0.0032, 0.0013

One of the most important advances in the Johansen cointegration procedure is the possibility to obtain short- and long-term relations simultaneously in a single estimation compared to e.g. the Engle-Granger method where a two-step estimation process is required. Table 14 presents the estimated short- and long-term coefficients for the error-correction model for the Scandinavian stock markets, expressed in local currencies.

TABLE 14. Short-term and long-run relations in error-correction representation of the VAR(2) model for Nordic stock market indexes. Local currencies

	FI_{t-1}	SW_{t-1}	NO_{t-1}	DE_{t-1}	*Constant*	*Trend*
Short-term relations						
FI	0.079	0.197	0.101	0.423	0.329	
t-value	(0.518)	(1.214)	(0.467)	(1.979)	(1.748)	
SW	-0.048	0.287	0.045	0.051	0.471	
t-value	(-0.290)	(1.624)	(0.191)	(0.219)	(2.299)	
NO	-0.003	0.017	0.011	0.226	0.076	
t-value	(-0.027)	(0.153)	(0.076)	(1.568)	(0.595)	
DE	-0.081	0.069	0.073	-0.121	0.029	
t-value	(-0.747)	(0.604)	(0.473)	(-0.802)	(0.220)	
Long-run relations						
FI	-0.012	-0.106	-0.041	0.074		0.021
	(-0.176)	(-0.649)	(-0.264)	(0.726)		
SW	0.099	-0.428	0.151	0.069		0.018
	(1.321)	(-2.406)	(0.898)	(0.622)		
NO	0.030	0.387	-0.358	-0.081		0.016
	(0.653)	(3.503)	(-3.424)	(-1.166)		
DE	-0.027	0.152	-0.015	-0.117		0.014
	(-0.553)	(1.311)	(-0.133)	(-1.617)		

Estimated long-run equilibrium relation is (standardized for Sweden):

SW = 0.026 x FI + 0.626 x NO + 0.261 x DE + 0.004 x trend

Similar estimation results using US dollar-valued series are shown in table 15. Both tables imply that all the Scandinavian stock markets have a positive long-run trend, which means that the stock indexes move upwards and that stock returns are positive. The results in both tables also seem to imply that Sweden has some significant positive long-term effects on other Scandinavian markets, except Finland. This may seem to be in line with previous studies in which Sweden has been found to be a "leading" stock market in Scandinavia. Nevertheless, I do not consider this a relevant inference, because it is not justified to draw conclusions on causality based on the basis of these results, for the following reasons:

- The results include several negative signs or otherwise not reasonable coefficients. The results obtained can not be explained by any practical reasoning or economic theory.
- The results contain only very few significant coefficients. Sweden has a significant long-run coefficient (0.387) for Norway, but the other coefficients have clearly lower t-values.
- According to table 63 (presented in the appendix), the hypothesis of weak exogeneity for Denmark and Finland can not be rejected. This may imply that both countries do not belong to the VAR model (as the hypothesis of $\alpha=0$ can not be rejected for Denmark and Finland). Additionally, the hypothesis of $\beta=0$ for Finland can not be rejected either, implying that Finland may not have a long run relation. These results mean that the four country VAR system is probably not the most relevant alternative in this setting. Previous studies have possibly also noted this problem.

TABLE 15 Short-term and long-run relations in error-correction representation of the VAR(8) model for Nordic stock market indexes. US dollars

	FI_{t-1}	SW_{t-1}	NO_{t-1}	DE_{t-1}	*Constant*	*Trend*
Short-term relations [a]						
FI	0.172	0.301	-0.638	0.714	1.213	
t-value	(1.138)	(1.065)	(-2.048)	(2.117)	(2.140)	
SW	0.063	0.077	-0.601	0.347	1.064	
t-value	(0.441)	(0.286)	(-2.029)	(1.080)	(1.975)	
NO	0.001	-0.145	-0.065	0.652	1.530	
t-value	(0.014)	(-0.734)	(-0.298)	(2.759)	(3.864)	
DE	-0.043	-0.153	-0.067	0.257	0.843	
t-value	(-0.407)	(-0.772)	(-0.307)	(1.081)	(2.119)	
Long-run relations						
FI	-0.161	-0.303	0.462	-0.307		0.003
	(-1.521)	(-1.163)	(1.538)	(-1.146)		
SW	-0.036	-0.190	0.339	-0.367		0.002
	(-0.360)	(-0.767)	(1.187)	(-1.438)		
NO	0.087	0.377	-0.262	0.535		0.001
	(1.177)	(2.071)	(-1.245)	(2.854)		
DE	0.036	0.265	-0.004	-0.472		0.000
	(0.480)	(1.450)	(-0.018)	(-2 505)		

Note: [a] Only first lags are reported in short-term relations. Additional lag estimator results are available from the author on request.

The results rather support the view of simultaneous adjustment to economic shocks in Scandinavia, rather than causal relationships. Therefore, analysing the leading characteristics of the Scandinavian system is not a relevant procedure.

These confused results are most probably due to "index construction bias", as the data consists of national indexes with a very different industry mix.

Table 15 gives results for the data in US dollars. Now Finland seems much more interrelated with the other Scandinavian markets. Nevertheless, the same problems are present, as several negative signs are found and almost all the coefficients are non-significant.

TABLE 16 Short-term and long-run relations in error-correction representation of the VAR(5) model for Nordic stock market indexes. Daily data

	FI_{t-1}	SW_{t-1}	NO_{t-1}	DE_{t-1}	*Constant*	*Trend*
Short-term relations [a]						
FI	0.069	0.170	-0.070	-0.063	0.485	
t-value	(2.643)	(7.602)	(-2.248)	(-1.525)	(2.017)	
SW	-0.060	0.123	0.018	-0.087	-0.005	
t-value	(-1.883)	(4.448)	(0.470)	(-1.710)	(-0.016)	
NO	-0.059	0.105	0.061	-0.037	0.595	
t-value	(-2.679)	(5.536)	(2.303)	(-1.052)	(2.908)	
DE	0.125	0.035	0.186	0.124	-0.109	
t-value	(9.256)	(2.999)	(11.439)	(5.779)	(-0.869)	
Long-run relations						
FI	-0.003	0.000	-0.003	0.000		0.019
	(-1.070)	(0.003)	(-0.675)	(0.102)		
SW	0.007	-0.240	0.011	0.006		0.017
	(2.162)	(-3.300)	(2.312)	(1.467)		
NO	-0.003	0.010	-0.007	-0.006		0.009
	(-1.337)	(1.908)	(-2.048)	(-2.211)		
DE	-0.002	0.008	0.001	-0.006		0.007
	(-1.700)	(2.706)	(0.727)	(-3 839)		

Note: [a] Only first lags are reported in short-term relations. Additional lag estimator results are available from the author on request.

Table 16 presents the results obtained by using daily data. The long-term relations have very small coefficients, which is not very surprising, as it is not possible with daily data to present strong long-term interrelationships. In short-term relations the most interesting phenomenon is the short-term importance of the Swedish market. Sweden seems to be an important country in this system, but again it is not justifiable to make assumptions about causal relationships or conclude that Sweden is a "leading" market in Scandinavia. Estimated coefficients are very small and few significant coefficients are found. The countries seem rather to adjust simultaneously to financial shocks. Attempts have been made in previous studies to analyse the causal structures of Scandinavian markets, but after these results, the reasoning seems rather suspect.

4.3 Granger causality

Table 17 presents the Granger causality results for the Nordic stock market returns in local currencies.

TABLE 17 Granger causality tests using LR test $\chi^2(2)$, marginal significance of retained regressors by country. VAR(2) model for stock indexes, local currencies

Series		*FI*	*SW*	*NO*	*DE*
FI	*, LR-test*	125.193 ** (0.000)	1.635 (0.442)	0.299 (0.861)	5.881 (0.053)
SW	*, LR-test*	1.938 (0.380)	27.543 ** (0.000)	0.977 (0.614)	0.589 (0.745)
NO	*, LR-test*	0.505 (0.777)	19.544 ** (0.000)	35.283 ** (0.000)	3.426 (0.180)
DE	*, LR-test*	1.330 (0.514)	4.906 (0.086)	0.258 (0.879)	98.053 ** (0.000)

Note: Probability (LR-test, $\chi^2(2)$) for retained regressors by country in parenthesis.

The results imply some effects from Sweden to Norway (but not vice versa) and may seem to support Sweden as a leading market in Scandinavia, because Sweden also has a slight causal effect on Denmark. Nevertheless Sweden does not have any causality in relation to Finland and a strong causal relation between Finland and Norway is completely absent. Some causality may come to Finland from Denmark, but this effect may be seen as an effect of Central European (German) influences on Finland, which have arisen due to the developments in European Integration, where Finland is a more eagerly participant than any other Scandinavian economy (e.g. only Finland decided to join the EMU on 1.1.1999). These decisions may be seen in the series.

TABLE 18 Granger causality tests using LR test $\chi^2(2)$, marginal significance of retained regressors by country. VAR(8) model for stock indexes, US dollars

Series		*FI*	*SW*	*NO*	*DE*
FI	*, LR-test*	89.727 ** (0.000)	14.691 (0.065)	26.270 ** (0.001)	16.655 * (0.034)
SW	*, LR-test*	13.317 (0.101)	66.158 ** (0.000)	18.523 * (0.018)	21.654 ** (0.006)
NO	*, LR-test*	17.826 * (0.023)	13.040 (0.111)	43.584 ** (0.000)	16.305 * (0.038)
DE	*, LR-test*	8.523 (0.384)	9.193 (0.326)	9.226 (0.324)	50.600 ** (0.000)

Note: Probability (LR-test, $\chi^2(8)$) for retained regressors by country in parenthesis.

Granger causality outcomes using USdollar series are presented in table 18. Now the interrelationship and dual-direction causality between Finland and Norway seems to be present. This interrelation may partly be due to similar exchange rate behaviour in Finland and in Norway, which from an international investors point of view (analysing stocks in real exchange rate terms), is a sign of spillover effects. This different behaviour of stock market returns according to the currency transformation also indicates that exchange risks are not fully hedged and the markets are not completely efficient.

Denmark seems to be slightly leading all the other markets. Previous studies have explained that this would indicate that in the 1990s (compared to the 1980s and previous studies) Sweden has lost its leading position to Denmark, which now may represent Central European impulses and the development of European integration, which may be stronger than before. Denmark is close to continental European markets and has been part of the European integration process since the 1970s. Nevertheless, these speculations are not strongly supported here and should be considered as highly suspect as it is aggregate stock market indexes that are being applied.

TABLE 19 Granger causality tests using LR test $\chi^2(5)$-test, marginal significance of retained regressors by country. VAR(5) model for stock indexes, daily data

Series		*FI*	*SW*	*NO*	*DE*
FI	*, LR-test*	13.958 * (0.016)	62.048 ** (0.000)	7.510 (0.185)	3.656 (0.600)
SW	*, LR-test*	13.817 * (0.017)	27.890 ** (0.000)	9.595 (0.088)	5.509 (0.357)
NO	*, LR-test*	24.324 ** (0.000)	39.693 ** (0.000)	11.484 * (0.043)	7.222 (0.205)
DE	*, LR-test*	95.350 ** (0.000)	24.190 ** (0.000)	145.60 ** (0.000)	55.348 ** (0.000)

Note: Probability (LR-test, $\chi^2(5)$ for retained regressors by country in parenthesis.

Table 19 presents the Granger causality results for the daily data. In these short-term relations causality properties seem to be much stronger than with the monthly data. Again Sweden seems to be the leading market in Scandinavia, but Finland too has causal links. Denmark does not have any causal effects on any other Scandinavian exchange (except itself). These results are rather similar to those obtained using monthly data except that the quantity of the relations is somewhat larger.

4.4 Convergence analysis

The cointegration property found here can also be used to address the question of whether financial market convergence is occurring within Scandinavia. Serletis and King (1997, p. 48) note that a necessary (but not sufficient) condition for multi-country convergence is that there be p-1 cointegrating vectors for p countries. This condition fails to hold for the Scandinavian stock markets presented here.

Nevertheless, Serletis and King (1997, ibid.) argue that for random series (such as stock market variables) convergence in general requires that the expected difference between the series becomes arbitrarily small or converges on some constant as time elapses. In the case of integrated series, convergence can also be defined in terms of the difference between the series, as these are of a lower order of integration than the original series.

In principle, the cointegration analysis cannot detect convergence, because convergence is a gradual and on-going process, which implies that statistical tests should lead to rejection of the null hypothesis of no-cointegration only when convergence has already taken place, meaning that the cointegration tests are tests for convergence over the whole period, not tests of a move from non-convergence to convergence. Cointegration techniques are also inappropriate for investigating whether the degree of convergence has been stronger lately than earlier. (Serletis and King (1997), p.49).

A possible remedy to that problem may be to estimate the first eigenvalues recursively, thereby obtaining information about the possible change in the cointegration relation. If the recursive cointegrating eigenvalues of the VAR models seem to increase during the estimation period, this would suggest convergence. In figures 4 and 5 (appendix) the recursively calculated eigenvalues are plotted. The largest (and non-zero) eigenvalue is in the upper-left corner. The other eigenvalues are also included but the hypothesis that they are of quantity zero cannot be rejected.

In figure 4 (appendix) the eigenvalues of VAR(2) model for the stock index variables denominated in the local currency are plotted. The graph shows a pretty stable path and is clearly not increasing. This means that no convergence can be observed among the Scandinavian stock markets during the 1990s. Figure 5 presents similar behaviour for the Scandinavian stock market indexes in the common currency. Here the graph in the left-upper corner is horizontal and even more apparently stable than in the previous figure.

From applying the recursive eigenvalue estimation technique, we conclude that although the Scandinavian stock markets seem to share three common trends, i.e. they are cointegrated, no change or increase can be observed in this interrelationship between the Scandinavian stock markets, which also means that we can not observe any convergence within Scandinavia during the 1990s.

4.5 Impulse response functions

Restriction testing on cointegrating relations was done by restricting the β -vectors of the cointegration matrix. The results are shown in table 63, as noted above. The significance of the β_i's are tested by calculating the $\chi^2(1)$ critical values. The null hypothesis $\beta_i=0$ can be rejected for (in this order) Sweden, Norway and Denmark, but not for Finland. Sweden has the heaviest weighting on the cointegration vector, because the null hypothesis $\beta_{SW}=0$ is highly significantly rejected with χ^2 test value equal to 39.6. The next strongest test values are calculated for Norway, Denmark and Finland, respectively. Hence, the particular Choleski decomposition ordering used here is of the form: Sweden -> Norway -> Denmark -> Finland, which means that Sweden is assumed to be the leading market affecting contemporaneously all the other Scandinavian markets, while e.g. impulses in the Danish stock market index are not assumed to contemporaneously affect the stock markets of Sweden or Norway, but perhaps have a contemporaneous effect on Finland.

Next the impulse response function analysis results for the Nordic stock market innovations are presented in the following tables and corresponding figures which can be found in the appendix section (The abbreviations used in figures 6-9 (appendix) are: LSWSP = Log series of the stock market index of Sweden's stock exchange, LNOSP = Log series of the stock market index of Norway's stock exchange, LTASP = Log series of the stock market index of Denmark's stock exchange, LFISP = Log series of the stock market index of Finland's stock exchange. Note also that the scales of the initial impulse responses are not equal to the scales used in the tables).

4.5.1 Sweden

Table 20 below and figure 6 in the appendix, trace the effects of a one-unit shock (the unit here is of the quantity of one standard deviation, 0.055) in the Swedish stock market index variable on the time paths of the Scandinavian stock market sequences. Only the first four periods are shown in the tables here, but a more complete picture of the lag structure can be drawn by calculating a maximum impulse response index, presented later in this paper, and seen also in the figures in the appendix section:

TABLE 20 Impulse responses after a shock in the stock market of Sweden

Period	*Sweden*	*Norway*	*Denmark*	*Finland*
1	0.055	0.032	0.027	0.016
2	0.058	0.048	0.033	0.037
3	0.047	0.053	0.035	0.037
4	0.038	0.051	0.035	0.032

As shown in table 20 and in graph 6, a one unit-shock in Sweden's stock market index causes Norway's index to rise also, but by lesser degree. Thus a one standard deviation unit shock (0.055) leads to rise of 0.032 units in Norway's contemporary index. Other contemporary changes are a rise of 0.027 in Denmark and 0.016 in Finland. The effects from Sweden's stock markets are sustained for several months and the greatest effects can be traced in the other Scandinavian countries markets after 3 (or 4 in Denmark) months. The effects in Denmark and especially in Finland remain small. The Scandinavian market most sensitive to the impulses in Sweden clearly seems to be Norway. All the impulse effects fade to zero after several periods (as shown in the figures in the appendix section), which support our assumption of stability in the variables.

4.5.2 Norway

A one-standard-deviation shock in Norway's stock market index series (equal to 0.050 units, logarithmic scale), induces a very small effects on the other Scandinavian stock markets. The impulse shock in the Norwegian stock market index fades away rapidly, as can be seen in table 21 below and in figure 7 in appendix section (the LNOSP variable shows the impulse response function impulses of Norway's stock market index in the lower left quarter panel).

TABLE 21 Impulse responses after a shock in the stock market of Norway

Period	*Sweden*	*Norway*	*Denmark*	*Finland*
1	0.000	0.050	0.010	0.022
2	0.012	0.035	0.008	0.031
3	0.018	0.027	0.007	0.030
4	0.019	0.024	0.008	0.027

A stock market impulse shock in Norway does not seem to have strong effects on the other Scandinavian markets. Cholesky decomposition ordering assumed here does not allow to any contemporaneous effect in Sweden's stock markets but during the following periods there is a small positive increase.

The impulse effects in Denmark and in Finland are almost zero during all periods. The impulse shock from Norway causes a small positive peak during the period following the initial shock, but this impulse effect fades rapidly. The only difference in Denmark compared to the behaviour in Finland is that the strongest positive effect comes only after several months; however in Denmark the quantity of these effects can be said to be practically zero, while in Finland there is a small positive effect, which nevertheless soon fades away.

4.5.3 Denmark

An impulse shock in the stock market index of Denmark has almost zero effects on the behaviour of the stock market indexes of Sweden and Norway as can be seen in table 22 below and in figure 8 in the appendix:

The contemporary effect on the stock market series of Finland also seems to be almost zero, but during the next period, i.e. one month after the initial shock in Denmark, the impulse effects are quite strong, at least compared to the impulse effects in Sweden and in Norway. The positive effects in Finland are almost equal in quantity to the original shock in Denmark, which seems to suggest a rather strong causal link in stock market behaviour from Denmark to Finland. This observation is also supported by the short-term VAR estimation results (table 14), where the coefficient of the lagged Denmark stock index variable was found to be statistically significant and non-zero positive. This one-directional causal link between the stock market of Denmark to that of Finland is one of the strongest links found amongst the Scandinavian markets. A fairly strong link also exists from Sweden to Norway, as noted already above.

TABLE 22 Impulse responses after a shock in the stock market of Denmark

Period	*Sweden*	*Norway*	*Denmark*	*Finland*
1	0.000	0.000	0.024	0.007
2	0.003	0.004	0.017	0.020
3	0.006	0.001	0.016	0.020
4	0.007	0.002	0.014	0.019

4.5.4 Finland

Table 23 below, and figure 9 in the appendix, presents the responses of the Scandinavian stock markets after an impulse shock in Finland. The strong causal relation between Denmark and Finland noted above is clearly not bi-directional. The impulse responses in the stock market of Denmark are practically zero, hence the negative impulses in Denmark during the first periods after the initial impulse are also not significantly different from zero.

TABLE 23 Impulse responses after a shock in the stock market of Finland

Period	*Sweden*	*Norway*	*Denmark*	*Finland*
1	0.000	0.000	0.000	0.027
2	0.001	0.001	-0.003	0.029
3	0.004	0.001	-0.003	0.027
4	0.006	0.004	-0.002	0.027

The effects on the stock markets of Sweden and Norway are both positive and they reach their maximum level after several months. There seems to be a slightly positive causal relation running from Finland to Sweden and to Norway, but this effect is quite small and slow.

In conclusion, we found strong causal links running from the Swedish to Norwegian stock market and another link running from the Danish to Finnish stock market.Other impulse responses were more or less limited and especially the stock exchange behaviour of Norway and Finland did not seem to affect the other Scandinavian stock markets. Previous results suggesting Denmark entering Scandinavian stock market relations as exogeneous cannot be rejected by these results. Another important result was that all the impulse responses eventually fade to zero so that the estimated relations can safely be concluded to be stationary.

4.6 Variance decomposition

The following table summarizes the results of the variance decomposition analysis, in which short-term reactions are examined (models contain no cointegration restrictions). In the following output, the variance decomposition results are abbreviated and only the 1 to 4 -step, 6-step, 12-step, and 24-step ahead forecast error variances are reported (SW = Sweden, NO = Norway, DE= Denmark and FI = Finland). The assumed Cholesky decomposition ordering is a very critical assumption in variance decomposition analysis, but these effects due to the ordering decrease considerably with large analysis horizons. Thus, we put great emphasis on the 24-step ahead forecast error variances reported in table 24 below.

TABLE 24 Innovation accounting (variance decomposition) for Nordic stock market indexes. VAR(2) model. Local currencies

Series / steps	*SW*	*NO*	*DE*	*FI*	*SW*	*NO*	*DE*	*FI*
Sweden St.er.= 0.055					*Denmark St.er.= 0.037*			
1	100.000	0.000	0.000	0.000	51.191	7.508	41.301	0.000
2	97.525	2.285	0.162	0.028	62.646	6.128	30.930	0.296
3	94.069	5.278	0.481	0.172	68.690	5.145	25.793	0.372
4	90.972	7.748	0.850	0.430	72.160	4.877	22.596	0.368
6	86.631	10.691	1.546	1.132	75.512	5.201	18.997	0.291
12	79.360	13.662	3.347	3.631	77.540	7.078	15.120	0.262
24	73.875	14.154	5.488	6.483	74.961	9.116	14.572	1.351
Norway St.er.= 0.060					*Finland St.er.= 0.039*			
1	29.418	70.582	0.000	0.000	16.663	31.690	3.688	47.959
2	46.975	52.826	0.191	0.008	31.963	28.815	8.818	30.405
3	57.719	42.109	0.146	0.026	35.516	27.708	9.824	26.953
4	63.047	36.701	0.143	0.109	35.561	27.123	10.711	26.605
6	66.300	32.896	0.264	0.541	32.925	26.468	12.491	28.116
12	64.178	31.524	1.194	3.103	26.025	24.226	16.668	33.080
24	59.888	30.682	2.862	6.568	23.215	21.961	19.688	35.137

Note: The Choleski decomposition ordering used is: SW -> NO -> DE -> FI. Ordering decided by β-restriction results.

The variable of the stock market index series of Sweden explains all of its own 1-step ahead forecast error variance and 73.88 % of its 24-step ahead forecast error variance. At 24-step ahead horizon, Norway, Denmark and Finland explain 14.15 %, 5.49 % and 6.48 % of the forecast error variances in Sweden's stock market index series. Thus, Norway seems to have the largest effect on the forecast error variance for Sweden while the two other Scandinavian exchanges have only a minor effect.

The behaviour of Norway's stock market explains 70.58 % of its own 1-step ahead forecast error variance. As can be seen from the table, the Swedish stock market series explains a large fraction of the Norwegian forecast error variance. At 24-step horizon, the Danish stock market explains almost none (2.86 %) of Norway's behaviour while Finland explains a slightly larger part, i.e. 6.57 % of the forecast error variance.

When we analyze the variance decomposition results for Denmark, again the importance of Sweden's stock market fluctuations can be found. Sweden explains 51.19 % of the forecast error variance of Denmark at 1-step horizon and 74.96 % at 24-step horizon. At the 24-step ahead horizon, Norway explains 9.12 % and Finland practically none of Denmark's forecast error horizon.

Compared to the previous results, the variance decomposition results for Finland seem to differ strongly. Finland's stock market index series explains 47.96 % of its own 1-step ahead forecast error variance. Norway seems to be important market in the 1-step horizon, while it explains the second largest fraction (31.69 %) of Finland's forecast error variance, compared those of Sweden and Denmark, which explain 16.66 % and 3.69 % of Finland's forecast error variance, respectively. But when we examine the longer horizon forecast error variances, using the 24-step ahead horizon, the importance of the stock market behaviour of Denmark receives larger emphasis. At the 24-step ahead horizon, Denmark explains 19.69 % of Finland's forecast error variance, while Norway's explanatory importance has dropped to 21.96 %.

In a conclusion, the stock market index series of Sweden explains most of the forecast error variance of those of Norway and Denmark, but Finland differs in this respect from the other Scandinavian stock markets. Norway and Denmark have a large effect on Finland, while Sweden's explanatory power concerning the stock market forecast error variance of Finland is very limited, as with the case of Norway and Denmark. Of course, because of the Cholesky decomposition ordering used here, the fact that Sweden has the strongest effect on Scandinavian stock market behaviour is not surprising, but Finland's forecast error variance results can not be derived directly from the initial assumptions.

These results were obtained using logarithmic stock index series in the local currencies. It would be interesting to look at how sensitive these results are to the behaviour of the international exchange rate. When we compare these results to the first variance decomposition measures (table 24), we see that the importance of Sweden is reduced and the explanatory power of Denmark's stock market index series, all series transformed to the common currency, is increased. Now, at the 24-step ahead forecast horizon, Sweden explains only 50.96 % of its own forecast error variance, while Denmark explains as much as 33.95 % of Sweden's variance. Similarly, Denmark explains 38.46 % of Norway's and 51.98 % of its own forecast error variances, both of which are much larger values than those obtained previously with local currency stock index series. Sweden, on the other hand, seems to lose a lot of its explanatory power, explaining 21.05 % of Norway's and 29.56 % of Denmark's forecast error variance. In table below, variance decompositions transformed to the common currency (US dollars), are presented:

TABLE 25 Innovation accounting (variance decomposition) for Nordic stock market indexes. VAR(8) model. US dollars

Series / steps	*SW*	*NO*	*DE*	*FI*	*SW*	*NO*	*DE*	*FI*
Sweden *St.er.= 0.046*					*Denmark* *St.er.= 0.032*			
1	100.000	0.000	0.000	0.000	32.851	4.579	62.570	0.000
2	96.955	3.032	0.001	0.012	38.287	2.988	58.722	0.002
3	97.541	2.420	0.004	0.035	42.857	5.305	51.705	0.133
4	94.508	4.945	0.516	0.030	45.049	4.938	49.561	0.453
6	90.464	5.899	3.601	0.036	43.706	10.060	45.234	1.000
12	70.681	12.141	16.013	1.166	41.896	12.645	42.815	2.644
24	50.963	13.888	33.953	1.196	29.556	16.139	51.983	2.322
Norway *St.er.= 0.043*					*Finland* *St.er.= 0.032*			
1	12.867	87.133	0.000	0.000	7.560	23.307	10.980	58.154
2	24.453	74.951	0.455	0.141	10.945	15.358	23.234	50.463
3	29.828	69.689	0.377	0.106	7.408	26.316	30.765	35.511
4	34.535	64.657	0.369	0.440	6.175	23.940	35.693	34.191
6	37.381	59.883	0.672	2.064	6.161	26.723	36.117	30.999
12	25.869	47.965	23.710	2.456	9.074	41.577	30.284	19.065
24	21.046	38.716	38.464	1.775	20.683	32.298	34.581	12.438

Note: The Choleski decomposition ordering used is SW->NO->DE->FI. Ordering decided by β-restriction.

This difference between the forecast error variance values, depending on the currency transformations on the stock market index series, imply that the exchange rate fluctuations are not completely hedged in the Scandinavian stock markets and that arbitrary profits are possible.

It is also interesting to analyze the variance decompositions of Finland using the stock index series in US dollars. At 12-step ahead forecast horizon Denmark and Norway explain more of Finland's forecast error variance than Sweden; hence the structure examined previously with local currency data is also seen here, but with even greater clarity. Denmark and Norway explain 30.28 % and 41.58 % (compared to 16.67 % and 41.58 % using local currency data) of Finland's forecast error variance, respectively, while Sweden now explains only 9.07 % (26.03 % with local currency data).

4.7 Alternative decomposition orderings

To conclude the innovation response analysis results and to compare the effect of the various decomposition orderings, the following table presents the maximum impulse response indexes, defined in the methodology chapter of this study:

TABLE 26 Maximum impulse response indexes for various decomposition methods

I_λ	C1	C2	C3	C4	C5	S-Bα	S-Bβ	S-Bγ
Sw → No	96_2	76_3	91_2	64_2	66_3	93_2	96_2	95_2
De → Fi	83_1	89_1	97_1	51_2	98_1	113_1	102_1	240_1
No → Fi	63_1	39_1	39_1	30_1	71_1	6_1	100_1	29_1
Sw → De	64_3	32_6	70_3	52_3	30_4	37_4	36_7	103_1
Sw → Fi	68_2	57_1	73_2	27_2	43_2	14_2	68_1	24_2
De → Sw	34_8	74_1	40_6	24_4	41_6	44_9	40_9	85_9
De → No	30_{12}	7_{11}	29_1	17_{14}	36_{10}	42_{12}	38_{12}	93_{11}

Appreviations used in table 26:
C1 = Cholesky decomposition ordering: Sw→No→De→Fi ; C2 = Cholesky decomposition ordering: De→Sw→No→Fi ; C3 = Cholesky decomposition ordering: Sw→De→No→Fi ; C4 = Cholesky decomposition ordering: Fi →No→Sw→De ; C5 = Cholesky decomposition ordering: No→De→Sw→Fi
S-Bα = Sims-Bernanke decomposition, similar to C1, but contemporaneous effects include only Sw→No and De→Fi
S-Bβ = Sims-Bernanke decomposition, similar to C1, but contemporaneous effects include Sw→No, De→Fi, Sw→Fi and No→Fi
S-Bγ = Sims-Bernanke decomposition, similar to C1, but contemporaneous effects include Sw→No Sw→De, De→Fi, Sw→Fi and No→Fi

Table 26 above contains various Cholesky decomposition orderings, which differ strongly and give at least somewhat different results. In the table only the most significant impulse relations are included; the other impulse responses were practically zero. The innovation response effects from Sweden on Norway can be concluded to be strong, according the table above. The index values are large, ranging from 64 to 96, and the variation in the index values is quite small.

Similarly most orderings yield the result that the largest impulse response in the Norwegian stock market after the impulse shock in the Swedish stock market can be observed after two periods (meaning after the two months). The Cholesky orderings C4 and C5 are definitely not the correct ones, but they are presented here to compare results using very opposite ordering choices.

A clear innovation effect seems to run from the Danish to the Finnish stock markets. The maximum index value is 83 (using C1 ordering), meaning that at most 83 per cent of the initial impulse occurring in the stock market index series of Denmark can be observed in that of Finland, reaching its maximum level after one period. Here again the variability of the I_λ index is quite small even when the extreme C4 and C5 orderings are applied. The maximum level of impulse effects is reached almost unanimously after only one period; hence the variability of the maximum effect's time period is also stable.

All the other suggested links are much smaller and they include significantly more variability in the calculation of the I_λ index. For example, the innovation effect of Norway's stock market on that of Finland is 63 per cent using the preferred Cholesky decomposition ordering (C1), but only 30 per cent when the C4 decomposition alternative is used (and only 6 per cent using the S-Bα ordering). The largest innovation effect comes after one period according to all the alternatives, but the large variance of the I_λ index suggests that the link from Norway to Finland is not as strong as the two links mentioned above.

The maximum innovation effect links from Sweden to Finland and to Denmark obtained I_λ index values of 68 and 64, respectively, but the results suggest strong variability concerning the lag structure. The number of periods after which the maximum effects from Sweden to Denmark can be observed varies from three to six using the Cholesky decomposition and an astonishing one to seven using the Sims-Bernanke decomposition alternatives. This variability suggests that we should view the innovation effect link from Sweden to Denmark with great caution. The innovation flow from Sweden to Finland is also suspect, since the I_λ index value varies from 27 to 73 (14 to 68 if we examine the Sims-Bernanke decomposition results).

The two additional links presented in the above table, the effects running from Denmark to Sweden and to Norway present no large maximum innovation effects. The I_λ index value is 34 for the link from Denmark to Sweden and 30 when we examine the maximum effects from Denmark to Norway. Both links are small and the index value show large variability when different decomposition orderings are used. Similarly the estimated period after which the maximum effect exists varies from one to nine (from Denmark to Sweden) and from one to a surprising fourteen (from Denmark to Norway). These two links cannot be seen as important or valid.

Table 26 also presents the Sims-Bernanke decomposition results, where the contemporaneous effects are more restricted than in the Cholesky alternatives. The S-Bα ordering includes contemporary effect links only from Sweden to Norway and from Denmark to Finland, which are the most probable and valid causal innovation links. Using that ordering, the I_λ index values concerning the two first links remain quite stable, except that now 113 per cent of the innovation impulse in Denmark's stock market index is observed in Finland's market, which is larger than the 83 per cent attained using the C1 ordering. The next three links (from Norway to Finland and from Sweden to Denmark and Finland) I_λ index values decrease now greatly. The I_λ index values for the last two links increase a little (from 34 to 44 and from 30 to 42), but nonetheless remain behind the largest index values and cannot be considered as significant.

The additional Sims-Bernanke decomposition alternatives, S-Bβ and S-Bγ are not as promising as the first Sims-Bernanke option, because now the contemporaneous effects include impulse links in the case of S-Bβ from Sweden to Finland and from Norway to Finland, and in S-Bγ contemporaneous effects also from Norway to Finland, and all these additional impulse response effects are not unanimously supported by the impulse response function analysis as is the S-Bα alternative. But even when we use the decomposition orderings of S-Bβ and S-Bγ, the I_λ index values show no clear change when we examine the first two causal links, from Sweden to Norway and from Denmark to Finland, except that the I_λ index measuring the maximum impulse response from Denmark to Finland increases to an astonishing 240 when S-Bγ decomposition is used.

The following table 27 summarizes the variance decomposition results, when we use the S-Bα decomposition ordering. When we compare these results to the first variance decomposition table (table 24) we find some major differences. Now Denmark explains over 25 per cent of the 24-step ahead forecast error variance of Sweden, when only 5,5 per cent was reported in table 24. Similarly the I_λ index for the maximum impulse response for the impulse from Denmark to Sweden using S-Bα was larger (44) compared to using C1 ordering (34).

TABLE 27 Innovation accounting (variance decomposition) for Nordic stock market indexes. VAR(2) model. Local currencies. Sims-Bernanke decomposition

Series / steps	*SW*	*NO*	*DE*	*FI*	*SW*	*NO*	*DE*	*FI*
Sweden *St.er.= 0.055*					*Denmark* *St.er.= 0.037*			
1	100.000	0.000	0.000	0.000	0.000	0.000	100.000	0.000
2	97.826	1.613	0.518	0.043	8.662	0.375	90.445	0.519
3	94.525	3.428	1.769	0.278	16.673	0.442	82.165	0.719
4	91.158	4.662	3.448	0.733	22.996	0.636	75.617	0.752
6	85.295	5.565	7.087	2.053	30.895	1.193	67.282	0.630
12	71.126	4.985	17.089	6.801	38.520	2.258	58.620	0.601
24	59.149	4.602	25.439	10.810	34.298	2.100	60.520	3.081
Norway *St.er.= 0.060*					*Finland* *St.er.= 0.039*			
1	29.418	70.582	0.000	0.000	0.000	0.000	32.465	67.535
2	44.656	54.782	0.550	0.012	1.075	0.206	50.267	48.451
3	56.302	43.213	0.446	0.039	1.488	0.212	54.184	44.117
4	61.976	37.340	0.516	0.168	1.156	0.156	56.250	42.438
6	65.113	32.702	1.304	0.880	1.223	0.274	57.981	40.521
12	59.562	27.969	7.040	5.428	6.493	1.775	56.125	35.608
24	51.417	23.582	14.682	10.319	12.796	3.639	52.670	30.894

Note: The Sims-Bernanke decomposition ordering used shows contemporary effects only from Sweden to Norway and from Denmark to Finland.

Norway's stock market behaviour seem to lose some of its importance to Sweden, while its behaviour now explains only 4.6 per cent of the 24-step ahead forecast error variance of Sweden, compared to 14 per cent using C1 ordering. The importance of the stock market behaviour of Denmark and Finland to the forecast error variance of Norway's stock exchange index series seem to be larger using the Sims-Bernanke decomposition. Now Denmark and Finland explain 14.7 and 10.3

per cent of the forecast error variance of Norway, respectively, compared to the values of 2.9 and 6.6 per cent using the original Cholesky decomposition. Similarly the I_λ index for the impulse effect from Denmark to Norway increased from 30 to 42 when Sims-Bernanke decomposition was used instead of the Cholesky decomposition.

The forecast error variances for Denmark using the Sims-Bernanke decomposition seem to be very different from those obtained using the Cholesky alternative. This variability is mostly due to the Sims-Bernanke assumptions concerning the contemporaneous effects between the Scandinavian stock markets, but analyzing the 24-step ahead forecast error variances we can conclude that Sweden still is a more important market concerning the behaviour of the Denmark's forecast error variance compared to Norway or Finland. Sweden has lost its importance to Denmark's forecast error variance (decrease from 75.0 per cent to 34.3) but this is at least partly due to our restriction that no contemporaneous effect on Denmark's stock markets exists, according the Sims-Bernanke decomposition ordering.

A more interesting result could be obtained by analysing the importance of stock market behaviour of Norway and Finland to Denmark. The previous Cholesky ordering yielded the result that Norway explains 9.1 per cent of the forecast error variance of Denmark, while Finland explains only 1.4 per cent. Now, using the Sims-Bernanke decomposition, Finland, with 3.1 per cent, explains more of Denmark's forecast error variance than Norway 2.1 per cent. Nonetheless these effects from Finland or Norway on the forecast error variance to Denmark remain significantly low.

When we finally analyze the forecast error variance of Finland using the Sims-Bernanke decomposition, the most apparent change is that the importance of the behaviour of Denmark's stock markets is increased from 19.7 percent (using the Cholesky decomposition) to the 52.7 per cent reported here (24-step ahead variances).

The importance of other markets, namely Sweden and Norway, has been decreased. A similar increase in the importance of Denmark's stock market explaining Finland's behaviour was seen from the impulse response I_λ index results, where the index value increased from 83 using the Cholesky decomposition to 113 when we used Sims-Bernanke decomposition.

To conclude from this Sims-Bernanke decomposition ordering analysis, and its significance to the variance decompostion results compared to the original Cholesky decomposition, it can be noted that the significance and the explanatory power of Denmark was increased significantly for the forecast error variances of all the Scandinavian stock markets. This increase in Denmark's explanatory power for Scandinavian forecast error variances may be explained by the assumption implied in the Sims-Bernanke decomposition, namely that there are no contemporaneous effects allowed to Denmark from the other Scandinavian markets, while the Cholesky decomposition allowed contemporaneous effects from Sweden and from Norway to Denmark. These restrictions may have caused these large changes in the forecast error variance analysis.

Using the Sims-Bernanke decomposition has one appealing advantage compared to the Cholesky decomposition. While the Cholesky decomposition is just identified, Sims-Bernanke allows the additional restrictions to be imposed, causing the VAR system to be over-identified, which allows tests for those restrictions. When testing the over-identification restrictions assumed by the Sims-Bernanke (variation α) by the likelihood ratio test, the $\chi^2(4)$ test value was 117.8, which significantly rejects the additional restrictions imposed in S-Bα. Similar, and even harsher were LR test values for the S-Bβ and for S-Bγ decompositions, $\chi^2(3)$=188.4 and $\chi^2(1)$ =428.3, respectively. Thus we conclude that the original Cholesky decomposition (C1) should be used, underlining that the strongest innovation impulse response effects are from Sweden to Norway and from the stock markets of Denmark to Finland, while all the other possible links remain significantly lower in importance.

Another important argument supporting the use of the Cholesky decomposition, instead of the Sims-Bernanke alternative, can be found in table 59, where the VAR system residuals are strongly correlated, implying significant contemporary relationships, which would be absent in the Sims-Bernanke decomposition. The large LR test values are mostly an implication of these strong contemporary correlations.

4.8 Analysis of international linkages by VAR systems

Next we analyse the international linkages and reactions of the Scandinavian stock market to the impulses coming from the three foreign markets (Germany, UK and US). Next the vector autoregressive models (VAR) for the Scandinavian stock market index variables are estimated, and the three international stock market variables (Germany, UK and US) are added as exogenous variables to the VAR system.

For the Nordic stock index variables denoted in local currencies, the optimal VAR system lag structure is found to be two lags for each endogenous variable, five lags using daily data and eight lags when US dollar-valued series are used. For the exogenous variables, two, four and one period lags are included for the VAR(2), VAR(5) and VAR(8) models, respectively. Table 62 (in appendix) concludes the VAR system diagnostic results, which indicate no autocorrelation or non-normality (except clear non-normality when daily data is applied, which is understandable when that frequency is applied) among the residual series of the VAR systems estimated.

The normality and non-autocorrelation assumptions for the residuals of both VAR systems are not rejected for the models with monthly data series. When daily data is applied, the error terms include the non-normality property, but not auto-correlation. Several information criteria (the Akaike and the Schwartz Bayesian criteria) were used to derive the most parsimonious model with the white noise residuals. The following table concludes all the coefficients estimated for the German, UK and US stock market indexes added exogenously to the Scandinavian stock market VAR system:

TABLE 28 VAR models for Nordic stock indexes using monthly data. Stock markets of Germany, United Kingdom and United States included as exogenous variables

Series	GE_t	GE_{t-1}	GE_{t-2}	UK_t	UK_{t-1}	UK_{t-2}	US_t	US_{t-1}	US_{t-2}
Local currenc.									
FI	0.418	0.017	-0.100	0.941	-0.708	-0.092	0.076	-0.558	0.270
(t-value)	(1.923)	(0.062)	(-0.498)	(3.624)	(-1.869)	(-0.346)	(0.277)	(-1.460)	(0.909)
SW	0.450	0.162	-0.551	0.534	-0.208	-0.147	0.807	-0.632	0.020
(t-value)	(2.100)	(0.589)	(-2.779)	(2.084)	(-0.556)	(-0.561)	(2.991)	(-1.675)	(0.067)
NO	0.252	-0.063	-0.116	0.487	-0.464	-0.074	0.269	-0.476	0.365
(t-value)	(1.829)	(-0.360)	(-0.908)	(2.960)	(-1.933)	(-0.439)	(1.553)	(-1.965)	(1.940)
DE	0.222	-0.290	-0.031	0.408	-0.224	0.013	0.429	-0.420	0.164
(t-value)	(1.451)	(-1.480)	(-0.221)	(2.230)	(-0.841)	(0.071)	(2.229)	(-1.560)	(0.784)
F-test on retained regressors. F(4,74) [a]	1.546 (0.198)	1.248 (0.298)	2.574 * (0.045)	3.931 ** (0.006)	1.199 (0.318)	0.150 (0.963)	2.590 * (0.044)	1.272 (0.289)	1.125 (0.352)
US dollars									
FI	-0.119	0.042		1.084	-1.205		0.022	-0.042	
(t-value)	(-0.469)	(0.177)		(3.872)	(-3.427)		(0.064)	(-0.116)	
SW	-0.069	0.087		0.957	-0.230		0.695	-0.590	
(t-value)	(-0.304)	(0.409)		(3.809)	(-0.728)		(2.254)	(-1.831)	
NO	0.373	0.096		0.444	-0.444		0.344	-0.024	
(t-value)	(2.339)	(0.645)		(2.525)	(-2.010)		(1.595)	(-0.108)	
DE	0.181	-0.019		0.719	-0.063		0.252	-0.092	
(t-value)	(1.171)	(-0.132)		(4.216)	(-0.293)		(1.206)	(-0.422)	
F-test on retained regressors. F(4,47) [a]	2.170 (0.087)	0.170 (0.953)		9.307 ** (0.000)	2.837 * (0.035)		1.901 (0.126)	0.790 (0.538)	

Note: [a] Significance level in parenthesis. Abbreviations used in the tables: FI= Finland , SW= Sweden NO= Norway , DE= Denmark GE= German, UK= United Kingdom, US= United States

4.8.1 Finland

The strongest effects on the stock markets of Finland seem to come from the stock market of the UK. The contemporary coefficient of the UK stock market is significant and positive. Nevertheless, it is difficult to find any reason or explanation for this effect. The obtained t-values are high, but the coefficients and especially their signs are not reasonable (both positive and negative). Estimations seem to suffer from some bias or disturbance factors, which once again I consider the "index construction bias".

The one period-lagged coefficient of the UK stock market index is also almost found to be significant (on the 95% level), suggesting that the effects from the changes in the UK stock market index last for at least one month. Another nearly significant coefficient is found coming from the German stock market. The contemporary coefficient for Germany is 0.418, which is positive and almost significant. None of the other coefficients is significant. Even the one period-lagged coefficient of the US stock market index is not significant.

International effects are very significant when daily stock exchange data is applied. Now the effects from Germany are highly significant. Strong effects from the UK (periods t and t-1) are also present and significant, but now the coefficients are much smaller (0.323 and -0.390 vs. 0.941 and -0.708). The US stock market seem not to effect the Finnish market as strongly as the UK and Germany: a two day-lagged coefficient for the US (-0.236) is alone highly significant in daily data analysis.

TABLE 29 VAR models for Nordic stock indexes using daily data. Stock markets of Germany, United Kingdom and United States included as exogenous variables

Series	GE_t	GE_{t-1}	GE_{t-2}	UK_t	UK_{t-1}	UK_{t-2}	US_t	US_{t-1}	US_{t-2}
Local currenc.									
FI	0.457	-0.522	0.022	0.323	-0.390	0.107	0.093	0.113	-0.236
(t-value)	(15.682)	(-12.584)	(0.483)	(8.353)	(-7.092)	(1.870)	(2.596)	(2.307)	(-4.596)
SW	0.450	-0.443	-0.021	0.642	-0.713	-0.008	0.247	-0.051	-0.133
(t-value)	(12.874)	(-8.901)	(-0.384)	(13.820)	(-10.80)	(-0.123)	(5.770)	(-0.868)	(-2.155)
NO	0.402	-0.495	0.054	0.335	-0.392	0.113	0.026	0.151	-0.193
(t-value)	(16.671)	(-14.402)	(1.431)	(10.438)	(-8.613)	(2.388)	(0.889)	(3.737)	(-4.524)
DE	-0.022	0.230	-0.192	-0.023	0.108	-0.018	0.019	0.009	0.025
(t-value)	(-1.265)	(9.303)	(-7.122)	(-0.985)	(3.284)	(-0.534)	(0.915)	(0.300)	(0.831)
F-test on retained regressors [a] F(4,2122)	118.07** (0.000)	98.989** (0.000)	13.26** (0.000)	62.65 ** (0.000)	42.79** (0.000)	2.414 * (0.047)	9.06** (0.000)	5.863** (0.000)	8.924** (0.000)

Note: [a] Significance level in parenthesis.

When we use the VAR system with stock market index series transformed into a common currency, the absolute t-values of the estimated coefficients for the Finnish stock market decreases. Only the coefficients of the UK indexes, contemporary and one-period lagged, are highly significant, with quantities of 1.084 and -1.205, respectively.

Finland does not seem to be open to either global financial market impulses coming from the US or to impulses coming from the largest financial market inside the European Monetary Union (EMU), namely Germany. Finland and Germany both joined the EMU at the beginning of 1999 and were both part of the intense development towards Monetary Union during the 1990s, but it seems that the relationship between the stock markets of Finland and Germany have not yet reached a high level. This will probably change in the near future, as in 1999 the stock exchanges of Frankfurt and Helsinki started a large co-operation project.

The low coefficient values and t-values for the US effects on Finland may be a sign of Finland's distant geographical status and its long history of a rather closed and restricted financial market. The stock market of the UK is in any case very important to the behaviour of the Finnish stock market, and this may imply that the international effects on Finland's financial market during the 1990s are strong, but are almost solely distributed through the largest European stock exchange, meaning the UK.

4.8.2 Sweden

The most obvious property of the international effects on Sweden is that all the large international stock markets, those of Germany, the UK and the US, all affect the stock market behaviour of Sweden. All the contemporary coefficients of Germany, the UK and the US are positive and significant, with t-values distinctly larger than two. The largest coefficient is for the US contemporary effects (0.807), while the coefficients for the UK and Germany are 0.534 and 0.450, respectively. Also the two period-lagged coefficient for Germany seems to be highly significant, but none of the other coefficients is significant.

The model using daily data gives similar results. All the international markets seem to affect Sweden on a daily basis. The coefficients for the UK are clearly larger in daily data model, but the effects from the US are smaller. Nevertheless, all the period t coefficients from the US, UK and Germany are highly significant. When we compare the results obtained by using the stock market index variables valued in the common currency, we find that the effects from the stock markets of Germany are no longer significant. The contemporary coefficients for the UK and US are similarly found to be positive and significant, as with the variables in local currencies.

Using the common currency variables, only Sweden is found to be affected by the US stock markets which is somewhat surprising as the US is the most important financial market in the world. When local currencies are used, all the Scandinavian stock markets, except Finland, are found to be affected by the impulses from the US but even there the only highly significant coefficient is for Sweden. On the basis of these findings it is concluded that the Swedish stock market seems to be the Scandinavian market most open to the effects of the external global stock market, which are examined here by using the US stock market as a proxy variable for a "world" stock market index.

4.8.3 Norway

The UK stock market seems to be the only stock market to have significant effects on the Norwegian stock indexes. The contemporary UK coefficient is positive (0.487) and highly significant. The effects from the stock markets of Germany and the US are close to being significant, the US especially seems to affect Norway's markets a little. The possible effects on Norway from the US are at least one period-lagged, while Germany is close to having significant contemporary effects on Norway. The behaviour of the Norwegian stock market is quite similar to that of the Finnish market, where only the UK market was found to significantly affect the stock indexes.

Using daily data reveals strong short-term links from the international markets to Norway. All the international exchanges have a highly significant coefficient for Norway. The largest coefficients are for Germany and the UK, while the US has smaller effects. Daily international stock exchange variation seems to have much stronger effects on Norway than those observed with monthly data.

When we compare these findings to the estimation results obtained by using stock index series transformed into a common currency, the contemporary coefficient of the UK remains significant and is of about the same quantity (0.444). The most apparent difference from the local currency estimation results is that now the contemporary coefficient for the impulses coming from the Germany is significant. The coefficient is 0.373, which is positive and significant at the 95% significance level. Using the stock market index series in a common currency, Norway's stock market seems to be the only Scandinavian stock market which is affected by the stock market index behaviour of Germany. Even with the common currency index series, the coefficients for the effects of the US stock market remain non-significant.

4.8.4 Denmark

Similarly to the other Scandinavian stock markets, Denmark has a noteworthly relationship to the largest and most influential European stock market, the UK market The coefficient for the contemporary behaviour of the UK stock market is positive (0.408) and significant. This relationship is also apparent when we examine the stock market index series transformed into a common currency, when the coefficient for the UK is again positive (0.719) and strongly significant. No other significant coefficient affecting Denmark's stock market is observed when the common currency series are used in the estimation.

When the daily market data are applied, the German stock market also seems to affect Denmark. The estimated coefficients for the UK and Germany are highly significant, but not especially large. Denmark seems to be less affected by foreign developments than the other Scandinavian markets on a short-term basis. The stock market of the US has no significant short-term effects on Denmark. In estimations using local currency series, the US stock market is also found to affect Denmark. The coefficient for the contemporary effects from the US is positive (0.429) and statistically significant. In addition to Sweden, Denmark is the only Scandinavian stock market which is found to be affected during the 1990s by the worlds largest stock market, namely the US market.

The F-test results on the retained regressors, also presented in table 28, suggest that for the entire VAR system, all the three international stock markets are significant when the VAR model for stock index variables valued in the local currency are used. The exclusion of the two period-lagged variable of the German stock market is significantly rejected by the F-test, as well as the contemporary variable of the UK and the contemporary variable of the US stock index. The most significant regressor is apparently the contemporary coefficient of the UK stock market index. When we use the stock index variables denominated in US dollars, the exclusion of the German and the US stock market variables cannot be rejected. Only the contemporary and the one period-lagged UK stock index variables are significant for the VAR system. It should also be noted that when daily data are used, the significance of foreign regressors increases clearly. All the foreign stock markets (lags 0-2) are significant for the entire VAR system as seen in table 29.

4.9 Results of analysis with sector specific data

4.9.1 Preliminary analysis

Tables 40 and 41 (presented in the appendix) summarise the descriptive statistics of the monthly banking and finance sector stock returns. As in all tables, the index values are given in local and in common currency forms. We also consider the series denominated in common currencies (US dollars) an interesting form, as it gives international investors a better view of the international development of the stock exchange. As seen in table 40, the largest stock returns from the Nordic banking sector were gained from Norway and the smallest from Denmark (local currencies) or from Sweden (common currency). Norway and Denmark had no deep bank crises during the 1990s resembling those of Sweden and Finland. The monthly stock returns were surprisingly negative from Sweden during our estimation period (1992-1998) when currency fluctuations were taken into account. No significant autocorrelation is found in any of the series and all the data series (except Swedish returns in $-form) are normally distributed.

Monthly telecom stock return data descriptions are presented in table 41 (in appendix) and the largest telecom stock returns are gained (not surprisingly) in Finland, as the success of Nokia is clearly exceptional in Scandinavia. Telecom sectors in Sweden and Norway also show large stock gains, but in Denmark these have been modest. The volatility of Finland's telecom sector has also been the greatest, as its large standard deviation proves. This has again to be due to Nokia's turbulent history, as in the early 1990s it experienced a great deal of uncertainty; however, with the boom in the mobile phone market it has since succeeded in becoming one of the largest technology companies. All the monthly stock return series are found to be normally distributed (except for Sweden in the local currency form) with no autocorrelation properties.

The descriptive statistics of the banking and telecommunications sector daily stock return series are given in tables 42 and 43 (in appendix) respectively. The largest daily banking sector returns were found in Sweden and Finland, as also was the greatest volatility (referring to large standard deviation values), which perhaps refers to the bank crises seen in Finland and in Sweden during the 1990s. Also, the largest daily telecom sector returns were gained in Finland and the smallest in Denmark. None of the daily data sets contain any autocorrelation, but they are not normally distributed. This may yield somewhat biased results, and therefore the daily data is included only for comparison with the monthly series.

The correlation coefficients are presented in tables 46-49 (in appendix) for the monthly banking and telecom sector stock returns, all presented in local and in common currency forms, including monthly and daily data sets. When the monthly Scandinavian stock returns are analysed, the main finding seems to be the apparent interconnection of the Swedish and Finnish stock markets, including both the banking and telecom sectors. The banking sectors of Norway and Denmark also seem to have a strong correlation, at least in data sets denominated in a common currency.

The daily stock return correlations are clearly weaker than those between the monthly returns, but here too the correlation between the telecom sectors of

Finland and Sweden is apparent. This is no surprise as the Finnish company Nokia and the Swedish company Ericsson are operating in the exactly same fast growing business segment. Other countries in the telecom sectors and no countries in the banking sector have significant correlations. Nevertheless, the correlation coefficients are larger with the common currency data sets, which is understandable as all the Scandinavian currencies have moved in the same direction and reacted quite similarly compared to the US dollar.

All the data sets are tested for unit roots and these results are presented in tables 53-56 (in appendix). All the applied stock index time series have the uniform property of being integrated by an order of one I(1), meaning that differencing the series once (i.e. using stock return series rather than stock indexes) is enough to secure the stationarity of the data sets. As pointed out e.g. in *Charemza W., Deadman D. (1997), p. 92,* the testing of stationarity is essential for the non-biased modeling of cointegration in the VAR context.

4.9.2 Cointegration analysis

Vector autoregression (VAR) models are constructed for every data set used in this study to analyse the cointegration properties of the Scandinavian banking and telecommunications sectors during the 1990s. In previous studies, aggregate stock market indexes were used and the index series were found to be cointegrated by an order of one, but here industry sector-specific data is applied to avoid the disturbing effects of the aggregation process and the apparent dissimilarities of the different national economic industry weightings seen in the national stock exchanges.

TABLE 30 Cointegration analysis for VAR(4) model for the monthly stock market indexes of the Nordic banks. Local currencies

H_0	λ_{max}	λ_{trace}	Critical values [a], λ_{max} 95 %	99 %	Critical values [a], λ_{trace} 95 %	99 %
$r = 0$	29.16	47.91	28.14	33.24	53.12	60.16
$r \leq 1$	15.56	18.75	22.00	26.81	34.91	41.07
$r \leq 2$	2.95	3.19	15.67	20.20	19.96	24.60
$r \leq 3$	0.24	0.24	9.24	12.97	9.24	12.97

Note: [a] Critical values are from *Osterwald-Lenum (1992)*, p. 467. Eigenvalues: 0.3800, 0.2251, 0.0472, 0.0040

The first VAR model was build for the Scandinavian banking sector (data in local currencies) for the monthly data. The cointegration test results obtained from the Johanssen test procedure are presented in the table 30 above. As in all the models presented in this study, a VAR model-building procedure of "general to specific" was applied, until the most efficient lag structure and best model with a normally distributed gaussian error structure was obtained. VAR model diagnostics and misspecification tests for each model are presented in the appendix, in tables 64-

71. All the models have normally distributed residual vectors with no autocorrelation properties.

In the first model (VAR(4)) the maximum eigenvalue test (for no co-integration) is close to reject H_0 at the 95% level, but as this rejection is very weak and is not even close to being supported by the trace test, we have no reason to reject our null hypothesis of no cointegration. Our monthly banking sector data is clearly not cointegrated.

TABLE 31 Cointegration analysis for VAR(2) model for the monthly stock market indexes of the Nordic banks. US dollars

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	22.72	46.51	31.46	36.65	62.99	70.05
$r \leq 1$	9.89	23.79	25.54	30.34	42.44	48.45
$r \leq 2$	7.99	13.90	18.96	23.65	25.32	30.45
$r \leq 3$	5.91	5.91	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.3335, 0.1618, 0.1330, 0.1001, -3.9795^{-017}

In table 31 (above) the same test is carried on for similar data, except that in this case the US dollar-denominated index series is applied. No cointegration is even weakly present in this case. The VAR model applied in this case has two lags and the model diagnostic tests are given in the appendix in table 65.

TABLE 32 Cointegration analysis for VAR(1) model for monthly stock market indexes of the Nordic telecoms. Local currencies

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	23.26	48.25	31.46	36.65	62.99	70.05
$r \leq 1$	16.29	24.99	25.54	30.34	42.44	48.45
$r \leq 2$	6.50	8.70	18.96	23.65	25.32	30.45
$r \leq 3$	2.19	2.19	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992)*, p. 469. Eigenvalues: 0.2550, 0.1862, 0.0790, 0.0274

Tables 32 and 33 present the Johansen cointegration test results for the Scandinavian telecommunications stocks (table 32 for local currencies and table 33 for common currency data). Again the VAR model diagnostics and misspecification test results are given in the appendix in tables 66 and 67. These VAR(1) and VAR(2) models have normally distributed residual vectors with no autocorrelation. As can be seen in the tables 32 and 33, cointegration tests are not even close to rejecting the null hypothesis of no cointegration between the

Scandinavian telecom stocks. Neither the Nordic banking or telecom industry stocks are found to be cointegrated.

TABLE 33 Cointegration analysis for VAR(2) model for the monthly stock market indexes of the Nordic telecoms. US dollars

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	25.12	58.68	31.46	36.65	62.99	70.05
$r \leq 1$	15.63	33.56	25.54	30.34	42.44	48.45
$r \leq 2$	11.60	17.93	18.96	23.65	25.32	30.45
$r \leq 3$	6.33	6.33	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.2753, 0.1815, 0.1382, 0.0779

The results obtained above contradict our previous results of cointegration between the aggregate Scandinavian stock market indexes. When we repeat the analysis here with indexes concentrated on banking and telecommunications stocks (which have been very important industries in the Scandinavian stock exchanges during the 1990s), the assumption of cointegration is clearly rejected. None of the VAR models, which are tested by using the Johanssen's testing procedure for cointegration, give any significant indication of cointegration or common trends present during the 1990s.

This result overshadows all the previous studies by other researchers and also our previous results, which share the same feature of using the nation and economy-wide aggregate stock market indexes as a proxy for the behaviour of the national stock exchanges. This procedure supplants the apparent differences between the industry weighting of particular industries in the countries in question. Therefore the unique economic situations and industry strengths are not taken into account, and the results say more about the aggregation processes than on the interrelations between the national stock markets.

TABLE 34 Cointegration analysis for VAR(14) model for the daily stock market indexes of the Nordic banks. Local currencies

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	25.80	54.04	31.46	36.65	62.99	70.05
$r \leq 1$	19.91	28.24	25.54	30.34	42.44	48.45
$r \leq 2$	5.60	8.32	18.96	23.65	25.32	30.45
$r \leq 3$	2.72	2.72	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992)*, p. 469. Eigenvalues: 0.0197, 0.0152, 0.0043, 0.0021

To be sure of the results presented here, we also repeat these tests for the daily data in the banking and telecommunications industries. Tables 34 and 35 present the results obtained by using the daily Nordic banking data for the cointegration testing. The model diagnostics results can be found in the appendix section (tables 68-71). The model residuals were again confirmed to be normal and no autocorrelation was present.

As can be seen in table 34 above and table 35 below, no cointegration is found by using either monthly or daily data. Table 34 presents the cointegration test results for the daily banking sector data (and table 35 for the similar index data but denominated in a common currency), but no cointegation is found. Both the maximum eigenvalue and trace tests are not even close to rejecting the 95% critical test values.

TABLE 35 Cointegration analysis for VAR(2) model for the daily stock market indexes of the Nordic banks. US dollars

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	16.76	41.87	31.46	36.65	62.99	70.05
$r \leq 1$	12.70	25.11	25.54	30.34	42.44	48.45
$r \leq 2$	8.00	12.40	18.96	23.65	25.32	30.45
$r \leq 3$	4.39	4.39	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.0126, 0.0095, 0.0060, 0.0033

TABLE 36 Cointegration analysis for VAR(3) model for the daily stock market indexes of the Nordic telecoms. Local currencies

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	24.60	52.89	31.46	36.65	62.99	70.05
$r \leq 1$	19.78	28.29	25.54	30.34	42.44	48.45
$r \leq 2$	7.02	8.50	18.96	23.65	25.32	30.45
$r \leq 3$	1.48	1.48	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992)*, p. 469. Eigenvalues: 0.0141, 0.0114, 0.0040, 0.0008

Tables 36 and 37 present the results obtained by using the daily telecommunications equity market data, respectively for local and US dollar denominated data. Again our null hypothesis is clearly not rejected as the maximum eigenvalue and trace test values obtained are not even close to the critical test levels. The misspecification tests and diagnostics of these VAR(3) and VAR(17) models are presented in the appendix (tables 70 and 71).

TABLE 37 Cointegration analysis for VAR(17) model for the daily stock market indexes of the Nordic telecoms. US dollars

H_0	λ_{max}	λ_{trace}	*Critical values* [a], λ_{max} 95 %	99 %	*Critical values* [a], λ_{trace} 95 %	99 %
$r = 0$	29.48	60.02	31.46	36.65	62.99	70.05
$r \leq 1$	14.02	30.54	25.54	30.34	42.44	48.45
$r \leq 2$	9.89	16.52	18.96	23.65	25.32	30.45
$r \leq 3$	6.63	6.63	12.25	16.26	12.25	16.26

Note: [a] Critical values are from *Osterwald-Lenum (1992), p. 469, table 2**. Eigenvalues: 0.0172, 0.0082, 0.0058, 0.0038

To conclude from these cointegration tests, we note that neither a significant common trend nor any cointegration was found when the telecommunications and banking sector stock indexes were applied. The result was the same regardless of the data frequency (monthly and daily data) or the currency (local and common currency) used.

This contradicts the previous results obtained by using industry-wide aggregate stock exchange indexes, where common trends were found. This result supports our view that the differences in the industry structures in different economies should be considered before applying aggregate stock indexes as a proxy of the national stock market behaviours.

4.9.3 Granger causality tests

Finally, the causality properties of the Nordic banking and telecommunications stock markets are analysed by using the Granger causality tests. Tables 72-79 include the LR test results obtained from all the models and data applied. Models were constructed to include the Nordic banking and telecom sector stock returns only, to ensure the stationarity of the data applied. All the diagnostics of the models applied can also be found in the appendix (tables 80-87). All the models used produce normal error vectors with no autocorrelation in the residuals. As we found no signs of cointegration in our analyses, stock market index levels can not be applied, but rather the first differences of those level series, i.e. the stock market return series. The VAR models were build for both the daily and the monthly data, also including data denominated in the local currency and common currency.

Causality between the monthly returns are not very practical in fast moving markets such as stock markets, because the stock market sentiment moves rather quickly and most new information is rapidly (in hours and days rather than weeks and months) discounted in the stock prices. Monthly causality between the Scandinavian banking and telecommunications sectors is therefore also quite modest. In table 72 (in appendix) the monthly Granger causality results between the Nordic banking sector are presented. There seems to be a dual-directional causality relationship between the Swedish and Finnish bank sectors. We have calculated the Granger causality LR statistics for both the local and US dollar denominated series, but we consider the local currency series as the more important as they represent pure national stock market effects without international impulses coming through the currency fluctuation. Table 73 shows the US dollar value data results and there are signs of significant causality from the Danish bank sector to the Norwegian market.

In the monthly telecommunications causality analysis (in table 74), no causal interrelationships between the Scandinavian markets are found. The only causal relationship present seems to be from the lagged Norwegian telecommunications stock to itself. No causality interrelationships are implied by the LR tests in the data transformed in either the local or common currency (in table 75).

Tables 76 to 79 (all in appendix) give the results obtained by using the daily data. This will be the most interesting frequency as the stock market movements are rapid and the international causal links operate more on a daily than monthly basis. In table 76 the dual-directional link between the Swedish and Finnish banking stocks seems to be significant. Changes in the Swedish bank sector seem also to significantly effect Danish bank stocks. In other cases the links between the Scandinavian banking stocks are weak. This is due to the domestic properties of the Scandinavian banking and finance sectors. All the Scandinavian countries had their own problems during the 1990s and the fluctuations in their operations are thus more domestic than international in nature. Therefore the interrelationships between the stock markets are also weak, except maybe for Sweden and Finland, which are rather close in their banking operations.

Table 78 presents Granger causality results for the daily Nordic telecommunications sector data. There the leading nature of the Swedish stock market is apparent as the changes in the Swedish stock market seem to flow to all the other Scandinavian markets as well. Finland and Denmark have no effects on the other Scandinavian markets, as Nokia was quite a modest influential factor during the early 1990s, but the Norwegian telecommunication market also seems to have a significant effect on the Danish and a slight effect on the behaviour of the Swedish telecom sector. Both the Granger causality results from the banking and telecommunications market seem to stress the leading nature of the behaviour of the Swedish stock market during the 1990s. Other linkages seem to be weaker, but there are also some links between the telecommunications stocks of Norway and Denmark, and the banking stocks of Finland to Sweden. But in all the other respects Sweden is found to be the most important and leading stock exchange in Scandinavia. This result is also well in line with the previous studies on Scandinavian stock market interrelationships, as e.g. the studies of *Mathur I., Subrahmanyam V.(1990, 1991), Malkamäki M.J., et al.(1993) and Booth G.G., et al.(1995).*

5 CONCLUSIONS

The integration of international and Scandinavian financial markets has been a topic of much research in recent years. Both investors and academic scholars have examined the implications of investing in international equity markets. In this paper, that extensive research activity was gathered together and some of the central implications for the empirical stock market integration modeling were discussed. Scholars working on equity market data analysing international financial linkages, face several empirical and methodological problems. In chapter two, some of those empirical problems were presented, as well as the possible remedies suggested by several scholars. The cointegration approach has acquired a stable position in empirical financial market integration modeling, as the scholars have understood the importance of testing a possible common trend in time series. If a vector of a stock market price series shares a common trend, then models which ignore this trend by only incorporating the equity returns are subject to serious specification biases. However, several authors point out that in cointegration testing proper model specification is crucial.

Most researchers find increasing financial integration and strengthening stock market linkages over the past two decades. Several papers also note the October 1987 stock market crash as a structural change in this respect, after which occasion international interdependence has increased. Most studies found the largest international stock markets, i.e. the US, the UK, Germany, Japan, to be co-integrated, and thus sharing common trends. Understandably, the US stock markets is found to be leading. The suggestion of cointegration between the international markets is interesting also from a portfolio diversification perspective. Scholars note that when stock markets apparently share common trends, then there are no long-term gains from international diversification.

Vector autoregression modeling and cointegration testing have been applied to the Scandinavian stock markets recently. The results concerning the co-integration properties of the four Scandinavian (Sweden, Denmark, Norway and Finland) stock markets are ambiguous. Several studies, mainly examining the 1980s, found no cointegration in the Scandinavian stock markets. Nevertheless, most studies agreed on Sweden being the leading stock market in Scandinavia.

One clear remedy is found to the contradictions all these studies analysed above. All the studies presented here use aggregate stock market indexes in their analyses, without expressing any doubts about the validity of using economy-wide aggregate indexes as representative of the behaviour of the national economy. One clear problem, which should be discussed in these studies, is, how adequate a proxy an aggregated national index is in finding international linkages or cointegration amongst international stock markets. It is apparent that national economies and stock exchanges have very different industrial structures and these industries are very differently weighted in aggregate stock market indexes. Even the industrial structures represented in the stock exchanges of the geographically close Nordic countries are different, as Finland and Sweden are known for their high-technology companies, Denmark has a very strong banking sector and the Norwegian stock exchange is loaded with influential transportation and energy companies.

The absence of any discussion on the validity of using wide aggregate stock indexes in modeling international linkages casts doubts on the results obtained. When international stock market linkages are analysed, the different weightings of the main national industries, implied in the aggregation process of these national stock market indexes, should be noted and the use of sector-specific stock indexes (e.g. analysing cointegration amongst the Nordic pharmaceutical industry indexes) considered as an useful alternative to aggregate indexes.

Contrary to the previous studies done on interrelationships between the Nordic stock markets (typically for periods in the 1980s), in this study, taking January 1990 - February 1998 as the period under consideration, the Nordic stock markets are found to be cointegrated. Cointegration in Scandinavia is not dependent on the data frequency used, as cointegration is supported in models using both monthly and daily stock market data. From an international investor's viewpoint, this means that long-term portfolio diversification between the Scandinavian markets does not seem to be effective. Liberalization of the stock markets and the increased flow of fast-speed financial information may be the reason for this stationary long-term relation, which can be found in the 1990s but not previously. The market segmentation hypothesis presented in introduction is therefore supported by this study. This increased interrelationship between the Nordic stock markets can now also support the common feature market hypothesis, as the Scandinavian economies have traditionally had close economic and political ties and they also exist in the same geographical area. According the cross-country market efficiency hypothesis the Scandinavian stock markets cannot be seen as collectively efficient because they seem to follow a common stochastic trend.

The models are estimated using Nordic stock market index series expressed in both local currencies and in US dollars. The results differ depending on if this exchange rate transformation is done or not. In particular,this seems to affect the relationships concerning Finland. This implies that the exchange risks in the Nordic stock markets are not fully hedged and that arbitrary profits can be gained. When the returns are expressed in a common currency (US dollars) the causality results seem to be much weaker than in the case of local currencies.

First the VAR model for Nordic stock market returns was modeled and the interrelationships were analysed using Granger causality tests. Compared to previous studies (e.g. Mathur, Subrahmanyan 1990, 1991; Malkamäki, Martikainen, Perttunen, Puttonen 1993) in which Sweden's strong influence on the other stock markets is usually reported, according the present study Sweden seems to have lost this leading ability in the 1990s. This finding is supported by Malkamäki (1993), who also found no causality between Finland and Sweden. The strongest interrelationship seems to exist between Norway and Finland. Highly significant causality seems to exist only from Norway to Finland.

When the stock returns are expressed in local currencies, Finland is affected by all the other returns except Sweden. Norway seems to be influenced by all the Scandinavian markets, while Denmark and Sweden do not. The validity of these estimations is nevertheless questioned, because precious information may have been destroyed by using the stock market returns, i.e. first differenced index series. After finding the Nordic stock market index series to be cointegrated, the models are re-estimated in error-correction form for the stock market indexes.

The Granger causality tests, when the Nordic stock index series are used in estimations, suggests the existence of highly significant causality from Sweden to Norway. The results may seem to support Sweden as a leading market in Scandinavia, because Sweden also has slight causal effect on Denmark, but not on Finland. Causal relationships are also strong from Sweden to other Scandinavian countries when daily stock market data is applied, while Denmark has no causal relationship to the other markets.

When the series are expressed in US dollars, a causal link seems to exist from Norway to Finland and vice versa. This interrelation may mostly be due to similar exchange rate behaviour, however. Denmark also seems to be slightly leading all the other markets. This may indicate that in the 1990s (compared to the previous studies) Sweden has partly lost its leading position to Denmark, which now may represent gaining in importance of Central European equity market impulses during European monetary integration.

Global and European financial integration, liberalization of the financial markets and the technical market information management innovations have changed the Scandinavian financial markets to a remarkable degree. Cointegration between the four Scandinavian stock markets was found using the Johansen's (1988) maximum likelihood estimation technique for the vector autoregressive systems. This cointegration is nevertheless not sufficient proof of Scandinavian stock market convergence. One cointegrating relation exists between the Nordic markets, but this relation did not change during the estimation period January 1990 - February 1998. The plotted recursive eigenvectors were apparently stable during the whole period under consideration. There was no change in this conclusion if stock market performance series denominated in a common currency instead of the local currency were used. The Scandinavian stock markets are thus strongly interconnected, as the contemporary correlation measures reveal, but this close relation has not been strengthened during the 1990s.

Impulse accounting methods were also applied to analyze the effects of the Scandinavian stock market impulses on the other markets in the same area. Noteworthy correlations between the Nordic stock market indexes seem to exist during the estimation period (January 1990 - February 1998) only from Sweden to Norway and from Denmark to Finland. All the other possible links were found weaker and did not hold using the various alternative decomposition orderings. These relations were found by calculating the impulse response functions and developing a maximum impulse response index (I_λ), which measures the maximum impulse response in the corresponding market variable, observed after an initial shock in one market. The I_λ index contains a sub-index, which notes the time period after which the maximum response is observed. The derived I_λ index may be applicable and also handy in the future research.

Alternatives to the usually applied Cholesky decomposition ordering was examined, but the Sims-Bernanke decomposition failed to pass the likelihood ratio test for the over-identifying restrictions. The results concerning the two strong impulse links (from Sweden to Norway and from Denmark to Finland) were nevertheless also found by using the Sims-Bernanke decomposition alternative.

Alternative orderings were found overall not to outstandingly affect the impulse response functions and the variance decomposition values, which was not surprising, while the contemporary correlations between the VAR system residuals (in table 59) were found to range between 0.4 and 0.7, indicating that the choice of decomposition ordering alters the innovation accounting outcomes. In that case, a valid procedure is required to imply the correct ordering. Here the Cholesky ordering used is decided according the cointegration weights and the cointegration vector restriction test results, which indicate the relative importance of the various Scandinavian stock markets, suggesting that Sweden is the most important stock market in Scandinavia, while Norway, Denmark and Finland affect the other markets to a lesser degree.

The results were obtained by using Scandinavian stock market index series calculated in local currencies. The innovation accounting results with the series transformed to a common currency (US dollars) would present different results, suggesting that Denmark is the leading market in Scandinavia. This means that international exchange rate behaviour affects the efficiency of the Nordic stock market in a way that is not completely hedged. The VAR system estimations, and the corresponding tables, containing the estimation results using the common currency series are presented in the appendix. The importance of Denmark's stock market in Scandinavia is similarly found to gain more momentum if we apply the Sims-Bernanke decompostion ordering instead of the Cholesky decomposition. Since that option is rejected according the LR test value calculated, this suggestion is not considered further. The long-run coefficient estimations from the error-correction VAR model suggests that Sweden has rather significant positive long-term effects on the other Scandinavian markets, except Finland, which does not seem to be strongly integrated with other Scandinavian stock markets.

The UK stock market seems to be the most important international factor influencing the Scandinavian stock markets during the 1990s. All the four Scandinavian stock exchanges included in this study are found to be positively and significantly affected by the contemporary effects of the changes in the UK stock index according the four variable Scandinavian VAR systems applied. This observation is supported by estimations using stock index variables transformed both in local and in common currencies.

The F-test values also support the notion of the UK as the most important (non-Scandinavian) international stock market for the behaviour of the Nordic stock market. This is not surprising, as the UK is the largest European financial market. The largest coefficient for the UK stock market is obtained for Finland, which seems to be the financial market most open to the middle-term market impulses from the UK. This notion is supported by estimations using both local and common currency transformations. When daily data is applied, Sweden is found to receive the strongest international effects from the UK. Monthly data models seem to give larger estimated coefficients. This is in line with our expectations, as long-term linkages can be better revealed by using lower frequency data. The level of significance of the coefficients is nevertheless increased when daily data is applied, which also implies solid short-term international linkages between the Scandinavian and foreign stock markets.

The most open Scandinavian stock market to the overall impulses of the international and global stock market is found to be Sweden, especially when short-term effects are considered. Sweden is affected by all the exogenously treated international stock markets, Germany, the UK and the US, when the stock index variables are presented in local currencies, and when the indexes are transformed to a common currency (US dollars), only Sweden is found to be affected by the US stock market in the long-term, implying that Sweden is the Scandinavian financial market most open to unpredicted global, as well as European, stock market impulses.

Nevertheless, since we have used data sets similar to those of the preceding studies on Scandinavian stock market integration, namely aggregate national stock market indexes, we remain rather suspicious about the results obtained in both this and those studies. We consider industry-specific national indexes the more valid instruments with which to analyse the interrelationships between national stock indexes, as this would eliminate the underlying differences in the national industry structures and the possible remedies concerning the process of aggregation of the wide aggregate indexes. As found in this study, some results were rather unclear (as there were several negative signs in the interrelationships between the stock indexes) and the process of aggregation most possibly has effects on the relationship results. We suggest that in future studies on international financial market integration, more intense thought should be given to the process of choosing the index series to be applied and that industry-specific indexes should rather be applied.

This study is unique in the sense that here also finally the sector-specific stock market indexes were also finally applied, rather than using the economy-wide aggregate stock market indexes as a proxy for the whole behaviour of the national stock market, which was then contrasted with the results obtained from the other international indexes. Contrary to our and others, previous studies on Scandinavian stock market interrelationships, we found the Scandinavian stock markets not to be cointegrated.

We used daily and monthly data frequencies and the stock market indexes used were also transformed to a common currency (US dollars) in addition to local currency denominated indexes. No differences were found in the case of cointegration, whichever data form was used. No cointegration was found between the Scandinavian stock markets, either in the banking or in the telecommunications industry sectors. We used the two most important sectors, banking and telecommunications, rather than aggregate stock indexes, to obtain the nation-specific stock market behaviours, and to better analyse the possible interrelationships.

Granger causality was also analysed between the Scandinavian banking and telecommunications stocks. One apparent result was the leading nature of the Swedish stock market in relation to all the other Scandinavian exchanges. This finding was supported by both the banking and telecommunications data. This result is also well in line with the previous studies.

Use of economy wide stock market indexes has previously been *de facto* standard in studies concerning international financial market linkages and international cointegration, but this study shows that the results obtained vary strongly depending on the industry structures and weightings of the particular industries contained in the national aggregate stock indexes. The Scandinavian stock markets were previously found to be cointegrated when the aggregate indexes were used, but no cointegration was present when industry-specific data was applied in this study.

This shows that the previous results have most probably been biased, as the use of economy-wide aggregate stock market indexes is done without any consideration as to the validity of that practice. The Scandinavian economies are examples of politically and geographically very close small stock markets, which nevertheless have very different kinds of industry structures. If the Scandinavian stock market interrelationships or cointegration is analysed by using the aggregate indexes, then the different weightings of different national industries affect the results obtained. This kind of analysis is doomed to analyse the interrelationships between different industries (such as the Finnish or Swedish telecom industry and Danish pharmaceutical and transportation industry), rather than the national economies.

As was noted in the introduction, equity valuations are based on two main factors, expected cash flows and the discount rate (by which the cash flows are discounted to their present value). The discount rate used in valuation reflects the interest rates and risk premium required. As the risk premium is based on a wide international consensus, this relates international stock markets and especially indexes together. Aggregate stock indexes include a wide variety of equities, which makes such indexes by nature more sensitive to overall economic risk factors, such as the risk premium. It is also very believable that aggregate indexes are more of a reflection of changes in interest rates, as they incorporate the reaction of the national stock exchange as a whole. Changes in the prices of individual equities and sector-specific indexes are derived more from company- and sector-specific information, and less from global economic factors (as interest rates or risk premium). Therefore, the use of sector indexes is a better alternative than aggregate stock indexes for analysing international stock exchange relations, as aggregate indexes incorporate wider economic influences, while sector indexes are based more on national sector trends and business performance.

The results of this study may very well reflect the different sensitivities of aggregate stock indexes and sector-specific indexes to common global economic factors. Interest rates and the stock market risk premium especially, are items likely to influence aggregate stock indexes but the narrower sector-specific indexes. Therefore, the cointegration found in the aggregate index data may reflect these common factors (interest rates, risk premium), as cointegration was not seen in the sector data.

The results mean that Scandinavian investors will benefit from diversifying their portfolios in different Nordic stock exchanges, and also within the same business segment (such as telecom or banking), as these sectors were not found to be cointegrated and can thus be considered as collectively efficient. The hypothesis of Scandinavian stock market efficiency can thus not be rejected. Nevertheless, investors will not benefit from diversifying into different Scandinavian index tracking funds, which are becoming currently popular, as diversifying at the level of the aggregate index is not justified. The cointegration found at the level of the aggregate index implies common moving factors and inefficiencies. Additionally, in future studies of the financial market, the use of sector-specific stock market indexes should be considered a more valid method for obtaining knowledge of the national properties of particular stock exchanges.

YHTEENVETO (FINNISH SUMMARY)

Pohjoismaisten osakemarkkinoiden integraatio

Pohjoismaisten osakemarkkinoiden integraatiota on viimeksi kuluneina kahtena vuosikymmenenä tutkittu ahkerasti. Ekonometristen VAR-mallien ja yhteisintegraatiotarkastelujen avulla on pyritty selvittämään onko näiden toisilleen maantieteellisesti läheisten osakemarkkinoiden välillä merkittäviä riippuvuussuhteita, viiverakenteita, samanperäisiä trendejä tai tilastollisesti havaittavaa yhteisintegraatiota. Tässä tutkimuksessa jatkan tätä tutkimusperinnettä, käyttämällä tosin uutta tutkimusperiodia (tammikuu 1990 - helmikuu 1998).

Edeltävät pohjoismaisten osakemarkkinoiden integraatiota analysoineet tutkimukset ovat käyttäneet laajoja kokonaisindeksisarjoja kustakin osakemarkkinasta (kuten HEX-yleisindeksi Suomesta ja OMX -indeksi Ruotsista) kuvaamaan kunkin maan pörssin ominaiskäyttäytymistä. Vastaavasti on menetelty muussakin kansainvälisessä rahoitusintegraatiota käsittelevässä tutkimuskirjallisuudessa. Tässä tutkimuksessa tämä kritiikitön, kunkin talouden ja kansallisen pörssin kehityksen samaistaminen yhteen aggregaatti-indeksiin asetetaan kyseenalaiseksi.

Tutkimuksen aluksi luodaan katsaus kansainväliseen rahoitusmarkkinoiden integraatiota käsittelevään tutkimusperinteeseen. Tutkittaessa osakemarkkinoiden yhteisriippuvuutta, kohdataan lukuisia empiirisiä ja metodologisia ongelmia. Merkittävimmät ongelmat esitellään, ryhmitellään, ja eteenkin tuodaan esiin edeltävistä tutkimuksista löytyvät koetellut ratkaisuehdotukset. Osakemarkkinoiden integraation tutkimuksessa on parhaimmaksi menetelmäksi vakiintunut yhteisintegraatiotarkastelu, jossa testataan kansainvälisten osakeindeksien aikasarjojen sisältämiä mahdollisia yhteisiä trendejä. Tässä tarkastelukehikossa mallinnuksen tehokkuudelle ja aikasarjojen luotettavuudelle asetetaan kuitenkin korkeat vaatimukset.

Useat edeltävät tutkimukset ovat havainneet kansainvälisten osakemarkkinoiden kehityksen samankaltaistumista viimeisten vuosikymmenten aikana. Erityisesti vuoden 1987 lokakuun pörssiromahduksen on havaittu muodostaneen tässä kehityksessä käännekohdan. Toisin kuin merkittävien kansainvälisten osakemarkkinoiden (esim. USA, Iso-Britannia, Japani), pohjoismaiden kesken eivät tutkimukset ole 1980-luvulla havainneet esiintyneen yhteisintegraatiota, vaan kussakin pohjoismaassa osakekurssien kehityksen ovat etupäässä määränneet muutokset kansallisessa ja yrityskohtaisessa talouskehityksessä. Tutkimukset ovat kuitenkin olleet verrattain yksimielisiä Ruotsin osakemarkkinakehityksen heijastumisesta myös muissa pohjoismaissa. Mikäli kansainvälisten osakemarkkinoiden välillä voidaan havaita yhteisintegraatiota, siis kurssikehityksen tilastollista samankaltaisuutta, ei sijoitussalkun pitkänaikavälin hajauttaminen näille markkinoille tarjoa merkittävää hyötyä tai suojaa kurssivaihtelulta.

Tässä tutkimuksessa kohdeperiodina ovat vuodet 1990-1998 ja tänä ajanjaksona havaitaan pohjoismaisten osakemarkkinoiden olevan yhteisintegroituneita. Sijoitussalkun hajauttaminen 1990-luvun aikana pohjoismaiden osakemarkkinoiden kesken ei näin tunnu saavan tuloksistani tukea. Yhteisintegraatio tulee havaituksi riippumatta aineiston frekvenssistä tai käytetystä perusvaluutasta. Syyksi tämän yhteisen osakemarkkinatrendin esiintymiselle, ja ilmaantumiselle vasta 1990-luvulla, ehdotan mm. kansainvälisen osakesijoittamisen sääntelyn vapauttamista, teknologiasijoittamisen valtaisaa yleistymistä, globalisaatiota ja tiedonkulun (sekä -määrän) nopeaa yleistymistä.

Testaan pohjoismaiden osakemarkkinoiden välisiä riippuvuuksia käyttäen joukkoa ekonometrisia menetelmiä. Impulssivastefunktioiden ja varianssihajotelmien käyttö paljastaa mm. Ruotsin osakemarkkinoiden vaikutussuhteen Norjaan, ja toisaalta Tanskasta Suomeen. Tulosten havainnollisuutta ja estimoinnin tehokkuutta pyritään parantamaan esittelemällä lisäksi maksimaalisen impulssivasteen indeksi, jota tulevissa tutkimuksissakin voitaisiin hyödyntää.

Tutkimuksen kuluessa herää kuitenkin epäilys aggregaattisarjojen käytön perusteltavuudesta. Osakemarkkinoiden kehityksen kuvaajana, ja siten pääasiallisena aineistona myös tutkimuksissa, on totuttu käyttämään kokonaisindeksejä (kuten HEX-yleisindeksi Suomessa). Kun näitä yleisindeksejä sitten käytetään kansainvälisissä vertailuissa, jää huomioimatta tärkeitä periaatteellisia ongelmia. Kunkin yleisindeksin muodostamismenelmät, ja erityisesti toimialojen painorakenteet, eroavat toisistaan ratkaisevasti. Tutkimuskohteena ei siten olekaan kansallisia osakemarkkinoita, vaan pikemminkin erilaisia toimialoja ja teknisiä indeksien laskentakäytäntöjä. Yleisindeksit reagoivat myös helpommin makrotaloudellisiin häiriöihin ja kansainväliseen markkinasentimenttiin. Näiden sudenkuoppien välttämiseksi toistankin tutkimuksen lopussa estimoinnit käyttäen pohjoismaiden yleisindeksisarjojen sijasta toimialakohtaisia havaintoja.

Pohjoismaiden toimialakohtaista osakemarkkinakehitystä kuvaamaan on valittu kaksi käyttökelpoisinta toimialaa: Pankit ja rahoitus, sekä telekommunikaatio. Toimialakohtaista osakemarkkinakehitystä tutkittaessa ei pohjoismaiden välillä havaita merkkejä yhteisintegraatiosta. Kuten aikaisemminkin, käytetyllä aineiston aikafrekvenssillä tai perusvaluutalla ei havaita vaikutusta tulokseen. Pohjoismaiden osakekurssit reagoivat ulkopuolisiin häiriöihin toimialatasolla tarkasteltuna siis erilaisesti, eikä niiden välillä voida katsoa vaikuttavan yhteisiä trendejä. Näiden markkinoiden kollektiivisen tehokkuuden voi siten katsoa toimivan. Pohjoismainen osakesijoitusten hajautuskin on täten sittenkin perusteltavissa.

Yleisindeksien käyttö kansainvälisten osakemarkkinoiden integraatiotutkimuksessa johtaa täten helposti harhauttaviin tuloksiin, mikäli käytetyn aineiston muodostamisperiaatteisiin ei kiinnitetä riittävää huomiota. Mikäli halutaan tutkia osakemarkkinoiden kansainvälistä integraatiota, tulisi mahdollisuuksien mukaan hyödyntää toimialakohtaista aineistoa.

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APPENDIX ; TABLES AND FIGURES

TABLE 38 Descriptive statistics of monthly stock returns

Series	*Mean* (10^{-2})	*St.dev* (10^{-2})	*Skew.*	*Ex.kurt.*	*Min*	*Max*	*Norm.test* $\chi^2(2)$	ρ_1	ρ_2	ρ_3
Local currencies										
Finland	0.927	6.763	0.140	-0.205	-0.129	0.219	0.362 (0.834)	0.357	0.027	0.088
Sweden	1.019	6.465	-0.417	2.525	-0.247	0.236	20.464 (0.000) **	0.125	0.016	0.047
Norway	0.816	4.917	-0.478	-0.116	-0.127	0.103	4.995 (0.082)	0.334	0.133	0.080
Denmark	0.643	4.176	-0.119	-0.219	-0.098	0.111	0.264 (0.876)	0.075	0.120	0.089
Germany	0.620	3.751	-0.767	0.963	-0.113	0.090	9.103 (0.011) *	0.246	0.129	0.026
U.K.	0.715	3.078	-0.170	0.047	-0.070	0.086	0.771 (0.680)	0.247	-0.152	-0.219
U.S.	1.077	2.553	0.175	2.532	-0.078	0.107	23.485 (0.000) **	0.147	0.046	-0.065
U.S. dollars										
Finland	0.589	7.123	-0.307	1.068	-0.261	0.179	6.636 (0.036) *	0.219	-0.069	-0.005
Sweden	0.748	6.343	-0.559	1.817	-0.248	0.177	11.390 (0.003) **	-0.005	-0.106	0.060
Norway	0.659	4.755	-0.132	-0.426	-0.095	0.112	0.708 (0.702)	0.220	0.082	-0.053
Denmark	0.581	4.227	-0.163	0.313	-0.118	0.113	1.692 (0.429)	-0.069	-0.034	0.016
Germany	0.544	3.926	-0.837	1.422	-0.126	0.096	10.308 (0.006) **	-0.053	0.031	-0.094
U.K.	0.691	3.515	0.016	0.081	-0.078	0.103	0.547 (0.761)	0.123	-0.179	-0.267
U.S.	1.077	2.553	0.175	2.532	-0.078	0.107	23.485 (0.000) **	0.147	0.046	-0.065

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis. ρ_i values are the autocorrelation coefficients of lag i.

TABLE 39 Descriptive statistics of daily stock returns

Series	*Mean* (10^{-2})	*St.dev* (10^{-2})	*Skew.*	*Ex.-kurt.*	*Min.*	*Max.*	*Norm.test* $\chi^2(2)$		ρ_1	ρ_2	ρ_3
Finland	1.269	20.033	-0.149	4.155	-1.229	1.387	673.6	(0.000) **	0.141	-0.037	0.033
Sweden	1.250	24.321	0.315	5.780	-1.304	2.088	1013.5	(0.000) **	0.095	-0.034	-0.031
Norway	0.721	16.910	-0.063	7.132	-1.236	1.374	1437.8	(0.000) **	0.115	-0.020	-0.025
Denmark	0.491	11.901	-0.611	5.496	-0.895	0.534	759.1	(0.000) **	0.171	0.033	-0.008
Germany	0.745	15.881	-0.611	4.947	-1.139	0.830	641.8	(0.000) **	0.030	-0.049	-0.013
UK	0.555	11.426	0.069	2.617	-0.530	0.697	343.5	(0.000) **	0.084	-0.045	-0.035
US	0.774	10.675	-0.538	6.767	-0.934	0.609	1112.2	(0.000) **	0.020	-0.021	-0.046

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis. ρ_i values are the autocorrelation coefficients of lag i.

TABLE 40 Descriptive statistics of monthly bank sector stock returns. Local and common currencies

Series	*Symbol*	*Mean*	*St.dev*	*Skew.*	*Ex.kurt.*	*Min.*	*Max.*	*Norm.test* $\chi^2(2)$		ρ_1	ρ_2	ρ_3
Local currencies												
Finland	FI	0.549	2.989	0.558	0.594	-5.586	8.056	3.808	(0.149)	-0.127	-0.123	0.154
Sweden	SW	0.531	1.485	0.735	0.976	-2.187	5.572	5.912	(0.052)	-0.047	0.093	0.415
Norway	NO	0.945	2.213	0.612	0.423	-3.368	7.098	4.262	(0.119)	0.172	0.098	0.035
Denmark	DE	0.499	1.320	0.026	-0.165	-2.514	3.634	0.116	(0.944)	-0.144	0.097	-0.032
U.S. dollars												
Finland	-	0.308	4.369	0.398	0.829	-11.307	14.044	4.203	(0.122)	-0.003	-0.178	-0.024
Sweden	-	-0.043	3.498	-1.435	5.828	-16.401	6.703	21.364	(0.000) **	0.012	-0.132	0.090
Norway	-	0.501	3.626	-0.149	0.219	-8.994	9.940	1.277	(0.528)	-0.014	-0.089	-0.190
Denmark	-	0.203	2.672	-0.548	0.833	-8.269	6.240	4.376	(0.112)	0.072	-0. 148	-0.109

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis.
ρ_i values are the autocorrelation coefficients of lag i.

TABLE 41 Descriptive statistics of monthly telecom sector stock returns. Local and common currencies

Series	*Symbol*	*Mean*	*St.dev*	*Skew.*	*Ex.kurt.*	*Min.*	*Max.*	*Norm.test* $\chi^2(2)$		ρ_1	ρ_2	ρ_3
Local currencies												
Finland	FI	0.954	2.754	-0.206	-0.411	-6.808	6.818	0.984	(0.611)	0.152	0.053	0.049
Sweden	SW	0.573	2.506	-0.054	3.140	-8.029	9.989	28.922	(0.000) **	-0.057	0.019	0.191
Norway	NO	0.543	2.514	0.084	-0.064	-6.369	6.362	0.295	(0.863)	0.267	0.058	0.224
Denmark	DE	0.131	1.808	-0.318	0.026	-4.734	4.445	1.513	(0.469)	-0.049	0.087	0.031
U.S. dollars												
Finland	-	0.427	4.472	-0.523	0.828	-15.548	10.365	4.735	(0.094)	0.077	0.026	0.077
Sweden	-	0.189	3.622	-0.297	-0.240	-9.079	8.733	1.471	(0.479)	0.070	-0.118	0.001
Norway	-	0.363	3.723	-0.281	0.498	-10.619	9.327	2.693	(0.260)	0.217	0.072	-0.131
Denmark	-	0.098	3.136	-0.401	-0.139	-8.587	6.784	2.634	(0.268)	-0.025	-0. 123	-0.064

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis.
ρ_i values are the autocorrelation coefficients of lag i.

TABLE 42 Descriptive statistics of daily bank sector stock returns. Local and common currencies

Series	*Symbol*	*Mean*	*St.dev*	*Skew.*	*Ex.kurt.*	*Min.*	*Max.*	*Norm.test* $\chi^2(2)$	ρ_1	ρ_2	ρ_3
Local currencies											
Finland	FI	0.026	0.535	0.900	8.073	-3.285	3.686	647.43 (0.000) **	0.078	-0.031	0.015
Sweden	SW	0.031	0.345	0.264	2.155	-1.761	1.415	144.69 (0.000) **	0.158	0.050	0.025
Norway	NO	0.027	0.244	0.451	3.735	-1.163	1.546	267.73 (0.000) **	0.129	0.049	0.023
Denmark	DE	0.018	0.265	0.206	1.249	-1.022	1.263	62.091 (0.000) **	0.107	-0.035	-0.017
U.S. dollars											
Finland	-	0.029	1.036	0.036	1.848	-5.292	4.353	123.76 (0.000) **	-0.035	0.012	-0.033
Sweden	-	0.023	0.870	-0.030	1.294	-3.665	3.921	68.897 (0.000) **	-0.022	0.031	-0.020
Norway	-	0.019	0.756	-0.048	1.717	-3.874	3.080	109.78 (0.000) **	-0.090	0.062	-0.068
Denmark	-	0.010	0.699	0.040	1.942	-3.335	3.330	133.97 (0.000) **	-0.054	0. 040	-0.048

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis.
ρ_i values are the autocorrelation coefficients of lag i.

TABLE 43 Descriptive statistics of daily telecom sector stock returns. Local and common currencies

Series	*Symbol*	*Mean*	*St.dev*	*Skew.*	*Ex.kurt.*	*Min.*	*Max.*	*Norm.test* $\chi^2(2)$	ρ_1	ρ_2	ρ_3
Local currencies											
Finland	FI	0.043	0.514	-0.382	6.376	-4.729	2.613	902.52 (0.000) **	0.069	0.015	0.026
Sweden	SW	0.025	0.488	-0.000	3.497	-3.227	3.259	429.22 (0.000) **	0.077	-0.043	-0.000
Norway	NO	0.022	0.588	0.351	11.415	-5.198	4.627	1985 (0.000) **	-0.080	-0.012	-0.019
Denmark	DE	0.005	0.350	-0.624	6.785	-2.834	1.671	835.78 (0.000) **	0.071	0.004	0.027
U.S. dollars											
Finland	-	0.020	0.992	-1.483	16.668	-12.379	3.687	1551.3 (0.000) **	-0.060	0.007	-0.001
Sweden	-	0.009	0.826	-0.290	2.732	-6.354	2.970	267.83 (0.000) **	-0.017	-0.013	-0.059
Norway	-	0.013	0.945	-0.219	4.404	-7.081	5.391	573.92 (0.000) **	-0.078	0.037	-0.014
Denmark	-	0.004	0.812	-0.132	2.588	-5.533	3.664	266.85 (0.000) **	-0.011	-0. 035	-0.026

Note: The test for normality is developed by Bowman, Shenton (1977) and later by Doornik, Hansen (1994). P-values are in the parenthesis.
ρ_i values are the autocorrelation coefficients of lag i.

TABLE 44 Correlation coefficients of monthly stock returns

	FI	*SW*	*NO*	*DE*	*GE*	*UK*	*US*
Local currencies							
FI	1.000						
SW	0.531	1.000					
NO	0.722	0.471	1.000				
DE	0.366	0.621	0.538	1.000			
GE	0.539	0.491	0.565	0.457	1.000		
UK	0.584	0.480	0.546	0.431	0.562	1.000	
US	0.387	0.476	0.400	0.404	0.502	0.600	1.000
U.S. dollars							
FI	1.000						
SW	0.477	1.000					
NO	0.644	0.433	1.000				
DE	0.276	0.580	0.514	1.000			
GE	0.367	0.370	0.476	0.444	1.000		
UK	0.510	0.512	0.504	0.537	0.547	1.000	
US	0.313	0.429	0.330	0.281	0.351	0.464	1.000

TABLE 45 Correlation coefficients of daily stock returns

	FI	*SW*	*NO*	*DE*	*GE*	*UK*	*US*
FI	1.000						
SW	0.509	1.000					
NO	0.464	0.549	1.000				
DE	0.030	-0.020	-0.015	1.000			
GE	0.537	0.519	0.558	-0.013	1.000		
UK	0.445	0.518	0.472	-0.026	0.571	1.000	
US	0.231	0.298	0.210	0.007	0.281	0.361	1.000

TABLE 46 Correlation coefficients of monthly bank stock returns

	FI	*SW*	*NO*	*DE*
Local currencies				
FI	1.000			
SW	0.576	1.000		
NO	0.429	0.361	1.000	
DE	0.402	0.347	0.386	1.000
U.S. dollars				
FI	1.000			
SW	0.639	1.000		
NO	0.633	0.568	1.000	
DE	0.621	0.516	0.722	1.000

TABLE 47 Correlation coefficients of monthly telecom stock returns

	FI	*SW*	*NO*	*DE*
Local currencies				
FI	1.000			
SW	0.600	1.000		
NO	0.035	0.219	1.000	
DE	0.362	0.282	0.143	1.000
U.S. dollars				
FI	1.000			
SW	0.699	1.000		
NO	0.385	0.530	1.000	
DE	0.549	0.594	0.537	1.000

TABLE 48 Correlation coefficients of daily bank stock returns

	FI	*SW*	*NO*	*DE*
Local currencies				
FI	1.000			
SW	0.241	1.000		
NO	0.189	0.298	1.000	
DE	0.188	0.227	0.223	1.000
U.S. dollars				
FI	1.000			
SW	0.552	1.000		
NO	0.634	0.591	1.000	
DE	0.646	0.553	0.801	1.000

TABLE 49 Correlation coefficients of daily telecom stock returns

	FI	*SW*	*NO*	*DE*
Local currencies				
FI	1.000			
SW	0.395	1.000		
NO	0.087	0.102	1.000	
DE	0.198	0.173	0.073	1.000
U.S. dollars				
FI	1.000			
SW	0.581	1.000		
NO	0.426	0.446	1.000	
DE	0.608	0.582	0.536	1.000

TABLE 50 Unit root tests of monthly stock indices/returns

Series	*levels*	*Δ*	Δ^2	*Conclusion*
Local currencies				
FI	DF_{CT} = -2.306	DF_{CT} = -6.929 **		I(1)
SW	$ADF_{CT}(3)$ = -2.933	$ADF_{CT}(2)$ = -5.232 **		I(1)
NO	$ADF_{CT}(1)$ = -2.281	DF = -6.867 **		I(1)
DE	DF_{CT} = -0.690	DF_{CT} = -9.515 **		I(1)
U.S. dollars				
FI	$ADF_{CT}(9)$ = -2.533	ADF(8) = -1.931 [a] ADP(8) = 1.056	ADF(7) = -7.144 ** ADP(7) = -2.837 **	I(1)
SW	DF_{CT} = -2.007	DF = -9.602 **		I(1)
NO	DF_{CT} = -1.987	DF = -7.773 **		I(1)
DE	DF = 1.414	DF = -10.240 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

[a] 95% critical value is -0.913, so the ADF-test does not reject. The more efficient version (Dickey-Pantula) of the unit root test clearly rejects a null hypothesis I(2) for Finland.

TABLE 51 Unit root tests of daily stock indices/returns

Series	*levels*	*Δ*	*$Δ^2$*	*Conclusion*
Monthly data				
FI	DF_{CT} = -2.306	DF_{CT} = -6.929 **		I(1)
SW	$ADF_{CT}(3)$ = -2.933	$ADF_{CT}(2)$ = -5.232 **		I(1)
NO	$ADF_{CT}(1)$ = -2.281	DF = -6.867 **		I(1)
DE	DF_{CT} = -0.690	DF_{CT} = -9.515 **		I(1)
Daily data				
FI	ADF(8) = 2.421	ADP(7) = -15.21 **		I(1)
SW	ADF(13) = 2.125	$ADF_{C}(12)$ = -11.66 **		I(1)
NO	ADF(10) = 1.702	ADF(9) = -13.57 **		I(1)
DE	ADF(14) = 1.258	ADF(13) = -10.17 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 52 Unit root tests of monthly and daily stock indices/returns

Series	*levels*	*Δ*	*Δ²*	*Conclusion*
Monthly data				
FI	DF_{CT} = -2.306	DF_{CT} = -6.929 **		I(1)
SW	$ADF_{CT}(3)$ = -2.933	$ADF_{CT}(2)$ = -5.232 **		I(1)
NO	$ADF_{CT}(1)$ = -2.281	DF = -6.867 **		I(1)
DE	DF_{CT} = -0.690	DF_{CT} = -9.515 **		I(1)
Daily data				
FI	ADF(8) = 2.421	ADP(7) = -15.21 **		I(1)
SW	ADF(13) = 2.125	$ADF_{C}(12)$ = -11.66 **		I(1)
NO	ADF(10) = 1.702	ADF(9) = -13.57 **		I(1)
DE	ADF(14) = 1.258	ADF(13) = -10.17 **		I(1)
GE	ADF(14) = 2.201	$ADF_{C}(13)$ = -11.82 **		I(1)
UK	ADF(7) = 2.572	$ADF_{C}(6)$ = -20.01 **		I(1)
US	ADF(17) = 3.745	$ADF_{C}(16)$ = -12.31 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 53 Unit root tests of monthly bank stock indices/returns

Series	*levels*	*Δ*	*Δ²*	*Conclusion*
Local currencies				
FI	$ADF_{CT}(9)$ = -1.549	DF = -8.662 **		I(1)
SW	DF_C = -0.629	$ADF_C(7)$ = -3.227 **		I(1)
NO	DF_C = -1.193	DF_C = -6.705 **		I(1)
DE	$ADF_{CT}(6)$ = -1.207	DF_C = -9.283 **		I(1)
U.S. dollars				
FI	DF_C = -1.625	DF = -7.876 **		I(1)
SW	$ADF_C(12)$ = -1.883	DF = -9.568 **		I(1)
NO	DF_C = -1.563	DF = -8.145 **		I(1)
DE	$ADF_C(9)$ = -2.199	DF = -7.291 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 54 Unit root tests of monthly telecom stock indices/returns

Series	*levels*	*Δ*	*Δ²*	*Conclusion*
Local currencies				
FI	DF_{CT} = -1.551	DF_C = -7.384 **		I(1)
SW	$ADF_{CT}(3)$ = -3.417	DF_C = -9.202 **		I(1)
NO	$ADF_{CT}(3)$ = -1.760	ADF(2) = -3.334 **		I(1)
DE	DF_{CT} = -2.350	DF = -9.290 **		I(1)
U.S. dollars				
FI	DF_C = -0.899	DF = -8.015 **		I(1)
SW	DF_C = -1.272	DF = -8.092 **		I(1)
NO	DF_C = -1.290	ADF(2) = -5.087 **		I(1)
DE	$ADF_C(9)$ = -1.930	DF = -9.019 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 55 Unit root tests of daily bank stock indices/returns

Series	*levels*	*Δ*	*$Δ^2$*	*Conclusion*
Local currencies				
FI	$ADF_C(1)$ = -1.523	DF_C = -33.55 **		I(1)
SW	$ADF_C(5)$ = -1.030	$ADF_C(4)$ = -16.57 **		I(1)
NO	$ADF_C(1)$ = -0.766	DF_C = -31.87 **		I(1)
DE	ADF_C (1) = -0.036	$ADF_C(6)$ = -15.15 **		I(1)
U.S. dollars				
FI	DF_C = -2.615	DF = -37.59 **		I(1)
SW	DF_{CT} = -2.544	DF = -37.11 **		I(1)
NO	$ADF_C(7)$ = -2.034	ADF (6) = -14.39 **		I(1)
DE	$ADF_C(6)$ = -1.791	ADF (5) = -16.78 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 56 Unit root tests of daily telecom stock indices/returns

Series	*levels*	*Δ*	*Δ²*	*Conclusion*
Local currencies				
FI	ADF_C (9) = -0.433	ADF_C (8) = -12.60 **		I(1)
SW	ADF_{CT}(13) = -2.998	ADF_C (12) = -10.13 **		I(1)
NO	ADF_{CT}(8) = -1.084	ADF_{CT}(7) = -13.92 **		I(1)
DE	ADF_{CT} (1) = -2.454	DF = -38.65 **		I(1)
U.S. dollars				
FI	ADF_C (1) = -0.876	DF = -44.13 **		I(1)
SW	ADF_{CT}(3) = -2.269	ADF (2) = -25.79 **		I(1)
NO	ADF_C (6) = -1.204	ADF(5) = -19.08 **		I(1)
DE	ADF_C(6) = -1.880	ADF (5) = -19.21 **		I(1)

Notes: ADF and DF stands for augmented and standard Dickey-Fuller unit root test procedure. During the testing process the significance of trend and constant are examined and they are included if necessary (C= constant, T=trend). Augmentation is included in unit root test if the autocorrelation properties suggest inclusion. The 95 and 99 per cent critical values are market with * and **, respectively. DP is a Dickey-Pantula unit root test, with the same critical values as DF- and ADF-tests.

TABLE 57 Granger causality test, marginal significance of retained regressors by nation. VAR(8)-model for stock returns, local currencies

Series	*FI*	*SW*	*NO*	*DE*
FI	22.741 ** (0.004)	12.836 (0.118)	16.255 * (0.039)	22.484 ** (0.004)
SW	17.333 * (0.027)	11.915 (0.155)	7.767 (0.457)	13.455 (0.097)
NO	21.084 ** (0.007)	34.5977 ** (0.000)	23.922 ** (0.002)	20.563 ** (0.008)
DE	22.926 ** (0.004)	13.552 (0.094)	9.970 (0.267)	8.443 (0.391)

Note: Probability (LR-test, $\chi^2(8)$) for retained regressors by nation in parenthesis.

TABLE 58 Granger causality test, marginal significance of retained regressors by nation. VAR(7)-model for stock returns, U.S. dollars

Series	*FI*	*SW*	*NO*	*DE*
FI	19.454 ** (0.007)	10.621 (0.156)	19.319 ** (0.007)	3.907 (0.790)
SW	13.749 (0.056)	10.642 (0.155)	13.928 (0.053)	13.631 (0.058)
NO	13.247 (0.066)	8.453 (0.294)	8.931 (0.258)	2.453 (0.931)
DE	9.734 (0.204)	8.797 (0.268)	12.738 (0.079)	9.293 (0.232)

Note: Probability (LR-test, $\chi^2(7)$) for retained regressors by nation in parenthesis.

TABLE 59 VAR(2)-model diagnostics and misspecification tests. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.542	1.000		
NO	0.716	0.618	1.000	
DE	0.408	0.694	0.570	1.000
System vector diagnostics				
Portmanteau	165.3			
AR (lags: 1-6, F(96,236))	1.202 (0.134)			
Normality $\chi^2(8)$	7.178 (0.518)			

TABLE 60 VAR(8)-model diagnostics and misspecification tests. U.S. dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.359	1.000		
NO	0.573	0.405	1.000	
DE	0.275	0.549	0.523	1.000
System vector diagnostics				
Portmanteau	98.699			
AR (lags: 1-6, F(96,117))	1.110 (0.294)			
Normality $\chi^2(8)$	11.077 (0.197)			

TABLE 61 VAR(5)-model diagnostics and misspecification tests. Daily data

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.510	1.000		
NO	0.456	0.546	1.000	
DE	-0.041	-0.034	-0.072	1.000
System vector diagnostics				
Portmanteau	151.8			
AR (lags: 1-7, F(112,8378)	1.223 (0.056)			
Normality $\chi^2(8)$	2843.3 (0.000)			

TABLE 62 VAR(2) - , VAR(8) and VAR(5) model diagnostics and misspecification tests

VAR-system vector diagnostics		
Local currencies (monthly data)		
Portmanteau	165.3	
AR (lags: 1-6, F(96,236))	1.202	(0.134)
Normality $\chi^2(8)$	7.178	(0.518)
U.S. dollars (monthly data)		
Portmanteau	98.699	
AR (lags: 1-6, F(96,117))	1.110	(0.294)
Normality $\chi^2(8)$	11.077	(0.197)
Local currencies (daily data)		
Portmanteau	151.8	
AR (lags: 1-6, F(96,117))	1.223	(0.056)
Normality $\chi^2(8)$	2843.3	(0.000)

TABLE 63 Restriction testing on cointegrating relations. Weak exogeneity testing. VAR(2) and VAR(8)-models. Local currencies. Rank=1

Series (i)	*Local currencies weak exogeneity test, $\alpha_i=0$, $\chi_2(1)$*	*significance of β_i's $\chi_2(1)$*
FI	1.048 (0.306)	0.215 (0.643)
SW	4.163 (0.041) *	39.583 (0.000) **
NO	9.679 (0.002) **	20.812 (0.000) **
DE	2.071 (0.150)	10.558 (0.001) **
trend		34.383 (0.000) **

Note: I tested also for restriction (local currencies series) α_{FI}, $\alpha_{DE} = 0$, $\chi^2(2) = 4.751$ (0.093)

TABLE 64 VAR(4)-model diagnostics and misspecification tests. Model for cointegration testing. Monthly bank data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.607	1.000		
NO	0.436	0.459	1.000	
DE	0.555	0.511	0.636	1.000
System vector diagnostics				
Portmanteau	80.626			
AR (lags: 1-4, F(64,100)	1.285 (0.130)			
Normality $\chi^2(8)$	11.465 (0.177)			

TABLE 65 VAR(2)-model diagnostics and misspecification tests. Model for cointegration testing. Monthly bank data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.595	1.000		
NO	0.709	0.594	1.000	
DE	0.644	0.658	0.748	1.000
System vector diagnostics				
Portmanteau	104.84			
AR (lags: 1-4, F(64,107))	1.336 (0.093)			
Normality $\chi^2(8)$	12.413 (0.134)			

TABLE 66 VAR(1)-model diagnostics and misspecification tests. Model for cointegration testing. Monthly telecom stocks data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.655	1.000		
NO	0.032	0.196	1.000	
DE	0.402	0.292	0.062	1.000
System vector diagnostics				
Portmanteau	159.34			
AR (lags: 1-5, F(80,199)	1.031 (0.424)			
Normality $\chi^2(8)$	6.572 (0.583)			

TABLE 67 VAR(2)-model diagnostics and misspecification tests. Model for cointegration testing. Monthly telecom stocks data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.723	1.000		
NO	0.437	0.537	1.000	
DE	0.527	0.567	0.521	1.000
System vector diagnostics				
Portmanteau	133.59			
AR (lags: 1-5, F(80,179))	1.329 (0.061)			
Normality $\chi^2(8)$	7.549 (0.478)			

TABLE 68 VAR(14)-model diagnostics and misspecification tests. Model for cointegration testing. Daily bank data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.222	1.000		
NO	0.179	0.315	1.000	
DE	0.185	0.234	0.241	1.000
System vector diagnostics				
Portmanteau	9.048			
AR (lags: 1-7, F(112,4792)	1.156 (0.126)			
Normality $\chi^2(8)$	991.73 (0.000)			

TABLE 69 VAR(2)-model diagnostics and misspecification tests. Model for cointegration testing. Daily bank data. US dollars

Correlation of the system residuals	*FI*		*SW*	*NO*	*DE*
FI	1.000				
SW	0.550		1.000		
NO	0.635		0.592	1.000	
DE	0.645		0.553	0.802	1.000
System vector diagnostics					
Portmanteau	170.9				
AR (lags: 1-7, F(112,5078))	1.231	(0.051)			
Normality $\chi^2(8)$	609.36	(0.000)			

TABLE 70 VAR(3)-model diagnostics and misspecification tests. Model for cointegration testing. Daily telecom stocks data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.397	1.000		
NO	0.075	0.095	1.000	
DE	0.189	0.170	0.058	1.000
System vector diagnostics				
Portmanteau	205.5			
AR (lags: 1-7, F(112,6670)	1.070 (0.290)			
Normality $\chi^2(8)$	3961.6 (0.000)			

TABLE 71 VAR(17)-model diagnostics and misspecification tests. Model for cointegration testing. Daily telecom stocks data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.567	1.000		
NO	0.417	0.424	1.000	
DE	0.601	0.558	0.530	1.000
System vector diagnostics				
Portmanteau	6.449			
AR (lags: 1-7, F(112,6349))	1.169 (0.108)			
Normality $\chi^2(8)$	3323.5 (0.000)			

TABLE 72 Granger causality test, marginal significance of retained regressors by nation. VAR(1)-model for monthly returns of bank stock, local currencies

Series	*FI*	*SW*	*NO*	*DE*
FI	12.146 ** (0.005)	9.182 ** (0.002)	0.958 (0.328)	1.888 (0.170)
SW	6.505 * (0.011)	0.094 (0.760)	0.999 (0.318)	0.234 (0.629)
NO	0.389 (0.533)	3.454 (0.063)	1.504 (0.220)	0.686 (0.408)
DE	1.295 (0.255)	1.827 (0.177)	0.100 (0.751)	0.887 (0.346)

Note: Probability (LR-test, $\chi^2(1)$) for retained regressors by nation in parenthesis.

TABLE 73 Granger causality test, marginal significance of retained regressors by nation. VAR(4)-model for monthly returns of bank stocks, U.S. dollars

Series	*FI*	*SW*	*NO*	*DE*
FI	2.523 (0.640)	4.210 (0.378)	0.925 (0.921)	2.898 (0.575)
SW	7.236 (0.124)	0.786 (0.940)	1.394 (0.845)	7.170 (0.127)
NO	11.126 * (0.025)	4.715 (0.318)	12.522 * (0.014)	14.312 ** (0.006)
DE	8.384 (0.079)	5.504 (0.239)	1.444 (0.837)	1.921 (0.750)

Note: Probability (LR-test, $\chi^2(4)$) for retained regressors by nation in parenthesis.

TABLE 74 Granger causality test, marginal significance of retained regressors by nation. VAR(4)-model for monthly returns of telecom stocks, local currencies

Series	*FI*	*SW*	*NO*	*DE*
FI	1.302 (0.861)	1.742 (0.783)	3.113 (0.539)	4.079 (0.395)
SW	1.473 (0.831)	4.735 (0.316)	0.651 (0.957)	5.803 (0.214)
NO	4.459 (0.347)	6.138 (0.189)	17.635 ** (0.002)	6.434 (0.169)
DE	3.616 (0.460)	2.473 (0.649)	0.698 (0.951)	0.911 (0.923)

Note: Probability (LR-test, $\chi^2(4)$) for retained regressors by nation in parenthesis.

TABLE 75 Granger causality test, marginal significance of retained regressors by nation. VAR(2)-model for monthly returns of telecom stocks, U.S. dollars

Series	*FI*	*SW*	*NO*	*DE*
FI	2.734 (0.255)	2.923 (0.232)	0.168 (0.919)	2.719 (0.257)
SW	1.464 (0.481)	1.896 (0.387)	1.317 (0.517)	0.105 (0.949)
NO	0.664 (0.717)	0.579 (0.748)	4.737 (0.093)	1.317 (0.517)
DE	0.201 (0.904)	1.554 (0.459)	1.225 (0.541)	0.495 (0.780)

Note: Probability (LR-test, $\chi^2(2)$) for retained regressors by nation in parenthesis.

TABLE 76 Granger causality test, marginal significance of retained regressors by nation. VAR(9)-model for daily returns of bank stock, local currencies

Series	*FI*	*SW*	*NO*	*DE*
FI	14.682 (0.100)	22.364 ** (0.008)	9.228 (0.416)	14.822 (0.095)
SW	20.332 * (0.016)	34.598 ** (0.000)	16.064 (0.065)	5.427 (0.795)
NO	13.338 (0.147)	8.885 (0.447)	26.491** (0.002)	9.024 (0.435)
DE	9.544 (0.388)	24.503 ** (0.004)	16.158 (0.063)	16.489 (0.057)

Note: Probability (LR-test, $\chi^2(9)$) for retained regressors by nation in parenthesis.

TABLE 77 Granger causality test, marginal significance of retained regressors by nation. VAR(1)-model for dai ly returns of bank stocks, U.S. dollars

Series	*FI*	*SW*	*NO*	*DE*
FI	1.228 (0.267)	2.056 (0.151)	2.211 (0.137)	0.588 (0.443)
SW	0.288 (0.591)	2.201 (0.137)	18.107 ** (0.000)	1.807 (0.178)
NO	3.389 (0.065)	0.839 (0.359)	2.575 (0.108)	1.798 (0.179)
DE	2.794 (0.094)	0.354 (0.551)	1.609 (0.204)	0.268 (0.604)

Note: Probability (LR-test, $\chi^2(1)$) for retained regressors by nation in parenthesis.

TABLE 78 Granger causality test, marginal significance of retained regressors by nation. VAR(1)-model for daily returns of telecom stocks, local currencies

Series	*FI*	*SW*	*NO*	*DE*
FI	0.604 (0.436)	25.232 ** (0.000)	1.604 (0.205)	0.001 (0.971)
SW	3.396 (0.065)	16.103 ** (0.000)	4.244 * (0.039)	0.885 (0.346)
NO	0.111 (0.739)	6.327 * (0.012)	13.044 ** (0.000)	0.165 (0.684)
DE	2.324 (0.127)	4.571 * (0.032)	11.21 ** (0.001)	5.809 * (0.016)

Note: Probability (LR-test, $\chi^2(1)$) for retained regressors by nation in parenthesis.

TABLE 79 Granger causality test, marginal significance of retained regressors by nation. VAR(1)-model for daily returns of telecom stocks, U.S. dollars

Series	*FI*	*SW*	*NO*	*DE*
FI	9.270 ** (0.002)	3.506 (0.061)	2.354 (0.124)	0.620 (0.430)
SW	0.949 (0.329)	0.033 (0.855)	6.710 ** (0.010)	0.255 (0.613)
NO	3.701 (0.054)	0.211 (0.645)	0.556 (0.455)	1.241 (0.265)
DE	0.737 (0.390)	0.001 (0.973)	3.464 (0.062)	0.908 (0.340)

Note: Probability (LR-test, $\chi^2(1)$) for retained regressors by nation in parenthesis.

TABLE 80 VAR(1)-model diagnostics and misspecification tests for the Granger causality model. Monthly bank data. Local currencies

Correlation of the system residuals	*FI*		*SW*	*NO*	*DE*
FI	1.000				
SW	0.615		1.000		
NO	0.477		0.555	1.000	
DE	0.431		0.406	0.500	1.000
System vector diagnostics					
Portmanteau	81.87				
AR (lags: 1-4, F(64,127))	1.102	(0.317)			
Normality $\chi^2(8)$	7.281	(0.506)			

TABLE 81 VAR(4)-model diagnostics and misspecification tests for the Granger causality model. Monthly bank data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.638	1.000		
NO	0.696	0.481	1.000	
DE	0.635	0.595	0.778	1.000
System vector diagnostics				
Portmanteau	62.169			
AR (lags: 1-4, F(64,96))	0.972 (0.544)			
Normality $\chi^2(8)$	4.148 (0.844)			

TABLE 82 VAR(4)-model diagnostics and misspecification tests for the Granger causality model. Monthly telecom data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.675	1.000		
NO	0.016	0.131	1.000	
DE	0.338	0.178	0.038	1.000
System vector diagnostics				
Portmanteau	81.12			
AR (lags: 1-5, F(80,140))	0.775 (0.893)			
Normality $\chi^2(8)$	14.673 (0.065)			

TABLE 83 VAR(2)-model diagnostics and misspecification tests for the Granger causality model. Monthly telecom data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.728	1.000		
NO	0.415	0.527	1.000	
DE	0.569	0.587	0.548	1.000
System vector diagnostics				
Portmanteau	137.31			
AR (lags: 1-5, F(80,179))	1.334 (0.059)			
Normality $\chi^2(8)$	6.630 (0.577)			

TABLE 84 VAR(9)-model diagnostics and misspecification tests for the Granger causality model. Daily bank data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.225	1.000		
NO	0.186	0.319	1.000	
DE	0.182	0.232	0.231	1.000
System vector diagnostics				
Portmanteau	69.45			
AR (lags: 1-7, F(112,4839))	1.154 (0.129)			
Normality $\chi^2(8)$	1061.9 (0.000)			

TABLE 85 VAR(1)-model diagnostics and misspecification tests for the Granger causality model. Daily bank data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.554	1.000		
NO	0.637	0.591	1.000	
DE	0.645	0.553	0.802	1.000
System vector diagnostics				
Portmanteau	179.0			
AR (lags: 1-7, F(112,5094))	1.139 (0.152)			
Normality $\chi^2(8)$	608.54 (0.000)			

TABLE 86 VAR(1)-model diagnostics and misspecification tests for the Granger causality model. Daily telecom data. Local currencies

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.390	1.000		
NO	0.078	0.094	1.000	
DE	0.189	0.169	0.063	1.000
System vector diagnostics				
Portmanteau	240.9			
AR (lags: 1-7, F(112,6710))	0.121 (0.181)			
Normality $\chi^2(8)$	4111.8 (0.000)			

TABLE 87 VAR(2)-model diagnostics and misspecification tests for the Granger causality model. Daily telecom data. US dollars

Correlation of the system residuals	*FI*	*SW*	*NO*	*DE*
FI	1.000			
SW	0.616	1.000		
NO	0.543	0.477	1.000	
DE	0.650	0.533	0.619	1.000
System vector diagnostics				
Portmanteau	220			
AR (lags: 1-7, F(112,5205))	1.131 (0.164)			
Normality $\chi^2(8)$	653.8 (0.000)			

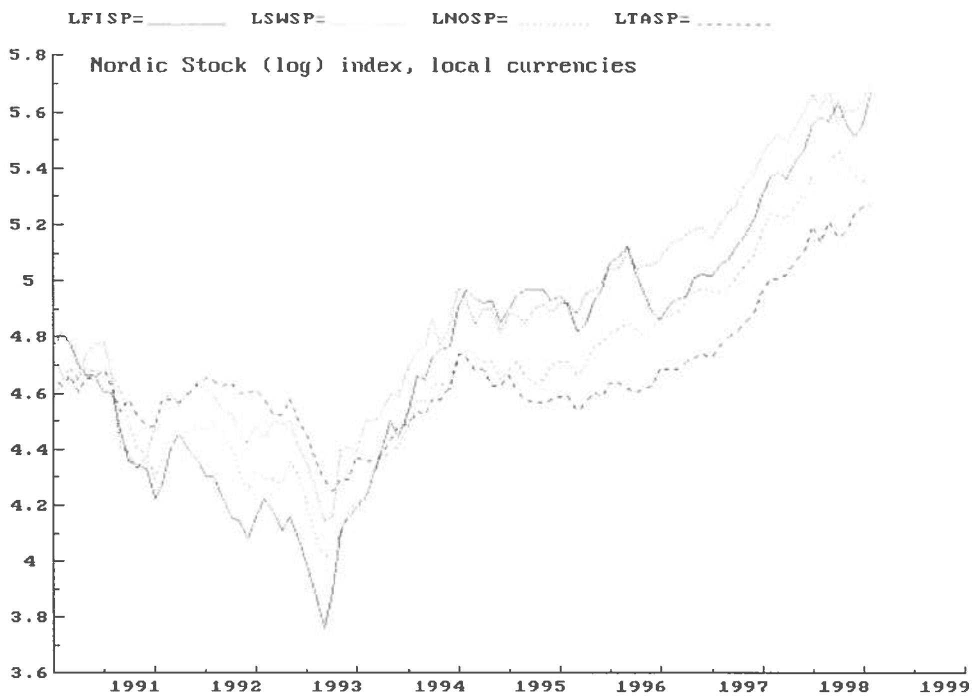

FIGURE 2 Nordic stock indices, local currencies (logarithmic scale)

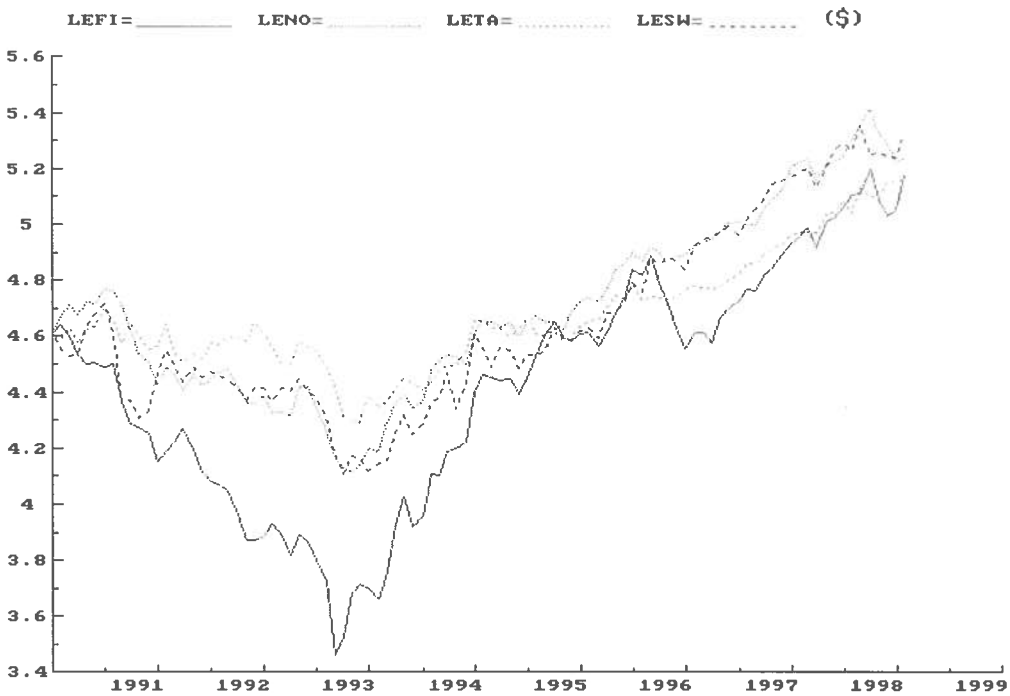

FIGURE 3 Nordic stock indices in common currency (U.S. dollars), logarithmic scale

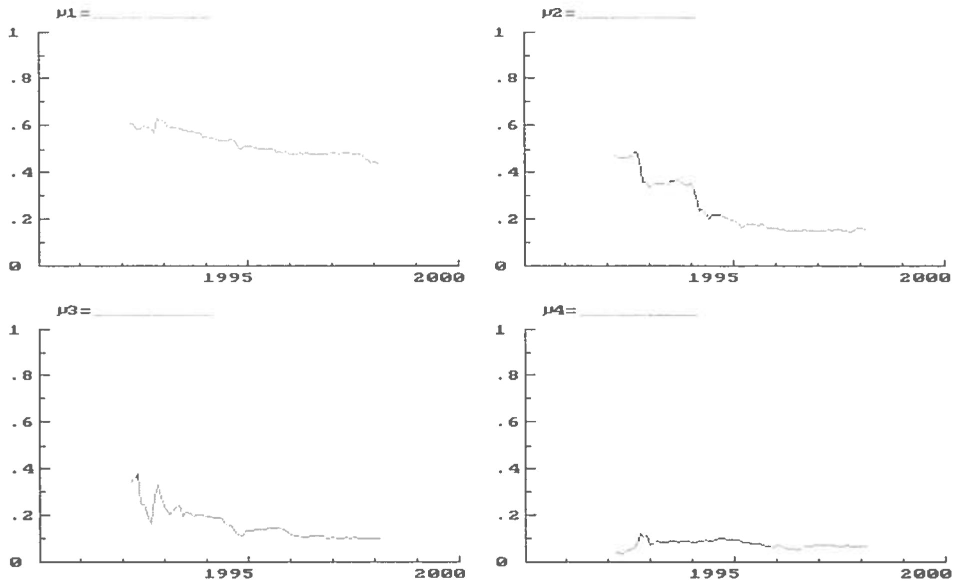

FIGURE 4 Recursive eigenvalues. (Local currencies)

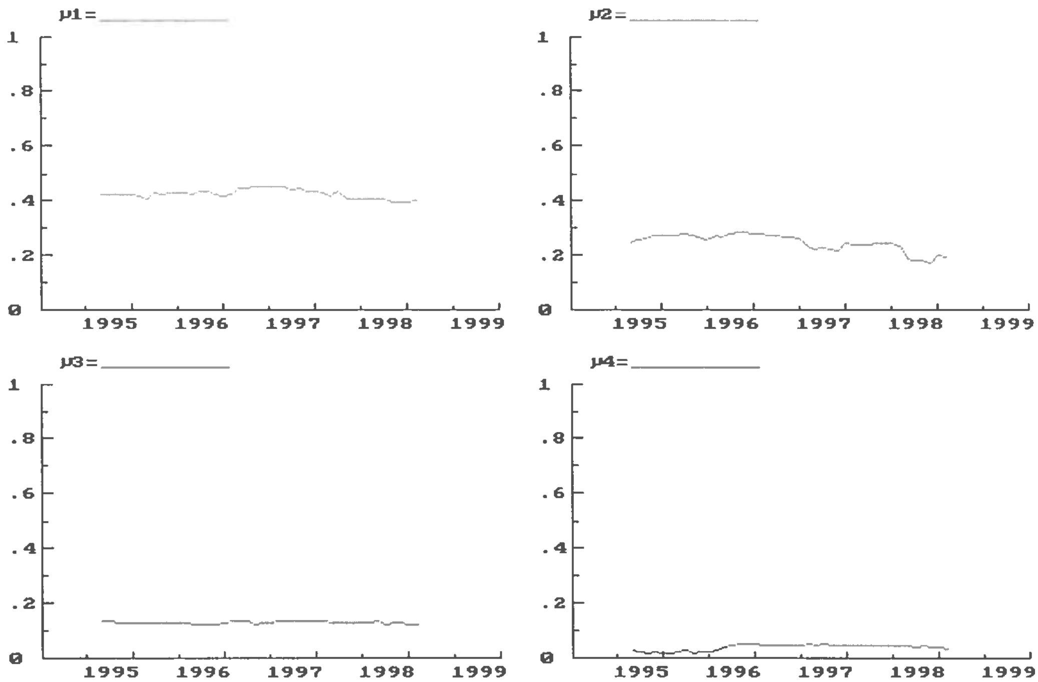

FIGURE 5 Recursive eigenvalues. (US dollars)

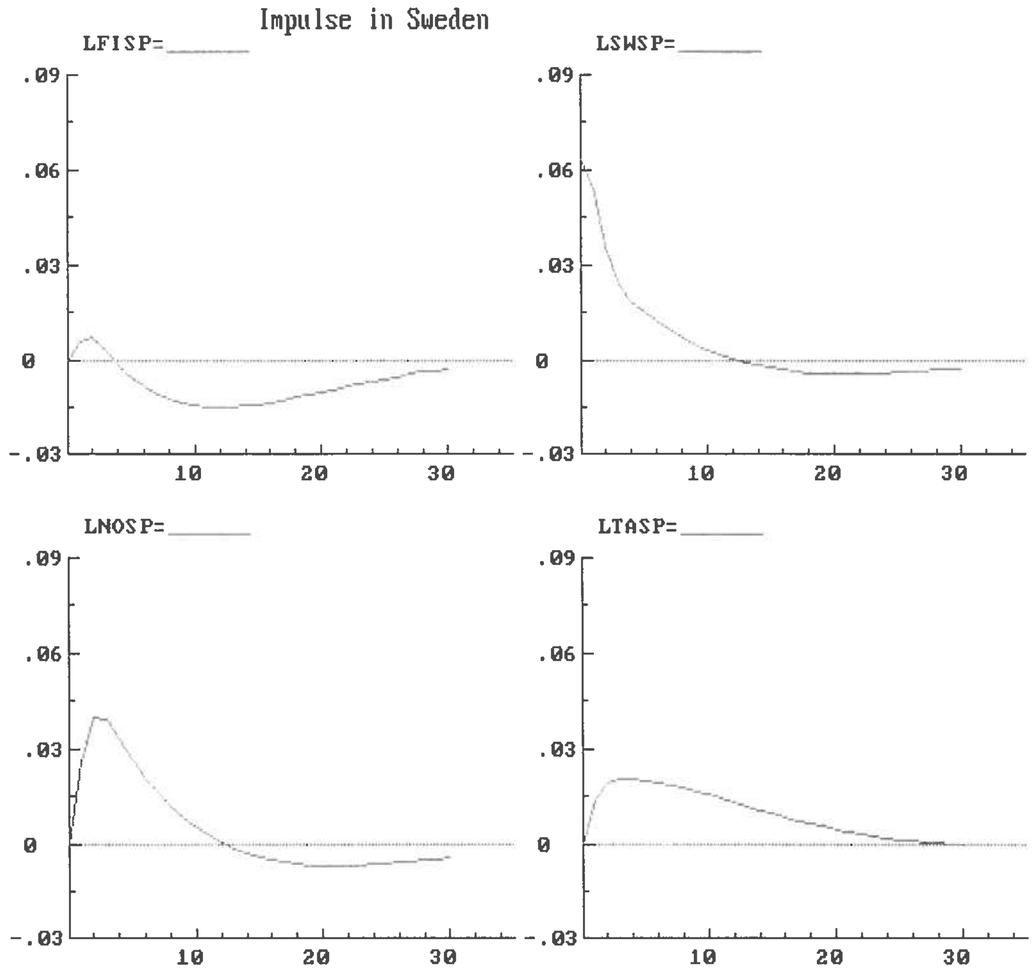

FIGURE 6 Impulse response in Sweden

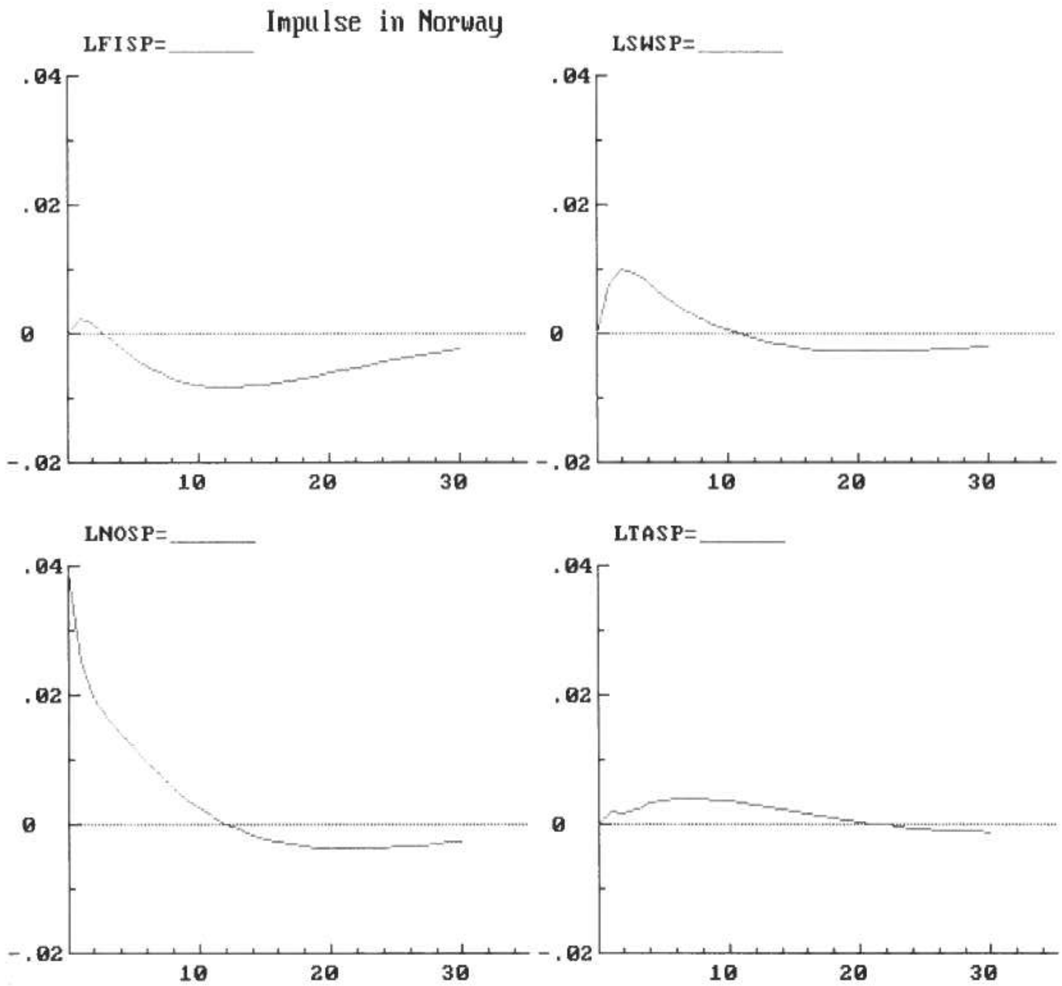

FIGURE 7 Impulse response in Norway

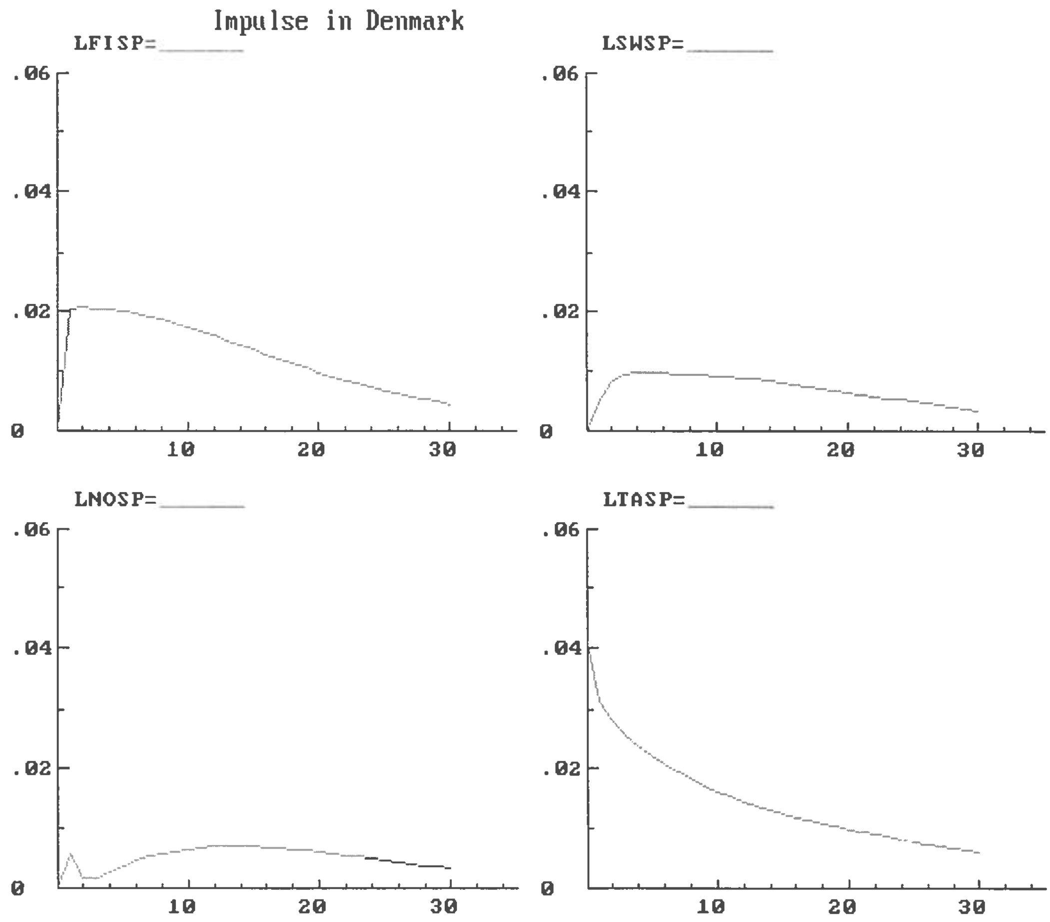

FIGURE 8 Impulse response in Denmark

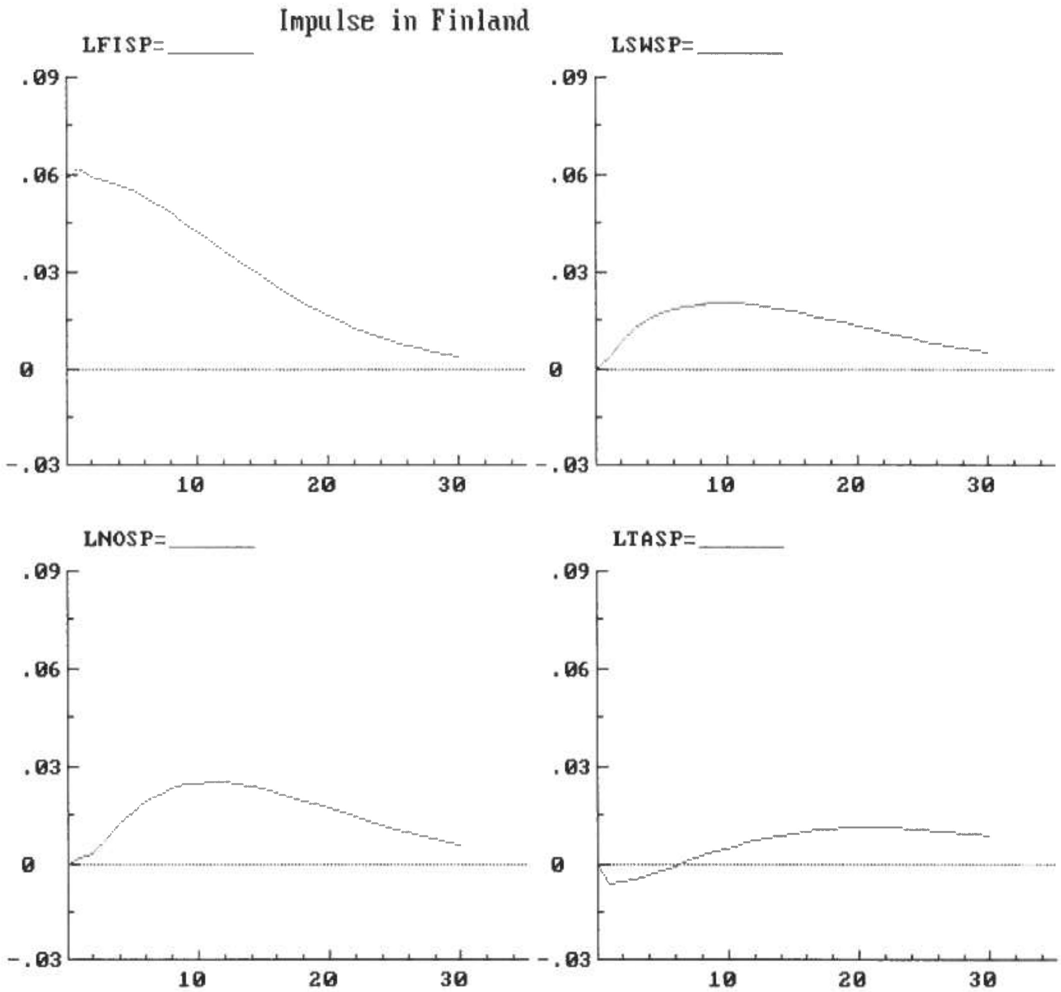

FIGURE 9 Impulse response in Finland

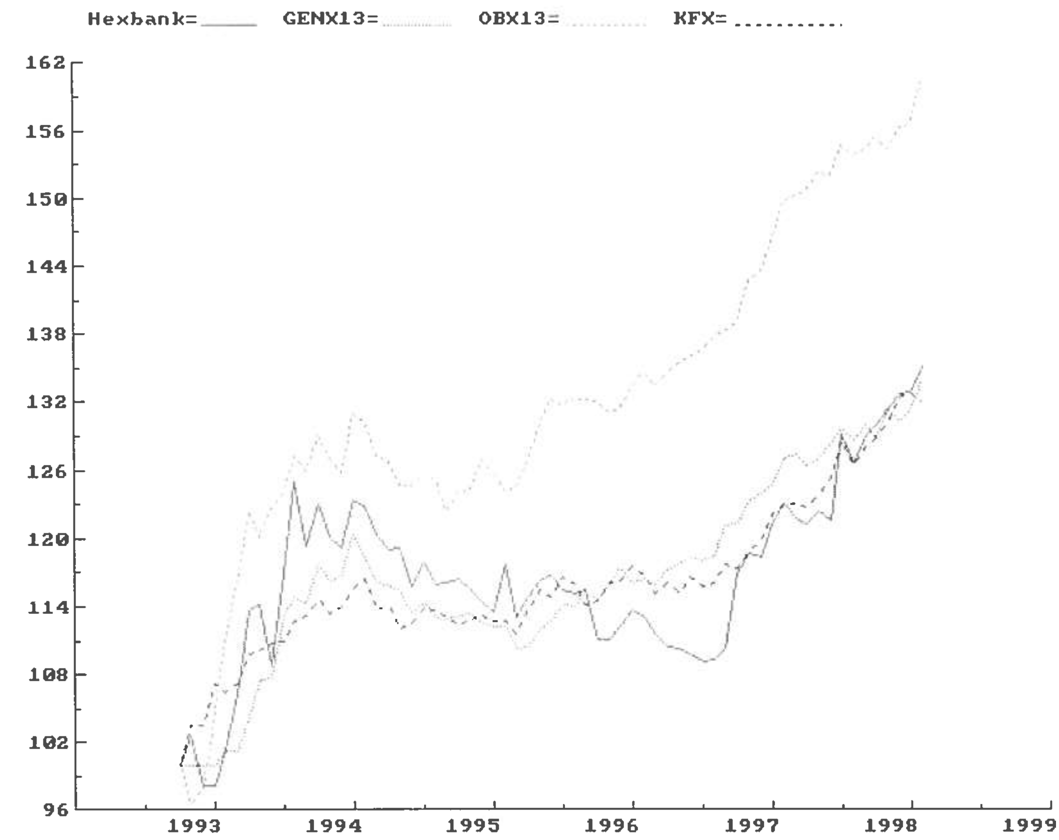

FIGURE 10 Monthly bank data. Local currencies

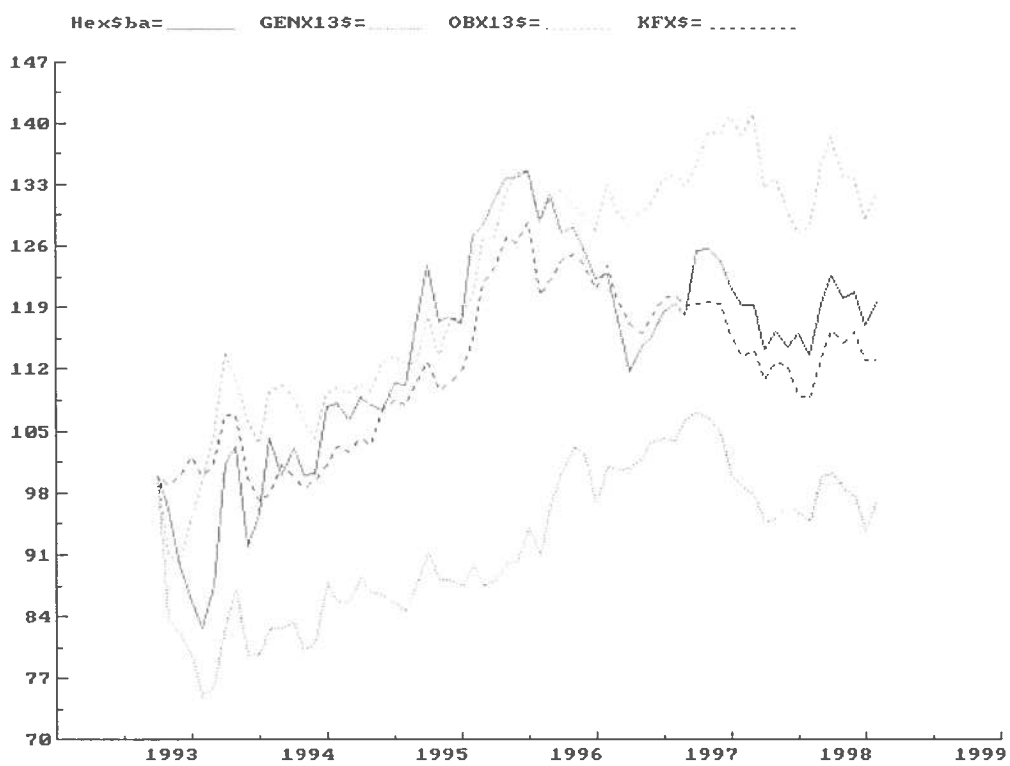

FIGURE 11 Monthly bank data. US dollars

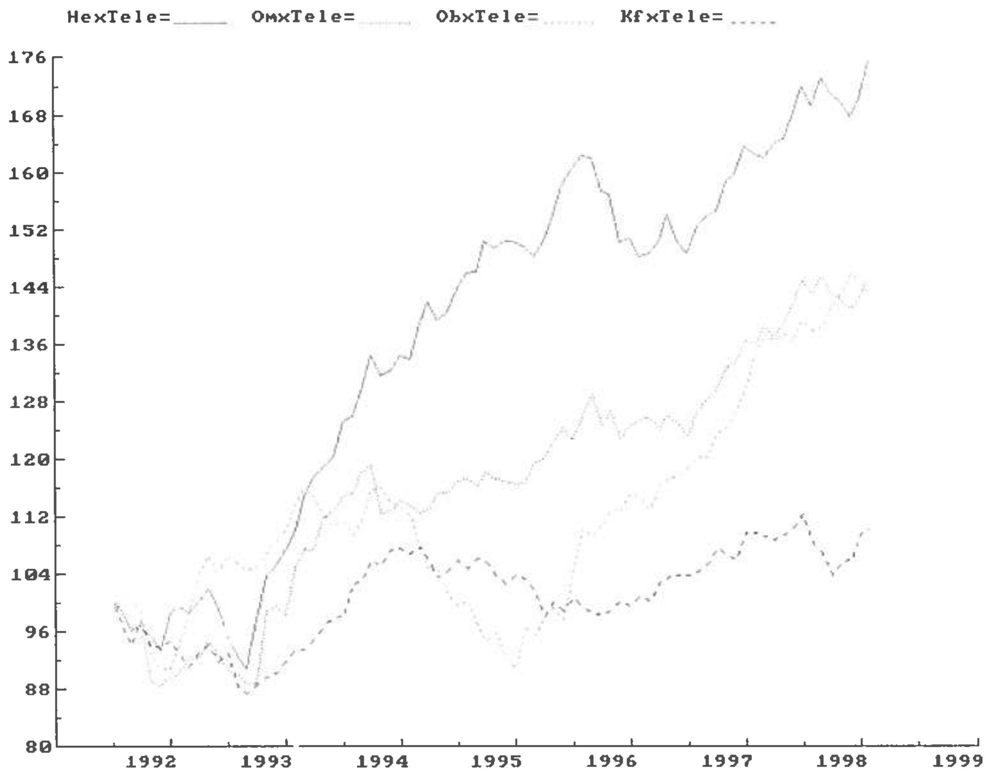

FIGURE 12 Monthly telecommunications data. Local currencies

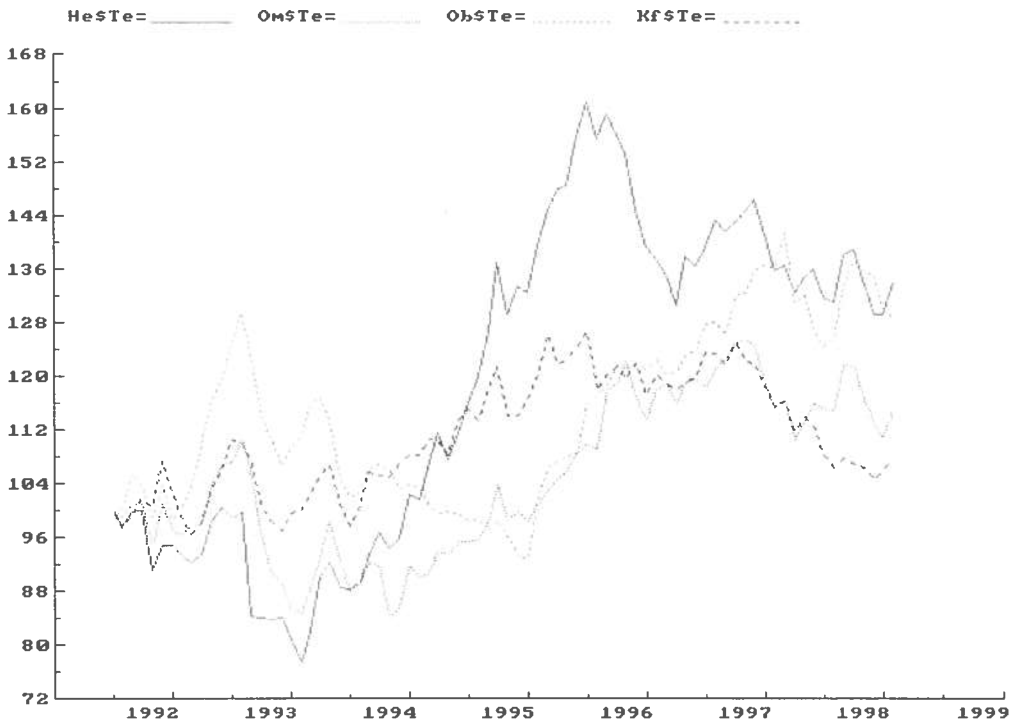

FIGURE 13 Monthly telecommunications data. US dollars

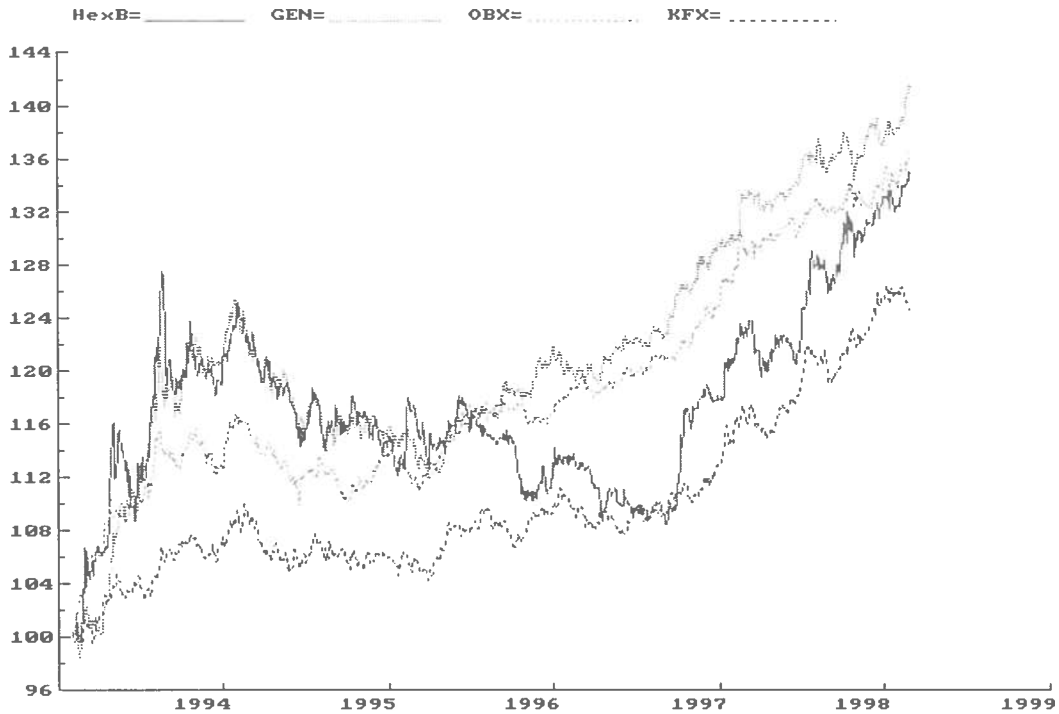

FIGURE 14 Daily banking data. Local currencies

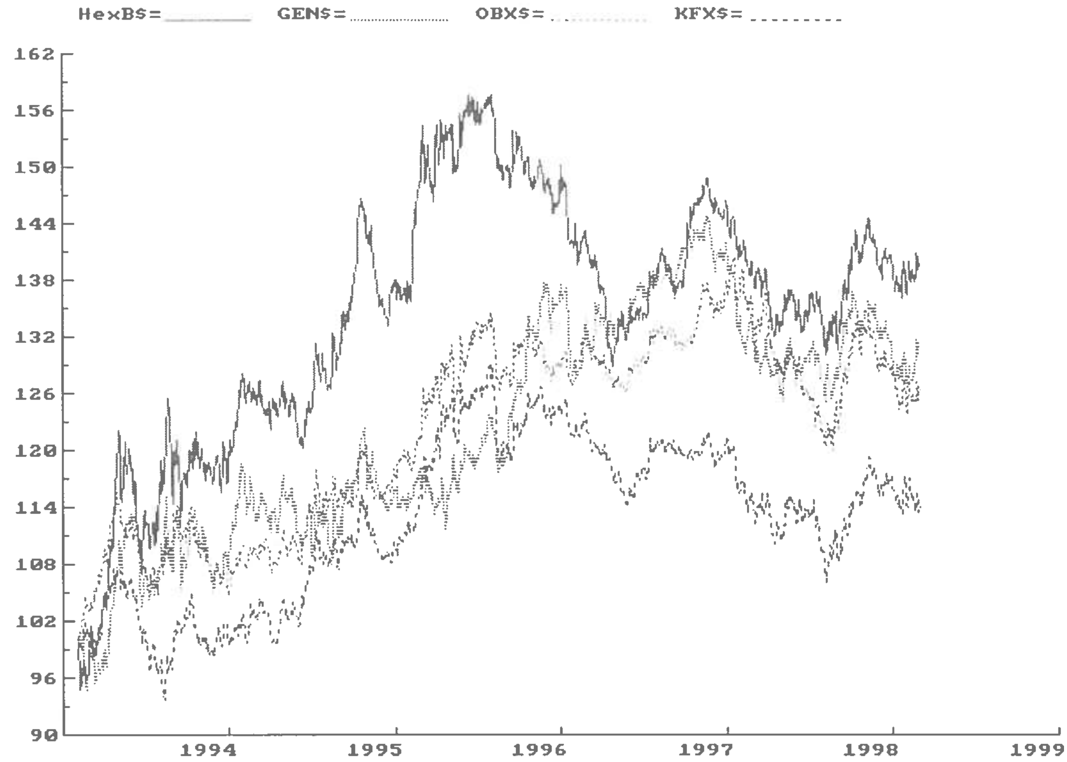

FIGURE 15 Daily banking data. US dollars

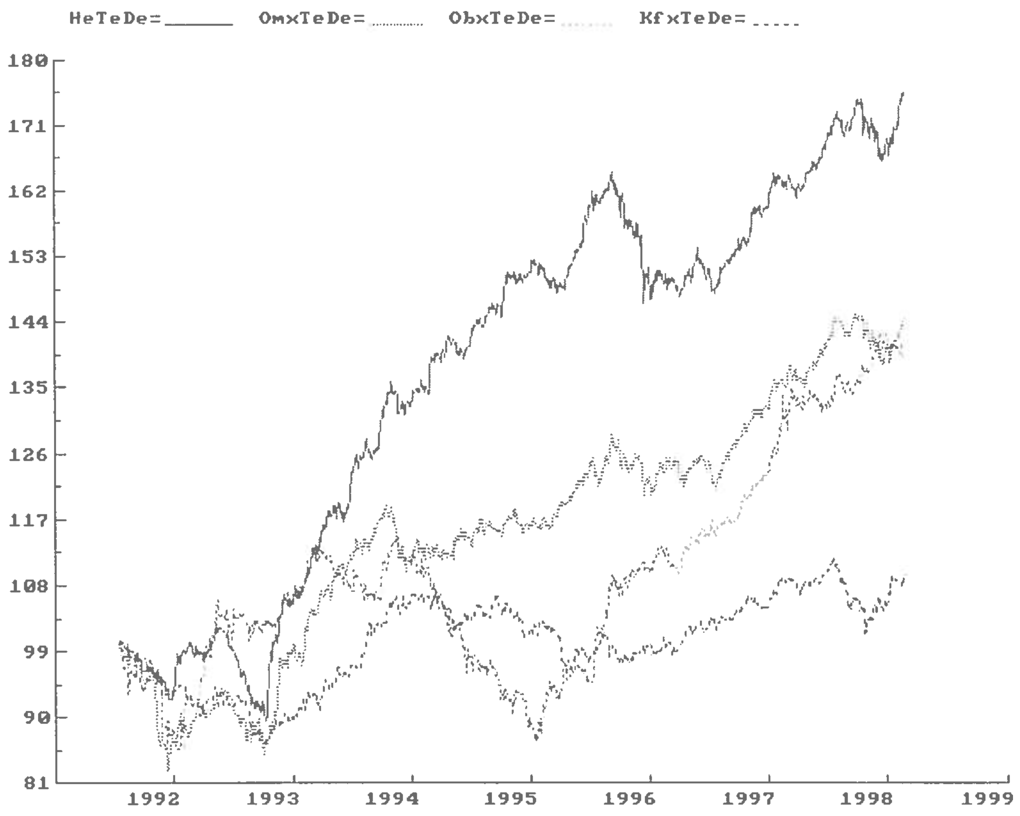

FIGURE 16 Daily telecommunications data. Local currencies

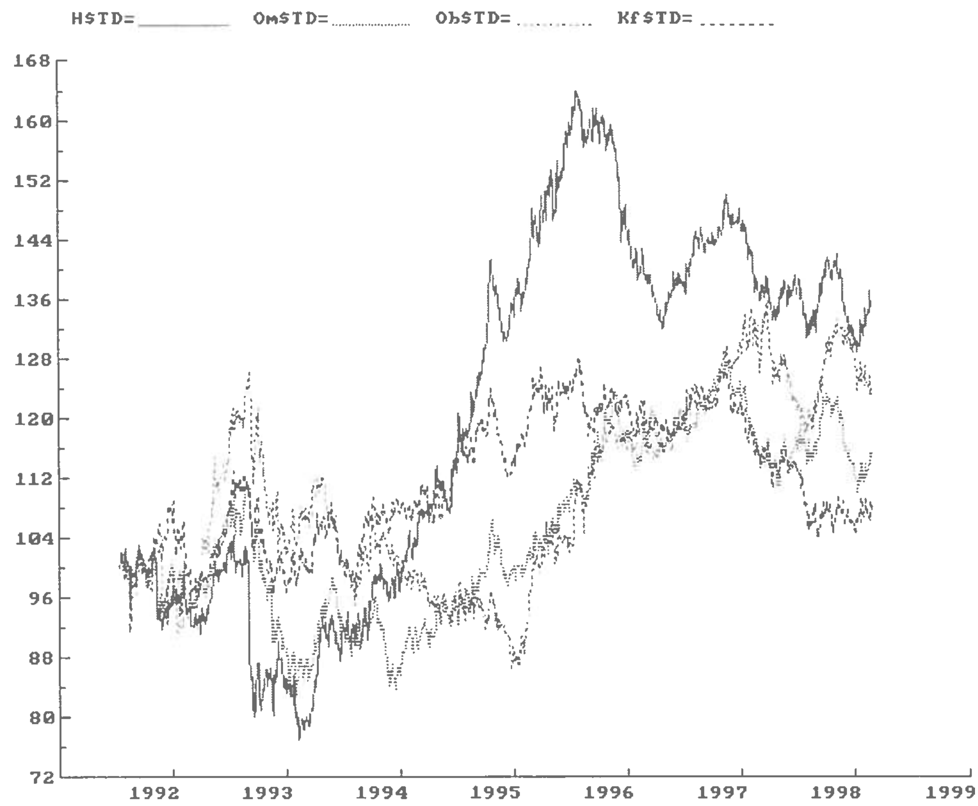

FIGURE 17 Daily telecommunications data. US dollars