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THE EFFECT OF EXCHANGE RATE CHANGES ON INDUSTRY-LEVEL STOCK RETURNS: EVIDENCE FROM THE NORDIC COUNTRIES

Master's Thesis
Finance
September 2019

UNIVERSITY OF OULU
Oulu Business School

ABSTRACT OF THE MASTER'S THESIS

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Title			
The Effect of Exchange rate Changes on Industry-level Stock returns: Evidence from the Nordic countries			
Subject	Type of the degree	Time of publication	Number of pages
Finance	Pro gradu	September 2019	64

Abstract

The risk associated with the exchange rate exposure is yet an undiscovered topic in Nordic stock markets. A comparative investigation of Finnish, Swedish, Norwegian and Danish industry-level stock indices enables to identify the effects of structural similarities but also differences in economic policy-making on exchange rate exposure. Thus, the main aims of this master's thesis are to analyse the industry- and country-specific similarities and differences in the detected exchange rate exposures alongside with detecting significant exposures.

The stock returns are investigated on post-euro period of 1999–2019 in Basic Materials, Industrials, Consumer Goods and Services, Healthcare, Telecommunication, Media and IT as well as in Financial sector. The empirical model detects the exchange rate movements against U.S. dollar and above the market sensitivities of the constructed indices. The model also takes into account the characteristics of variance in the financial data with the usage of GARCH (1,1) specification.

Statistically significant exchange rate exposure parameters are reported in all Nordic countries. The parameter is in most instances positive for a specific industry, which describes the industry being a net-importer, and vice versa. Consumer Goods and Services, Telecommunication, Media and IT and Financial sector seem to be the three, which are exposed in Finland, Sweden and Norway. Although the significant exposures are found in the mentioned industries, the signs do not exhibit consistent pattern across countries. Thus, the average exposures of each country seem to diverge largely despite the structural similarities and geographical locations of Nordic countries. The only exception is the similarity of the magnitude and sign of the exposures in Swedish and Norwegian industries, which are almost identical.

The other two countries, Finland and Denmark, seem not to stand in line. Denmark seems to be the most divergent country as Healthcare industry being intensely and negatively exposed to exchange rate movements. The suggested explanation concerns the high exports of packaged medicaments to the United States and the highly developed healthcare technology of Denmark. Finland, in the other hand, possesses the most intense parameter values for all industry indices, which is assumedly due to the higher importance of the United States as a trading partner. Hence, it could cautiously be suggested that joining EMU, in the perspective of trade with the United States, might not be as beneficial for Finland as supposed earlier. The other Nordic countries maintain having local currencies as their argument is that it creates flexibility though possible undervaluation against other currencies but also leaves room for possible devaluation. This finding of Finland not having overall benefit in being a member of EMU pegs for further studies in order to consider it as a fact. The results are generalizable concerning the exchange rate exposure against the world's largest currency, U.S. dollar. Additionally, the generalization of the fact that there are differences in exchange rate exposure in otherwise similar Nordic countries, is plausible.

Keywords

Exchange rate exposure, currency exposure, EMU, euro

Additional information

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

The effect of exchange rate exposure on firms and the risk associated with the unanticipated changes in the exchange rates has been a topic of literature since 1980s, but the evidence remains ambiguous. The former research focuses geographically mainly on the United States and other larger developed countries leaving smaller economies yet intact. Thus, this master's thesis concentrates in rarely studied Nordic countries: Finland, Sweden, Norway and Denmark. The chosen economies are relatively small and open compared to the countries investigated previously aiming to detect exchange rate risk in stock market returns. Furthermore, Nordic countries are dependent on foreign trade and connected to other trading partners outside country borders. Additional to the international ties, Nordic countries are linked to each other due to industrial and structural similarities, but also economic policy-making.

In January 1999, the common currency, euro, was established for eleven European countries. Among Italy, Portugal, Spain and Ireland, also Finland was identified as a weak euro country. The nomination as a "weak euro country" was due to the faced depreciations against German mark in 1990s. The common currency was seen beneficial in terms of intensified monetary commitment and preventing depreciations of domestic currency. Although, Sweden and Denmark have been members of EU before the establishment of euro, they have opted out from the single currency. Norway, in contrast, has not been and is not a member of EU. Sweden and Norway have floating currency systems and own currencies. Denmark, in the other hand, has tied the exchange rate to euro allowing it to deviate in a narrow band. Thus, the Nordic setting creates an eye-opening test laboratory in order to evaluate the similarities and differences in exchange rate exposures not only in industry-level stock indices but also by country. The country-specific analysis allows the evaluation of the different policy-making choices and their effects on the exchange rate exposures.

Koutmos and Knif (2011) study the monetary changes and the effects of the introduction of euro in Finland – after joining common currency, of the foreign trade became a part of the home currency area. The joint currency regime has formerly been investigated by Bartram and Karolyi (2006) among others. The common belief is that the event led to a decrease in the foreign exchange rate exposure among non-financial firms (Bartram & Karlolyi, 2006; Koutmos & Knif, 2011). Furthermore, the empirical

results that Koutmos and Knif present support the fact that joining euro moved the focus away from regional competitiveness and became more sector or firm-specific when comparing pre- and post-euro periods.

The investigation of the Scandinavian countries, alongside with Finland, is interesting as it is suggested that the economies are positively tied to European economy when studying historical spill over effects. It is argued that adoption of euro could be beneficial as a larger Eurozone would diminish the currency risk among multinational companies but also small companies through decreasing volatility in the outcomes of corporate transactions. (Kiohos & Stoupos, 2019.) A lower exposure to market risk and exchange rate risk, alongside with the decreasing cost of capital would be thus presumable results of the common currency. Additionally, Bris, Koskinen and Nilsson (2009) posit that the common currency through more stable characteristics affects positively on firm valuation as the future cash flows ought to be more stable.

Although, the generalized perception is that the exchange rates affect firm cash flows and thus, firm value, the literature has not found consensus on the significance of the exposure on stock returns. The former findings also suggest several factors, such as hedging with financial derivatives and industry competitiveness to affect the findings on exchange rate exposure and the significance of the exposure. The exchange rate exposure, its significance and the direction are noticed to be country- and sector-specific and time-varying. (Dominiguez & Tesar, 2006; Muller & Verschoor, 2006.)

The aim of this master's thesis is to detect, whether there is exchange rate exposure sensitivity in Nordic sector indices, which are Basic Materials, Industrials, Consumer Goods and Services, Healthcare, Telecommunication, Media and IT and Financial sector. Six broad sector stock indices are constructed and investigated in order to draw conclusions on the similarities and differences of exposures among the industries and the countries as well. The research questions are following:

1) Do the stock markets in Nordic countries exhibit exposure to exchange rate risk? And how is this risk priced?

2) Do we find differences in exposure and pricing among the countries?

3) Are there differences between industries rather than countries?

The empirical section of this master's thesis is conducted through estimating parameters for a time-series regression following GARCH (1,1) process. The sector index returns are regressed on country's exchange rate quoted against U.S. dollar above the sensitivity to the national stock market movements. The use of this quantitative method is supported by the earlier papers on the topic (e.g. Bodnar & Wong, 2003; Muller & Verschoor, 2006).

The main result of my investigation is, that there is statistically significant exposure to exchange rate risk in all Nordic stock markets between January 1999 and February 2019. The findings support earlier evidence detecting exposure in industry- and firm-level data (Doige, Griffin & Williamson, 2006; Dominiguez & Tesar, 2006; Gulati, Knif and Kolari, 2013; Koutmos & Knif, 2011). The largest exchange rate exposures are consistently found from the Finnish sector indices, especially Consumer Goods and Services index. Additionally, Finnish stock market exhibits the highest mean exposure of all Nordic countries, which is assumedly due to the high importance of the United States as a trading partner.

The Swedish and Norwegian stock markets and industries seem to behave hand in hand, but the Danish stock market, in the other hand, deviates a lot from the other Nordic countries. Danish Healthcare industry seems to exhibit high and negative exposure to exchange rates, which could be explained by the high export figures of pharmaceuticals to United States. There are also some industry-specific trends able to be detected in Nordic countries with the exception of Denmark. The Consumer Goods and Services, Telecommunication, Media and IT and Financial sectors seem to exhibit statistically and economically significant exposures on exchange rate movements in Finland, Sweden and Norway.

Interestingly, the large Finnish exposures leave wondering for the benefits of joining the single currency regime and the possibilities of one's local currency along with the pros which derive from a decision of opting-out. For example, if Finland would have remained Finnish mark as a local currency, could there have been more benefits for the possible depreciations and devaluations compared to the current situation?

The empirical results leave room for further studies, which should concentrate more specifically on changes in the exposures over time and detecting the asymmetries of the exposures. Also, the use of trade weighted exchange rates could reveal incremental effects, which would be interesting to compare with my results. The exchange rate exposures in the Nordic stock markets are still an unravelled topic, which pegs for further studying.

The structure of this master's thesis is as follows: the next section covers the associated definitions and theories according to exchange rate exposure in order to get an adequate understanding for the later on presented empirical work. The third section elaborates the monetary policy similarities and differences in Nordic countries after which the former empirical findings and literature review of the topic are presented. In the fourth main section, the used data, methodologies and empirical model are specified in order to analyse the effects of exchange rates on sector indices in the fifth section. Lastly, the sixth section concludes the main findings and requests for further studies.

2 EXCHANGE RATE EXPOSURE

In the history of monetary changes, the largest events include the collapse of the Bretton Woods system and after that the launch of European common currency area. The establishment of the common currency, euro, has had large effects. These effects include increases in international trade and investments. Nowadays, EMU (Economic and Monetary Union) is not regarded as a flexible currency system, in the perspective of monetary policies. However, EMU is generally seen as an event after which the international trade is easier among EMU countries but also the transparency of pricing is increased. (Adjaoute & Danthine, 2003.)

The global changes towards openness have created the profound to the internationalisation of finance. The pros of internationalization are greater ability of businesses to, for example, diversify their financing. The other side of the coin is the risks associated with the exposure to foreign currency. (Adler & Dumas, 1984; Bhatti & Moosa, 2011, p. 2–4.)

The cross-border transactions together with widely used flexible currency systems expose businesses to other than domestic currencies but also to the risk associated with the fluctuations in exchange rates. In the microeconomic perspective, the exchange rate exposure is present even though a business might not directly deal with the rest of the world. The business is exposed to exchange rate risk as its market share in the domestic market is affected also indirectly (Moosa & Bhatti, 2011, p. 1–4). In other words, the company does not necessarily need to have foreign currency exposure for example, in the form of receivables, but if their customer base has, they are naturally affected (Adler & Dumas, 1983).

Adler and Dumas (1983) highlight that there is an important difference between the terms of exposure and risk. They state that a certain currency is not risky, because it could devaluate, i.e. exposure to certain currency is not necessarily risky. The actual risk arises from the fact that the magnitude and timing of the future exchange rate movements cannot be determined with certainty. Hence the exposure can be measured in terms of how much one has at risk (Adler & Dumas, 1984).

In the same sense, Madura (1989) defines exchange rate risk to mean unexpected change in rate that has an effect on the value of the firm. Madura states that it is a possibility of a direct or an indirect loss resulting from a movement of exchange rates affecting on firm's cash flows, assets and liabilities, net profit or market value. The direct exchange rate exposure arises from international transaction whereas the indirect exposure is due to competition, aggregated demand or cost of input. Thus, the risk management perspective is a central part of corporations (Allyannis & Ofek, 2001).

Adler and Dumas define the exposure to be measured as the coefficient of a linear regression model:

$$P = a + b * S + e, \quad (1)$$

where P is the price of the stock or an asset, S is the exchange rate, a is the regression constant and b is the coefficient which stands for the exposure in the foreign currency terms. In the equation (1), e is the random error.

Among others, Shapiro (1996) and Madura categorize the exchange rate exposure into three major categories: transaction exposure, translation exposure and economic exchange rate exposure. Transaction exposure includes the cash flow risk associated with exchange rate movements affecting accounts receivable, payable or dividend repatriations (Papaioannou, 2006). The movements of exchange rates have direct exchange rate exposure effect through transactions denominated in foreign currencies. The transaction risk arises as the actual transaction takes place in the future and the exchange rates cannot be anticipated beforehand.

Shapiro and Madura state that the translation exposure affects the balance sheet item valuations. For example, having a foreign subsidiary consolidated with the parent company balance sheet creates an exposure to the movement in exchange rates through valuation differences. The foreign subsidiary exposes the balance sheet items to the subsidiary's domestic currency as the assets and liabilities are accounted in parent company's operating country's currency.

Economic exchange rate exposure is associated to the distortion effects on operating cash flows as the movements in exchange rate changes both operating expenses and

revenues. Usually, economic exposure is used when assessing the present value of future cash flows and thus, it directly affects firm's market value. (Madura, 1989; Shapiro,1996.) Economic exposure is the type of exposure that the literature is aiming to detect in stock returns.

As a conclusion, the exposure does not only depend on the international transactions but also on the openness of the economy and the industry factors (Nydahl, 1999). Economic exchange rate exposure affects the cash flows in terms of present value and future value, and the effect will show not only in firm value but also in prices of purchased materials and end products. Also, appreciation in home currency is beneficial to exporters as they can increase profit margins by increasing prices of their goods. In other hand, the appreciation will do harm to domestic players (Feenstra & Taylor, 2014).

3 MONETARY POLICIES IN NORDIC COUNTRIES

After Bretton Woods system's collapse in early 1970s the shift from fixed (the exchange rate set against another currency or basket of currencies) to flexible (or floating) exchange rates set the foundation for the uncertainties arising from the cross-border transactions. Governments, firms, and individuals began increasing every-day interactions across national and area borders. The last years and the breakdown of Bretton Woods started a volatile time period in the exchange rate markets and caused the European Economic Community (EEC) to increase the urge for a common currency regime.

Finally, in 1992 Economic and Monetary Union (EMU) was launched and the integration of EU economies was facing a new turn. In the preparation for EMU the EU Member States agreed upon a set of criteria that the countries should follow in order to adopt euro. One of which was price stability meaning controlling inflation, for which European Central Bank (ECB) took later on the charge of in EU countries. In addition, the EU Members are obligated to stay in the set limits of government borrowing and debt in order to avoid heavy deficit. Exchange Rate Mechanism (ERM II) is a mechanism which the EU countries are obligated to follow without strong deviations for at least two years before adoption of the common currency. More specifically, ERM II is a means to ensure the exchange rate fluctuations between euro and other EU members' currencies not to vary too much and create instability within the trading area. (European Commission, 2019.)

Lastly, the long-term interest rates should be on the levels that seem durable in the sense of maintaining the former criteria. The aim is that the EU member states could manage their economies without any excessive currency fluctuations and in the end, to adopt euro and pass the monetary policy-making to ECB. (European Commission, 2019.)

The ECB was established in 1998 and the euro was launched as book money in January 1999. Since establishing EMU, the EU member countries have been obligated to realize the same economic policies described earlier– including Sweden and Denmark. After three years of using euro as book money, the coins and bank notes were launched in 2002, 12 EU countries changing their currency to euro, including Finland.

Nowadays, the EU contains 28 members, which of nineteen have taken part into EMU. One member, Denmark, has opted out from it, but nevertheless is part of EMR II.

The Mundell-Fleming (1963) "trilemma" states that two of the three traits are possible to be achieved at the same time: i) a fixed exchange rate, ii) free capital mobility and iii) autonomous monetary policy. In other words, a country has to choose one to give up on, in order to get the other two benefits. The trilemma is important framework for assessing the Nordic countries decisions affecting their policy-making.

Interestingly, Sweden and Finland are part of EU since 1995, but Sweden has not taken on the common currency, euro, nor has Sweden applied the ERM II. Rather the country has kept Swedish krona as their own currency, has maintained autonomous monetary policy and free capital mobility (European Commission, 2018). Nevertheless, Sweden has reflected to a large extent similar monetary policy in the past as is required by the convergence criteria. Thus, Swedish Riksbank states to target for equal inflation (2 %) – as ECB and other central banks and as Sweden is a member of EU.

The main reason not being part of common currency regime, has been stated by Sveriges Riksbank, to be the inflexibility of policies in states of economic downturns (*Monetary Policy in Sweden,* 2010). The Swedish krona is a floating currency, although the policy-making reflect a lot of those in Eurozone. For Sweden, the Exchange Rate Mechanism II is a missing part of fulfilling the criteria as they believe flexible exchange rate makes the revaluations of currency possible.

The Danish krone, unlike Swedish krona, is fixed to euro since 1999, meaning that the exchange rate can fluctuate only with a narrow band of -/+2.25, i.e. Denmark is part of the ERM II system. However, Denmark has no intention to join euro and has agreed upon that with European Commission. Additionally, Danmarks Nationalbank states to replicate the ECB's inflation targets, i.e. has given up on autonomous monetary policy. Thus, Danmarks Nationalbank uses interest rates linked to lending and deposits to conduct their policies. Naturally, changing the interest rates affects the exchange rate of the krone against euro, especially in the long-run. (Danmarks Nationalbank, 2017.)

Norway, in the contrary, is not an EU country and they have their own currency, krone. The government of Norway has set an inflation target, which is also close to 2 percent

over time (Norges Bank, 2006). Although, Norway is not required to follow ECB's or any other agent's policies, Norges Bank states that intervening exchange markets is not appropriate as long as there is not a need for unconventional policies. The exclusion from EU creates more flexibility to the exchange rate policies – a device with which the government and central bank is able to affect economic situations.

Although, Norway is not a part of EU, it is part of European Economic Area (EEA) – an agreement granting the access to European single market. EEA covers the EU member states in addition to Norway, Lichtenstein and Iceland. The other agreement linking EU member states and Norway is The European Free Trade Association (EFTA), which consists of the same three countries in addition to Switzerland. EFTA has free trade with non-EU countries, Canada, Mexico, etc. Thus, Norway has the advantages of interconnectedness in trade, but still is free from some of the EU's policies. On the other hand, Norway has less power to affect in the common rules of the EU area. For example, Norway does not formally participate in decision-making in Brussels, where the European Commission gathers. (EFTA, 2007.)

As a conclusion, there are no structural weaknesses among Sweden, Norway and Denmark – they could join euro. Still, they have decided to opt-out as the government and people of those countries are remaining sceptical about the participation in EMU (Kiohos & Skouptos, 2019.)

4 EXCHANGE RATE EXPOSURE IN STOCK RETURNS

The empirical findings that will be presented in the following chapters include findings on linkages between exchange rate risk and stock prices. The results have been mixed and a consensus still remains not found. The studies have aimed to find evidence across industries, geocarpic areas and different currency regimes.

There are few important remarks on the models used; some are using conditional moments, meaning the input of variance (affecting beta estimators), is fixed for the investigation period (e.g. Choi, Hiraki & Takezawa, 1998 and De Santis & Gerard, 1998). The other models are using unconditional and letting the input vary over time (e.g. Jorion, 1990). Additionally, some models use macroeconomic multifactor models based on APT. Contrarily, CAPM extensions (De Santis & Gerard, 1998) and Fama-French model-extensions (1993) are exploited by Apergis, Artikis and Sorros (2011) among others. The extensions as benchmarks of capturing the effects of exchange rate exposure in addition to other factors that are found to explain premia in the stock market (e.g. Bartram & Karloyi, 2006 and Antell & Vaihekoski, 2012).

Other differences include variables, which are specified differently depending on the perspective of the study. Some models use trade-weighted, i.e. effective exchange rates (e.g. Bartov & Bodnar, 1994) and contrarily, some include bilateral exchange rate(s) of the most important trade partners as explanatory variables (Muller & Verschoor, 2006). Brusa, Ramadorai and Verdelhan (2014) even argue, that the exchange rate exposure would be best captured by creating new variables, such as carry-factor.

4.1 Direction of causality – the two models

The evidence shows the relationship between exchange rate exposure and stock prices to be rather puzzling – the evidence is ambiguous around the causality, the direction of the causality and if there even is any relation. “Flow-oriented” models, first introduced by Dornbusch and Fisher in 1980, state the country’s trade balance performance to determine the exchange rates. Thus, the flow-oriented models assume exchange rates to affect international competitiveness and trade balance causing economic variables such as real income and output to vary.

Because the price of a share or shares of a company is evaluated with the discounted present value of future cash flows, any variable affecting those cash flows should be incorporated to the valuation as Efficient Market Hypothesis suggests (Fama, 1980). Thus, there is a clear positive relation between the exchange rate exposure and stock price, and causality from exchange rates to stock prices. (Dornbusch – Fisher, 1980).

"Stock-oriented" models presented by Branson, Halttunen & Masson (1977) explain the causality the other way around and highlight the correlation to be negative. Stock-oriented models posit that the financial account transactions are the mechanism with which the variables are affected. Namely, buying and selling domestic securities in foreign currency as a response to stock price changes affect the exchange rates. In other words, one buys domestic stocks in foreign currency, when the domestic stock market is at low levels and this action drives the domestic currency up.

Although, the evidence in some studies states that the exchange rate exposure in the stock market is only moderately significant, the majority of studies taking the contrarian view state that there is a significant linkage and causality – to both directions. Ramasamy and Yeung (2005) state, that the direction of the causality may change from time to time and that the chosen time period as well as the frequency of data has an effect on the findings and the direction of the causality. They base their implication to their studies of causality in Asian countries in addition to the U.S.

Another argument stated by Solnik (2000) is that financial crises in general have negative effects on exchange rates and stock markets, but the mechanism with which the crisis start is different in developed and emerging markets. The developed markets' financial crises usually start from crashes in stock market and in emerging markets the crises usually start as a currency crisis. This could be one explanation to the causality, for which the evidence is ambiguous (Solnik, 2000).

4.2 The early findings on exchange rate exposure in the stock market

Amongst the first pioneering empirical findings of exchange rate exposure being priced in the stock market was made by Jorion (1990). He examined, whether the currency risk is priced, using macroeconomic two-factor and multifactor models during 1971–1987 in the monthly data from U.S. stock market. The results suggested

that the unconditional risk premium associated with foreign currency exposure is moderate and insignificant. Thus, Jorion concludes the currency risk is not priced according to the stock market data. He used a sample of U.S. multinational companies' stock returns and as a proxy for exchange rate exposure effective U.S. dollar exchange rate and controlled for market risk premium. Interestingly, Jorion found that there are differences in the cross-section of U.S. multinationals and their non-significant exposure, which seems to change over time. Parallel results were obtained by Amihud (1993), who also studies contemporaneous changes in the stock prices.

Bartov and Bodnar (1994) study U.S. stock returns in partly overlapping time period 1978–1989 among firms possessing large foreign currency adjustments. As they reckon earlier studies might lack due to weak sample selection having not enough foreign trade. Bartov and Bodnar find out that the firms having foreign currency exposure have negative correlation with lagged effective exchange rate movements. They state this negative relationship to be significant and economically important. Especially, lagged changes in exchange rates have significant effect and the contemporaneous changes exhibit insignificant effects stating that the lag might be one reason for poor earlier results. Thus, Bartov and Bodnar suggest a lag in order the stock market to have time to capture the changes in exchange rates. Additionally, Bartov and Bodnar find that the sample selection is not a problem in the former studies in order to be able to detect exposure. They conclude that it seems investors act based on the end of the fiscal year documentation of the corporations.

Favouring Jorion, Griffin and Stulz (2001) state later that the effect of exchange rate exposure is economically insignificant when studying contemporaneous industry index returns. The industry indices are divided into non-traded industries, having no international trade and traded industries engaging in foreign trade. Regardless of the fact that the magnitude of exposure is higher for industries trading internationally, the effect of exchange rate exposure on returns is still insignificant. Empirical estimation is done using weekly and monthly data in the U.S, the UK, Germany, Japan and France during 1975–1997.

Logically, Griffin and Stulz state that in the light of their evidence, they find the U.S. excess returns being less dependent on the exchange rate returns, as the country is also more independent on foreign trade. Their evidence posits that in Canada, the UK,

France and Germany the effects of exchange rate against U.S. dollar is the least important factor determining returns, and most important it is in Japan. The fact of smaller countries being more dependent on foreign trade is also detected by He and Ng (1998) studying Japanese stock return reactions to changes in exchange rates. Griffin and Stulz also state that the explanatory power of exchange rates increases with the increasing time interval of returns from week to year as the earlier studies argue (Bartov & Bodnar, 1994).

Interestingly, Soenen and Hennigar (1988) found the relationship to be strong and negative when investigating a shorter time period 1980–1986 and using monthly industry returns in U.S. stock market. They use a model specification, which includes only foreign currency exposure and a variable of NYSE index explaining market movements. They use an effective exchange rate against 15 countries as the variable describing exchange rate. Soenen and Hennigar attempt to divide the time period in the phases of strong and weak U.S. dollar without success of obtaining any changes in the results. They also analyse the effects separately in seven industries as they note that the exchange rate exposure can be asymmetric between industries. Results show in general, that weak dollar encourages stronger economy, which would be intuitive for export-oriented and dependent industry. In the end, adding the market component to the model actually diminishes the significance of the exchange rate exposure coefficients.

Contrarily, Bartov, Bodnar and Kaul (1996) highlight positive linkages by adding to the scope the volatility effect of exchange rates on the U.S. multinationals' stock returns. They state, that their perspective adds to the former investigation by providing an additional framework for understanding the price determination of stocks. Bartov et al. conclude that increase in variability of exchange rates increases the non-diversifiable market risk and this increase in exchange rate variability increases also stock volatility. This effect was dominant after the collapse of Bretton Woods system of fixed exchange rates. Their study covers two five-year periods of monthly returns, the complete period being 1965–1978 and the model specification adds also other controlling macro variables.

Several studies have been able to present evidence for significant and positive premium for foreign exchange exposure. A noticeable similarity among these studies

is the geographic area, which is widened to other stock markets than that of U.S. For instance, Ferson and Harvey (1994) like Bartov et al. use a multi-factor macroeconomic model in eighteen developed markets in 1970-1989 and find the exchange rate risk to be the crucial explanatory factors when explaining international equity index returns. Ferson and Harvey use macroeconomic variables, such as Eurodollar – U.S. Treasury bill yield spread, real interest rates and industrial production growth as other explanatory variables, in addition to exchange risk exposure.

Compared to the earlier studies of Jorion (1990) and Soenen and Hennigan (1988) the key difference is the wider geographical area, shorter time period and model specifications of the studies, both of which supposedly affects the obtained results and implications. Also, in contrary to studies of Soenen and Hennigar, Bartov, Bodnar and Kaul and later Giffin and Stulz, Ferson and Harvey use broad equity indices presenting national stock exchanges rather than industry indices.

De Santis and Gerard (1998) find evidence that a significant proportion of total risk premium is represented by the exchange rate risk which is priced, when using conditional multivariate model, International CAPM. The model includes foreign exchange risk and global market risk as explanatory factors, which are detected to produce premia when time-variation is allowed. The evidence is found from monthly data in Germany, Japan, The UK and the U.S. stock indices. De Santis and Gerard also propose that the time variation in the risk premium could explain why the unconditional models cannot find evidence on currency risk which is priced in stock market. Interestingly, like Griffin and Stulz (2001) later also De Santis and Gerard posit that according to the evidence U.S. firms are not that dependent on foreign trade and thus, they are not able find such a significant exchange rate exposure in the United States. as for example in Germany.

Choi, Hiraki and Takezawa (1998) agree with the former findings of De Santis and Gerard (1998) that the conditional currency risk is present in monthly stock returns of firms in Japan. Choi et al. use a macroeconomic model controlling for market risk, interest rate changes and exchange rate risk. They find this with both, conditional and unconditional models, but find differences in the significance of the premium when using different measures for the exchange rate. When Choi et al. use the unconditional

model, which provides proof that as the bilateral exchange rate is used the exposure is priced, but as the trade-weighted measure is used, the results are mixed. When the conditional model is used, the evidence is more aligned regardless the chosen measure of exchange rate. In conclusion, although they are able to find priced currency risk in Japan, the evidence on the correct model is somewhat mixed.

Favouring the studies of De Santis and Gerard (1998) and Choi et al. (1998), also Patro, Wald and Wu (2002) are able to detect risk premium for currency exposure in equity index returns of the 16 OECD countries in 1980–1997. They use a two-factor CARGH model with MSCI word market index and trade-weighted basket of exchange rates as the two risk factors. The specification of Patro et al. is based on the same model that Adler and Dumas (1983) introduce. Different from the earlier studies, Patro et al. use weekly observation in the stock market to detect the possible time-variation in betas, which they are able to find.

Patro et al. include in their studies Sweden, Norway and Denmark and find positive and significant exchange rate exposure in these countries during 1980-1997. The country-specific returns are measured in local stock market indices and their returns. This is one of a few findings, where the sample includes these Scandinavian countries.

4.3 Industrial structure effects and other explanations on differences in Exchange rate Exposure

From panel data, for example Chaieb and Mazzotta (2013), Marston (2001) and Allyannis and Ihrig (2001), have found evidence implying the industry structure to have an effect on the exchange rate exposure of firms. Chaieb and Mazzota measure exchange rate exposure with trade-weighted exchange rate and divide U.S. firms into eleven industry clusters. Chaieb and Mazzotta divide the exchange rate exposure component into major trade-weighted currency exposure and to other important trading partners' trade-weighted currency exposure. They allow heterogeneity among firms and assess every firm separately (Jorion, 1990). As a result, from their tests they find the exposure to be economically significant

Allyannis and Ihrig detect the differences in U.S. manufacturing industries, when dividing the total industry into 18 groups in which they are able to find significant

exposure in 4 of them. They find out that there are important factors one should take into account when detecting the exposure and its' magnitude, such as mark ups, competitive structures of an industry and imports and exports of a country. They study monthly U.S. firms' stock returns during 1979–1995.

In the same sense, Marston (2001) suggests that the net foreign revenues are the most important factor affecting the exposure of a firm. Marston posits that the economic exposure of an exporting firm is a proportion of the foreign net revenues. As such, exporting firms are tied to the price elasticity of the product demand. In practice this means that the value of a net-exporter decreases, when the domestic currency appreciates. A net-importer's value, in the contrast, rises.

Also, Doidge, Griffin and Williamson (2006) focus on the factors affecting the exchange rate exposure and the magnitude of the exposure. They study firms in over 18 countries, including Norway and Denmark. They find economically and statistically significant exposure for the firms. The main implication from their study is that the firms having international trade outperform 0.72 %/month, when large depreciations take place. Contrarily, they underperform by 1.10 %/month, when currencies appreciate. They use broad stock indices in each country and find positive and significant exposures also for Norway and Denmark.

Jorion (1990) argues that exchange rate exposure can be divided into two factors on which the random exchange rate movement affect. The two factors are 1) the value of monetary assets with fixed payoffs and 2) the value of real assets held by the firm, which are affected by the exchange rate exposure nevertheless they would be domestic. For example, a domestic firm can be affected by the competing firm's imported goods, which in the appreciation of a currency seem cheaper than the domestic goods. Thus, the effect of real assets causes the effect of exchange rate movements to affect also the solely domestic firms.

One plausible reason for the ambiguous evidence of exchange rate exposure among firms is that companies are hedging the exposure. According to Bartram, Brown and Fehle (2004) 45 % of non-financial firms in 48 countries hedge with currency derivatives and other instruments. The usage of derivatives for hedging is mostly determined by the economic risks. Allyannis and Ofek (2001) find posit hedging to be

the main purpose of using financial derivatives, as in their U.S. data the foreign trade to sales–ratio is positively correlated with the use of currency derivatives.

Also, Chaieb and Mazzota (2010) argue that the insignificance of the results on exchange rate exposure might partly be due to hedging, as their evidence suggests that the emerging market currency index exhibits higher coefficients. They state that this could be due to the fact that the emerging market currencies are harder to be hedged against than the major currencies. Additionally, Chaieb and Mazzotta posit that the insignificance could arise from the methodology – using individual firms without taking into account the evidence of all firms jointly can create a lack of power. The focus of cross-sectional differences can still be significant.

Another explanation stated by Griffin and Stulz (2001) as they state that their period of investigation; years 1975–1997, includes dramatic increase of international trade in importance and value. During this time period financial market grew to be more integrated and the openness increased hastily, and thus the current situation may not be reflected in the result of earlier empirical evidence. Chaieb and Mazzota (2010) state later that the business cycle seems to affect the exposure and it magnifies during recession. They found evidence for the argument almost in all U.S. industries. Dominiguez and Tesar (2006) add that the variability of exposure over time tells a story of firms' adaptability to changes in exchange rates.

Additional suggested explanations for the cause for markets not pricing exchange rate risk, is the income smoothing and earnings management usage by the financial managers. Earnings management is used as a buffer against shocks affecting firms, which would otherwise have a deteriorating effect on the income (Barton, 2001; Chang, Hsin and Shiah-Hou, 2013).

4.4 The Modern Portfolio Theory and the Exchange rate Risk Premium

Apergis, Artikis and Sorros (2011) take a notably different perspective in modelling the returns – asset pricing model perspective. They add an exchange rate factor to the model of Fama and French (1993) three-factor model and Carhart four-factor model (1997). Apergis et al. move the concentration to Europe, more specifically exploring daily data from Germany. They use a model explaining stock returns by the following

factors: market, size, value, momentum, foreign exchange exposure and the volatility of foreign exchange exposure. As the foreign exchange exposure measure, they use the effective exchange rate of the Euro. Their measure is based on the bilateral euro exchange rates against 21 major trading partners of the Euro area.

Apergis et al. state that the exchange rate risk is present in the cross-section of German stock returns in 2000–2008. This finding is contrary to findings of Jorion (1990), but in line, for instance, with the findings of De Santis and Gerard (1998). Apergis et al. results show also the relationship to be nonlinear as the foreign currency exposure is larger for small cap stocks and value stocks. Also, the earlier studies taking on a strong portfolio approach but rather using tracking portfolio have founds that the foreign currency exposure is larger for value stocks (Du, 2009).

Brusa, Ramadorai and Verdelhan (2014) study cross-section of monthly equity returns from 46 developed and emerging countries from 1976 to 2011 and find evidence that exchange rate risk being priced in the stock market. Additionally, they find it important to investigate mutual funds and hedge funds with other equities. Interestingly, one of the models they use includes factors such: the market portfolio and two currency factors – dollar factor and carry factor.

They define carry factor as the difference between the returns on the top portfolio deducted by the returns on the bottom portfolio. The dollar factor is constructed in a way that each month the investor would borrow in US dollars and invest in all other currencies. They argue these factors are shown to capture the effects of changes in bilateral exchange rates. The perspective taken in the study is new as the explanatory variable used as a substitute for exchange rates. The use of carry factor instead of trade-weighted exchange rate could be reasoned, as U.S. economy is not as dependent on international trade as other economies. (Bursa, Ramadorai and Verdelhan, 2014.)

4.5 Previous studies focusing on Nordic stock markets

There is not a broad stream of studies focusing on Nordic countries to be found, however, for example Koutmos and Knif (2011), extend the earlier studies by concentrating in Finland. The earlier period of the evidence largely focuses in major world economies rather than smaller economies more dependent on foreign trade.

Koutmos and Knif are interested in the monetary changes and the effects of the introduction of euro, as joining common currency 1/3 of the foreign trade became a part of the home currency area. The joint currency regime is formerly investigated by Bartram and Karolyi (2006) among others, and it is shown that it leads to a decrease in the foreign exchange rate exposure among non-financial firms. Furthermore, the empirical results that Koutmos and Knif present support the fact that joining euro moves the focus away from regional competitiveness as the competition becomes more sector- or firm-specific.

Another view they take on is the asymmetric responses to appreciation and depreciations of currencies, which is already found by Muller and Verschoor (2006) and Koutmos and Martin (2003) some studies to mention. Lastly, Koutmos and Knif look at exchange rate volatility affecting international trade and thus cash flows of firms. Koutmos and Knif investigate weekly stock returns for sector- and size-portfolios constructed from Finnish Stock Exchange (FSE). They define exchange rates as bilateral rates – Finnish Markka per US dollar (FIM/USD) and later EUR/USD. The investigation period is 1994–2006 whilst the financial turmoil of 1990–1993 is excluded from the sample. The results show, all portfolios exhibiting some type of an exposure to movements in exchange rates and the exposure is defined as "positive normal" exposure, i.e. the depreciation of a domestic currency increases stock returns. Additionally, Koutmos and Knif find that the volatility of exchange rates seems to have positive and significant effects on stock returns also found by Koutmos and Martin (2003).

Muller and Verschoor (2006) use European firm-level data in analysing the effects of exchange rate risk on stock returns. They exploit bilateral exchange rates with the major trading partners' currencies, Japanese yen, U.S. dollar and UK pound. Their data exhibits both positive and negative significant exposure in subsample periods, complete period being 1988–2002. The most important implication of their study remains in the fact, that the short-term exposure is commonly well hedged, but in the longer term 65% of the firms exhibit significant exposure.

Likewise, Bartram and Karolyi (2006) find that the launch of euro in 1999, in general, led to changes in stock return volatility, market risk and foreign exchange rate exposure. The investigation concentrates on weekly returns in 18 countries, in addition

to United States and Japan. The highlight the finding that the market risk exposure significantly decreases after the introduction of the euro. In addition, they conclude that the volatility in stock markets increases after joining euro, but less in European countries implying a beneficial effect of the common currency regime.

Antell and Vaihekoski (2012) investigate exchange rate risk in Finnish and Swedish stock markets in 1970–2009 by extending the time period and widening the geographical area from the earlier work of Antell and Vaihekoski (2007). More precisely, Antell and Vaihekoski (2012) divide the variable of stock market risk into global and local stock market risks and add currency risk as another factor. Interestingly, they find out that the currency risk is priced in both stock markets, but the risk premium decreases after flotation of currencies in 1992, this is seen more starkly for Finnish stock market. They state it is an important implication as there are still emerging countries that have fixed, managed or tied currencies.

Interestingly Gulati, Knif and Kolari (2013) focus on Finland and use Sweden as a benchmark when assessing exchange rate shocks, but in the perspective of competitiveness between industries in the Nordic neighbour countries. The results indicate the exposure to be stronger in the Finnish stock index after the introduction of euro. Additionally, Gulati et al. find that the co-movements between industries would indicate the increasing competitiveness rather industry to industry than regionally. They use two-factor model including MSCI world index and the exchange rate of FIM/SEK. As additional factors, controlling for Swedish industry returns and an interaction term is added.

The earlier stage empirical work focuses on the linkage between the returns in the stock and exchange rate exposure i.e. the first moment of the distribution. Also, the second moment of the distribution, variance, is investigated more later on. These studies are presented in the next section.

4.6 Volatility linkages across exchange rate and stock markets

Blau (2018) refers to the stream of ambiguous research aiming to find out the effect of exchange volatility on asset prices. Some of the studies state that a fixed exchange-rate economy suffers higher volatility in asset markets when random shocks arise. The

higher volatility according to these studies affect interest rates, output, prices and money supply by increasing them. (Artis & Taylor, 1994; Frenkel & Mussa, 1980; Flood & Rose, 1995). Other studies state the contrary – exchange rate volatility effect depends the way the shocks that affect both the domestic and foreign currencies. For instance, Henderson and McKibbin (1993) highlight that only shocks from domestic supply create increased volatility in asset prices, when talking about fixed exchange rate economy. Flood and Hodrick (1986) state that both domestic and foreign supply shocks decrease volatility in asset prices.

Adding to former findings, Blau finds out that exchange rates affect stock prices, and therefore the policies influencing the stability of currency values have an effect on asset prices. He studies volatility of American Depositary Receipts (ADRs) which represent shares of a foreign stock traded on U.S. exchange. While the variation in home country currency is conditioned, Blau finds a strong relation between asset price variation and exchange rate volatility. He is also able to draw a parallel conclusion – it is vital to assess the stability of home-country currency markets when cross-listing securities to access international financial markets as it has a possible volatility effect on the stock price.

5 SECTOR INDEX RETURNS, EXCHANGE RATE AND MARKET INDEX RETURNS – THE BUILDING BLOCKS OF THE MODEL

My thesis concentrates on detecting whether the exchange rate risk is priced in the Finnish, Swedish, Danish and Norwegian stock markets. The study is conducted in the way that comparison between industries across the chosen countries is possible. Firstly, I will elaborate about the process of gathering data, the characteristics and the complications arising from the limitations of the data. Latter parts of this section consist of the analysis of the data in order to answer the following questions:

1) Do the stock markets in Nordic countries exhibit exposure to exchange rate risk? And how is this risk priced?

2) Do we find differences in exposure and pricing among the countries?

3) Are there differences between industries rather than countries?

5.1 Exchange rate exposure model specification

The model is constructed along with the majority of the former literature, including Adler and Dumas (1983) and Jorion (1990). In the model, the exchange rate risk, i.e. index-level sensitivity for the exchange rate exposure, is measured above the market's sensitivity to exchange rate changes. This means, that the model specifies the effect of the exchange rate exposure on value of the firm in excess of the market sensitivity. Additionally, as suggested by Bodnar and Wong (2003) controlling for market movements increases the reliability of the estimates. The model is represented as:

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \beta_{2i} X_t + \varepsilon_{it}, \quad (2)$$

where the R_{it} represents the returns of the industry i in the period t, R_{mt} is the local stock market return in the period t and β_{1i} is the sensitivity of the industry i to the market returns in the same period. X_t is the rate of return of the domestic currency against the U.S. dollar and β_{2i} is the sensitivity of the industry i to the changes in exchange rates independent of market movements. ε_{it} represents the error term, which

represents the noise affecting the industry returns. The financial time series data is converted into logarithmic returns to adjust the outliers and also for normalizing the distribution of the observations. [1]

According to the model specification, Muller and Verschoor (2006) state that a net-importer should have a positive exchange rate risk coefficient as the appreciation of domestic currency makes the imported goods cheaper. In the same perspective, a net-exporter should have a negative coefficient suggesting that the exported goods become cheaper in foreign currency as the home currency appreciates.

The model expects heteroskedasticity of the error term, i.e. acknowledges the time-varying variance in financial data such as stock returns and exchange rates. Thus, the model is specified as presented above (11), with the adjustment of GARCH (1,1) process. GARCH (1,1) is supported by previous studies of De Santis & Gerard, 1998, Patro, Wald and Wu (2002), Muller & Verschoor (2006) and Koutmos and Knif (2011). Thus, the model used allows the heteroskedasticity of the error term:

$$h_{it} = \alpha_{0i} + \alpha_{1i}\varepsilon_{it-1}^2 + \alpha_{2i}h_{it}, \quad (3)$$

where h_{it} denotes the conditional variance of the residuals and the right-hand side of the equations denotes the process of time-varying variance. With the GARCH (1,1) model, the test statistics and parameter values are more reliable.

5.2 Construction of sector indices and data collection

The data is gathered from Thomson Reuters, which provides sector-specific indices, which can be created with preferred set of criteria. Thomson Reuters was chosen to be

[1] The logarithmic returns are computed as follows: $\ln\left(\frac{x_t}{x_{t-1}}\right) * 100$, where the x_t is the return at time t and x_{t-1} is the return of the former time period. The logarithmic returns are then multiplied with 100 to obtain percentage results, which are easy to understand and analyse further. All of the variables, meaning industry returns, stock market returns, and exchange rate returns are computed in logarithmic terms.

the source, because of the next introduced aspects of industry-specific data, which requires to make own adjustments to the construction of indices. Firstly, the amount of listed companies in Nordic stock exchanges is low. Hence the amount of data is limited, and some industry indices contain only one or few listed stocks. For example, in the Finnish Media sector there is only one listed company, Alma Media.

The low amount of listed stocks is a challenge, when researching industry-specific characteristics, because the ability to make generalizations concerning wider industries deteriorates. The Finnish Stock Exchange Nasdaq OMX Helsinki contains shares of 140 listed companies and the respective amounts for Nasdaq OMX Stockholm, Oslo Stock Exchange and Nasdaq OMX Copenhagen are 378, 191 and 141. The puzzle lies behind the decision of including an adequate amount of listed companies in each index representing an industry.

Secondly, the frequency of the observations is a feature that has been noticed to affect the results in former studies. The shorter frequency has been noticed to produce less exposure than the longer frequency (for example, daily data versus monthly), for which one possible explanation could be the short-term hedging policies covering exposures. Still, it is also found by Dominiguez and Tesar (2006) that no matter the frequency, the industries and firms exposed to exchange rate risk maintain the exposure. I use weekly price data, as it exhibits more volatility in observations and I will get samples of observations, enough large in order to get more reliable results. Additional argument for choosing weekly data is that most of the past studies exhibiting ambiguous evidence use monthly data and the choice of daily data would be too extreme in the sense of return variation.

Thirdly, a vital aspect is to include companies having international trade or other international functions into the data. The inclusion enables to extract differences in exchange rate exposure between industries and draw conclusions for the chosen research questions represented above. In other words, the international companies have intuitively and according to former studies more exposure to exchange rate risk. Thus, when detecting the industry-specific characteristics, it is important to obtain an adequate sample of exposed companies. In the other hand, Jorion (1990) and Dominiguez and Tesar (2001) suggest that also the companies not engaging in foreign trade, can be exposed to exchange rate risk indirectly and through other channels. The

data consisting of listed stocks includes a variety of stocks exposed to international currencies and the obtained results will be mirrored on foreign trade characteristics when analysing the results.

As being described earlier the aim is to research the industry effects across countries. To succeed, it is essential that the constructed indices include a) enough listed shares for generalizing the effects as industry-wide, and b) observations after the launch of euro, from January 1999 to February 2019, i.e. the constructed indices must in all instances include shares of listed companies. Thus, I have included subindustries into the main industry indices represented in the Table 1. Indices are constructed in essence to include comparable industries having adequate amount of listed companies in each. Lastly, an index of Financial sector is added, which is rather a rarity compared to earlier studies investigating non-financial companies. Financial sector is an interesting inclusion as it is generally assumed not being exposed to variables that could be eliminated, such as exchange rate risk.

There are some country-specific exceptions in the exploited indices from the represented in Table 1. From the Norwegian data it is not possible to construct a Healthcare index and for Denmark the missing indices are Basic Materials and Telecommunications, Media and IT. For Sweden and Finland, it was possible to construct all the indices presented in Table 1. The reason for missing indices for Norway and Denmark is the fact that there are no listed or not enough listed companies for those industries in order to build indices that would exhibit reliable and generalisable results.

Table 1 Industry indices created and chosen for investigation and examples of the included fields and subsectors

Industry index	Included fields and subsectors
Basic Materials Industry	Forestry and Paper, Chemicals, Industrial metals and Mining
Industrials	Construction and Materials, Machinery, Aerospace and Defence, Electronic, General
Consumer Goods and Services	Automobiles and Parts, Food and Beverages, Personal and Household Goods and Services
Healthcare	Healthcare services and equipment, Pharmaceuticals and Biotechnology
Telecommunication, Media and IT	Media Agencies, Publishing, Broadcasting and Entertainment, Teleoperators, Computer Services and Software, Computer Hardware and Equipment
Financial	Banks, Insurance, Financial Services

The time period of interest is from January 1999 until February 2019, which adds a period of stable growth after the financial crisis to the former studies. The resent studies have been conducted before the Nordic economies recovered from the worst crashes of the crisis and in this sense, the past decade is an interesting and possibly an informative addition (e.g. Apergis, Artikis & Sorros, 2011; Gulati, Knif & Kolari, 2013). All of the industry indices have in total 1052 index points and none of those used has zero constituents during the investigation period.

5.3 Descriptive statistics on industry index returns

Table 2 summarizes the characteristics of the chosen sector indices. As the Table 3 indicates, for the investigated period (January 1999 to February 2019) the means of the weekly log returns are generally positive with a few exceptions. In Sweden, the mean returns of the Basic Material, Industrial, Consumer Goods and Services and Healthcare sectors are statistically significant. Additionally, Norwegian Consumer Goods and Services and Danish Healthcare and Financial sectors have earned positive and different from zero returns on average. Interestingly, Finland has no indication of statistically significant returns in any sector.

The characteristic of a weekly data is a variation in observed returns, which is clearly seen in the Table 2. The weekly standard deviation σ is high and additionally the extreme values are far away from the mean returns. Interestingly, all the industries in Denmark seem to exhibit less volatility than in other countries.

Also, the data exhibits statistically significant skewness and kurtosis, which indicates that the time series data exhibits fat tails and is asymmetric around the mean. Negative skewness and excess kurtosis indicate with the Jarque-Bera test statistic that the time series observations are non-normally distributed around the mean. The data is also autocorrelated, which typically characterises financial time series data. The autocorrelation is indicated by the Ljung-Box Q-test, which is statistically significant in all of the indices provided in Table 2. Thus, the data is not independently distributed, and it exhibits serial correlation.

Table 2 Descriptive statistics on logarithmic sector-specific returns in Finland, Sweden, Norway and Denmark

	μ	Min	Max	σ	SK	Kurt	JB	Q(10)
1) Finland								
Basic Materials	0.08	-18.95	16.30	3.23	-0.60*	4.09*	800*	47*
Industrial	0.15	-13.82	11.62	2.69	-0.50*	2.73*	373*	66*
Consumer	0.11	-20.22	16.62	3.63	-0.61*	4.28*	870*	54*
Health	0.12	-13.49	11.30	2.61	-0.68*	3.44*	602*	80*
Telecom, Media and IT	-0.06	-21.14	14.99	4.01	-0.42*	2.26*	256*	68*
Financial	0.18	-18.26	34.37	3.08	0.57*	17.24*	13132*	50*
	μ	Min	Max	σ	SK	Kurt	JB	Q(10)
2) Sweden								
Basic Materials	0.19*	-15.54	11.64	3.03	-0.49*	2.55*	329*	71*
Industrial	0.18*	-13.27	11.91	2.67	-0.50*	2.59*	339*	46*
Consumer	0.17*	-12.22	12.46	2.29	-0.16*	2.12*	203*	41*
Health	0.17*	-16.72	14.38	2.59	-0.30*	3.67*	608*	79*
Telecom, Media and IT	-0.04	-33.85	17.46	4.21	-0.98*	8.68*	3477*	67*
Financial	0.10	-15.60	14.19	2.74	-0.35*	4.28*	828*	24*
	μ	Min	Max	σ	SK	Kurt	JB	Q(10)
3) Norway								
Basic Materials	0.07	-19.82	14.37	3.47	-0.64*	3.64*	655*	66*
Industrial	0.15	-20.77	8.45	2.55	-1.03*	5.95*	1745*	78*
Consumer	0.20*	-13.58	17.46	2.89	-0.48*	4.13*	793*	63*
Telecom, Media and IT	0.14	-16.74	16.16	3.39	-0.53*	3.30*	529*	58*
Financial	0.15	-21.44	19.21	3.13	-0.95*	8.24*	3153*	48*
	μ	Min	Max	σ	SK	Kurt	JB	Q(10)
4) Denmark								
Industrial	0.14	-18.33	12.33	2.09	-0.54*	2.71*	375*	56*
Consumer	0.10	-24.12	14.49	2.66	-1.00*	9.48*	4124*	89*
Health	0.23*	-12.57	7.35	2.30	-0.67*	2.71*	403*	46*
Financial	0.21*	-12.08	15.35	2.24	-0.37*	4.65*	976*	40*

μ = mean return, Min = minimum value of the time series, Max = maximum value of the time series, σ = standard deviation, SK = skewness, Kurt = Kurtosis, JB = Jarque-Bera test with the null hypothesis of the normality of sample, Q(10) = Ljung-Box test for autoregression with the lag of 10, * = statistically significant at 5 % confidence level

The formerly mentioned high range of the observations is connected market turmoil periods, which is indicated in the Table 3. The total time period includes turbulent subperiods, such as Tech bubble, which peaked in Europe years 2000–2003 and financial crisis years 2008– 2009 and additionally the EU sovereign debt crisis around 2012-2014. The minimum and maximum values are usually in each sector index and country reached during those periods, which can be seen in Table 3. The turbulent periods are not excluded as they are regarded as parts of the cycles of the economy.

Especially, the Telecom, Media and IT sector has suffered during the Tech bubble, the data exhibiting minimum values of time series in 2000–2003. The effect of Tech bubble can be seen in every investigated country on the specific index returns. Other sector indices have the minimum values during financial crisis time period or past that, when financial crisis still affected in Nordic countries.

Table 3 The minimum and maximum values during the sample period, with the dates of the extreme values

	Min	Max
1) Finland		
Basic Materials	-18.95	16.30
	1.8.2011	4.5.2009
Industrials	-13.82	11.62
	6.10.2008	4.5.2009
Consumer	-20.22	16.62
	10.10.2005	2.9.2009
Healthcare	-13.49	11.30
	14.11.2005	13.7.2015
Telecom, Media and IT	-21.14	14.99
	11.6.2001	2.9.2013
Financial	-18.26	34.37
	6.10.2008	28.9.2009
2) Sweden		
Basic Materials	-15.54	11.64
	15.5.2006	24.10.2011
Industrials	-13.27	11.91
	6.10.2008	8.12.2008
Consumer	-12.22	12.46
	6.10.2008	3.11.2008
Healthcare	-16.72	14.38
	6.10.2008	15.2.2016
Telecom, Media and IT	-33.85	17.46
	22.4.2002	17.3.2003
Financial	-15.60	14.19
	19.1.2009	3.1.2008
3) Norway		
Basic Materials	-19.82	14.37
	17.11.2008	8.12.2008
Industrials	-20.77	8.45
	6.10.2008	14.10.2002
Consumer	-13.58	17.46
	17.11.2008	4.11.2008
Telecom, Media and IT	-16.74	16.16
	9.12.2002	6.10.2008
Financial	-21.44	19.21
	6.10.2008	3.11.2008
4) Denmark		
Industrials	-18.33	12.33
	6.10.2008	4.5.2009
Consumer	-24.12	14.49
	6.10.2008	3.11.2008
Healthcare	-12.57	7.35
	22.7.2002	5.1.2009
Financial	-12.08	15.35
	6.10.2008	2.10.2000

Min = minimum value of the index time series, Max = maximum value of the index time series
The table gives the range of the observations for each sector index and denotes the data, on which the extreme observation has taken place.

5.4 The modelled variables – the bilateral exchange rates and market indices

The exchange rate risk is expressed by each country's rate of return against the U.S dollar. The quotation if two different currencies, with the value of one currency against another, is called a currency pair. All exchange rates are quoted in the sense of how much of the quoted currency is able to be obtained with one unit of domestic currency. For example, EURUSD quotation shows how many U.S. dollars equals one euro. The currency pairs that are used in the thesis are presented in Table 4. As shown in the Table 4, each country or currency regime has its own currency abbreviation. For example, abbreviation SEK represents the Svenska krona.

Table 4 Quotations and abbreviations of currency pairs

Currency pair	Country
EURUSD	Finland
SEKUSD	Sweden
NOKUSD	Norway
DKKUSD	Denmark

The U.S. dollar is chosen as a quote currency, because it is the most exchanged currency in the world and thus, the best fit for the purpose of detecting objective changes in exchange rates. Another possibility would have been to use an effective exchange rates and create a trade-weighting for each industry index separately according to the trading partners' currencies. The effective exchange rate is calculated as follows, when there are N currencies in the basket, and there is trade with N partners:

$$\frac{\Delta E_{effective}}{E_{effective}} = \frac{\Delta E_1}{E_1} * \frac{Trade_1}{Trade} + \frac{\Delta E_2}{E_2} * \frac{Trade_2}{Trade} + \cdots + \frac{\Delta E_N}{E_N} * \frac{Trade_N}{Trade}. \quad (4)$$

The right side of the equation (4) demonstrates the trade-weighted average of bilateral nominal exchange rate changes. In order to calculate the change in domestic effective exchange rate, each exchange rate is multiplied by the corresponding trade share and then the products are summed up. The trade-weighting is rejected, because it would cause an excessive amount of work for a master's thesis level purposes.

As explained, the data includes weekly data points of one-week-average index prices and exchange rates. In other words, the data points are averages for the whole week

and have understandably a smoothing effect as if the data point were sole day-of-a-week prices. Day-of-a-week prices would more possibly exhibit more random volatility as random shocks affect the variables.

Figure 1 represents the exchange rates in Nordic countries across the investigated time period 1999–2019. As we can see there is a stark periodic volatility clustering around 2008 financial crisis period in all countries. Although the use of weekly average there is still evidence of high variation during the turmoil period. Additionally, it is obvious from the Figure 1, that the countries have same patterns in the quotation against U.S. dollar over time. This is intuitive in the sense that Finland, Sweden and Denmark are all included in the EU and Norway in EEA – Sweden and Denmark following the ECB in policy and decision-making and Norway operating in the common single market.

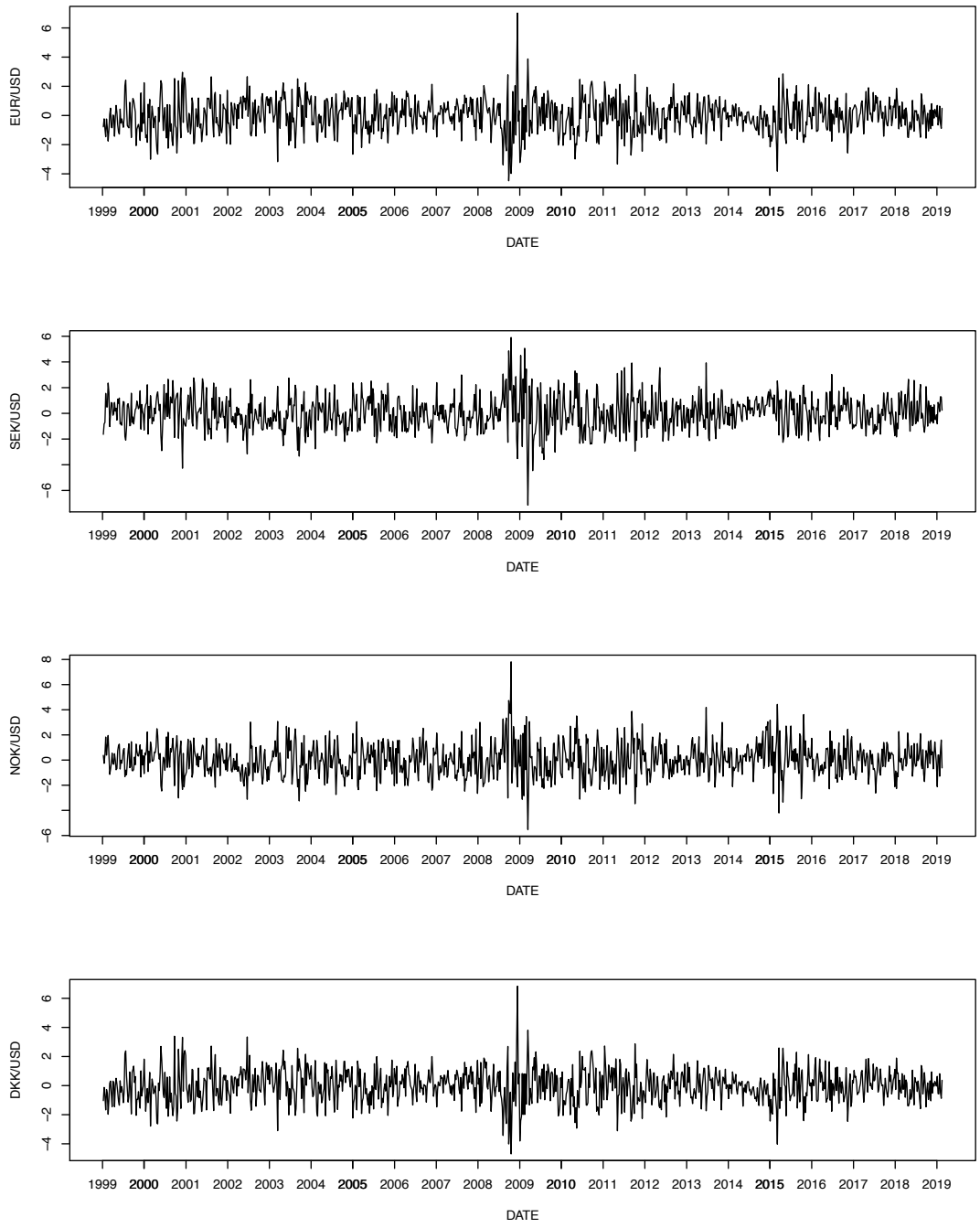

Figure 1 The weekly returns of exchange rates against U.S. dollar

As the market risk component was chosen the country-specific market value weighted indices. The indices describing the stock exchanges are commonly used in the previous studies and they are accepted as factors explaining the stock returns. Additionally, it is argued by Dominiguez and Tesar (2006) that the equally weighting compared to value weighting produces no significant differences when looking at the parameter

coefficients of stock returns. The integration of a value-weighted market portfolio is also in line with the suggestion of standard CAPM model. Contrarily to CAPM suggesting the use of global portfolio, studies suggest the usage of a country portfolio to better explain the industry level returns.

5.5 Descriptive statistics on exchange rates and market indices

Table 5 elaborates the characteristics of the data on the time series variables, which exhibit non-significant mean returns with the exception of the Copenhagen Market Index. The minimum and maximum values are not that extreme compared to sector indices described above and also, the standard deviation is lower. As typical for financial time series data, the Jarque-Bera test's null hypothesis of normality is rejected, and the data points seem to be autocorrelated as the significant Ljung-Box Q-statistic argues.

Table 5 Descriptive statistics on logarithmic exchange rate and market index returns in Finland, Sweden, Norway and Denmark

	μ	Min	Max	σ	SK	Kurt	JB	Q(10)
EURUSD	0.00	-4.48	7.02	1.12	0.06	1.69*	127*	68*
SEKUSD	0.01	-7.15	5.91	1.29	0.13	1.51*	104*	55*
NOKUSD	0.01	-5.53	7.81	1.30	0.35*	1.58*	132*	47*
DKKUSD	0.00	-4.70	6.83	1.12	0.05	1.63*	118*	61*
OMX Helsinki	0.04	-17.29	13.23	3.18	-0.56*	3.04*	463*	58*
OMX Stockholm	0.10	-13.83	11.28	2.50	-0.47*	2.50*	316*	37*
OMX Oslo	0.12	-14.83	13.79	2.44	-0.96*	4.80*	1174*	55*
OMX Copenhagen	0.15*	-16.72	9.99	2.22	-0.98*	5.42*	1464*	50*

μ = mean return, Min = minimum value of the time series, Max = maximum value of the time series, σ = standard deviation, SK = skewness, Kurt = kurtosis, JB = Jarque-Bera test with the null hypothesis of the normality of sample, Q(10) = Ljung-Box test for autoregression with the lag of 10, * = statistically significant at 5 % confidence level

As stated in section 4.3., the turmoil periods include the extreme values – minimums and maximums that are included in the time series data. This is again described in the Table 6, where the dates are indicated below the minimum and maximum values. Although the extreme observations are able to be traced to the same turmoil periods, the values are not as extreme as for the sector indices. This is an important notation,

when assessing the results of the estimated parameters and the possibility of the extremes affecting the results.

Interestingly, OMX Helsinki has the largest effect of the Tech bubble rather than financial crisis. This is probably due to the fact of high market value and weighting of Nokia shares in the OMX Helsinki market index. Sweden, Norway and Denmark seem to exhibit the extremes associated to financial crisis.

Table 6 The minimum and maximum values of exchange rate and market index returns during the sample period, with the dates of the extreme values

	Min	Max
A) Currency pair		
EURUSD	-4.48 29.9.2008	7.02 15.12.2008
SEKUSD	-7.15 16.3.2009	5.91 20.10.2008
NOKUSD	-5.53 16.3.2009	7.81 20.10.2008
DKKUSD	-4.70 20.10.2008	6.83 15.12.2008
B) Market index		
OMX Helsinki	-17.29 11.6.2001	13.23 23.10.2000
OMX Stockholm	-13.83 6.10.2008	11.28 3.11.2008
OMX Oslo	-14.83 6.10.2008	13.79 3.11.2008
OMX Copenhagen	-16.72 6.10.2008	9.99 3.11.2008

Min = minimum value of the index time series, Max = maximum value of the index time series
The table gives the range of the observations for each sector index and denotes the data, on which the extreme observation has taken place.

6 THE EFFECT OF EXCHANGE RATE ON STOCK RETURNS

As discussed earlier, there is not much empirical research concentrating the Nordic countries of my interest. The studies taking on a large geographic perspective, usually focus on individual firms gathered into an aggregate (mean) value representing the whole equity market of the country (Doidge et al., 2006). The other alternative is that the wider empirical work rather focuses on equity indices, which also cause an aggregation of the whole market (Patro et al., 2002). Secondly, the earlier literature focuses on the pre-Euro period, whereas the thesis focuses on post-Euro period (e.g. Knif and Kolari, 2013).

There is some work from Gulati, Knif and Kolari (2013) and Knif and Koutmos (2011) that provide views on Finland and Sweden. Gulati et al., take on a perspective of interconnectedness between the two neighbours before and after the common currency. Knif and Koutmos rather focus on the shifts from Finnish Markka to common currency euro specifically in Finland. Thus, there are relatively few papers to compare the results with. Also, not many of the studies concentrate on the industries in Nordic countries, while those sector-specific studies are conducted mainly in U.S. markets.

6.1 Results on the GARCH (1,1) estimation

The coefficients for currency risk $\beta_{2\mathrm{i}}$ are in Nordic countries largely positive with the exception of some industries. According to Muller and Verschoor (2006) the positivity of the coefficient indicates that the industry is a net-importer for the specific industry and the negativity of the coefficient indicates the industry being a net-exporter. The overall results in the Tables 7, 9, 11 and 13 are aligned with those of Muller and Verschoor, who study European countries and the firm-level exposure and pricing of currency risk against Japanese yen, UK pound and U.S. dollar. Their results indicate the European countries to be net-importers having positive coefficients.

The findings of positive coefficient align also with the findings of Patro et al. (2002) who study Swedish, Norwegian and Danish market indices among other countries. In contrast, when comparing to Bartram's (2004) findings in Germany, the coefficients are not as large in magnitude although they are positive, too. The magnitude could

obviously be due to the fact that Germany trades more than Nordic countries outside the common currency regime, for example with the United States.

Muller and Verschoor find both positive and negative coefficients in industry-level, which indicates that the exposure within an industry can be asymmetric and thus, there can occur averaging effect. The averaging effect can cause the non-significance of some coefficients (Muller and Verschoor, 2006). Nevertheless, the coefficients of the industries are not only of the magnitude that Muller and Verschoor find but also statistically significant.

Table 7 reports the results of Finnish sector portfolios indicating positive and statistically significant exposure on currency risk in Industrials, Consumer Goods and Services and Financial sectors. The coefficient indicates them to be net-importers. Only Telecommunication, Media and IT sector seems to exhibit negative and significant exposure indicating net-exporters.

Koutmos and Knif (2011) concentrate geographically in Finland and contrary to their findings the overall results in Table 7 seem to exhibit statistically significant exposure to currency risk in post-euro period. Koutmos and Knif study the effect of the launch of common currency on the significance of the exchange rate exposure and find out that the launch diminishes the significance at industry-level returns. The important remark is that they study asymmetric effects of unanticipated movements in exchange rates, which can cause the different obtained results in this thesis. Koutmos and Knif study a time period of 1994–2006, which excludes the financial crisis and thus, the extreme values that my observations include, which could have an effect on the differences among the results.

Gulati, Knif and Kolari (2013) concentrate also in Finland, aiming to find evidence of exposure on pre- and post-euro periods in the aspect of competitiveness with Sweden. They are able to show non-significant exposure in Finnish Stock Market among sectors, except within Industrials. The vital difference to my study is, that they use FIM/SEK exchange rates for the pre-euro and EUR/SEK exchange rates for the post-euro periods. Additionally, the investigated post-euro period ends 10 years earlier in 2009, which excludes a period of stable growth after the financial crisis.

First, the most intriguing finding in Table 7 is the Financial sector having a significant exposure, because intuitively it seems contradicting as the sector should in theory be well hedged for this kind of macro-economic factors affecting the returns and value of the business. Secondly, which is rather logic is the highest positive exposure of Consumer Goods and Services, which is the most affected by the unanticipated exchange rate movements. It would be clear to draw a conclusion of high import statistics in this sector, which seems to hold when looking at Table 8.

Table 7 GARCH (1,1) parameter estimates for sector returns in Finland during 3.1.1999–28.2.2019

Sector index	β_0	β_1	β_2	α_0	α_1	α_2	SER
1) Finland							
Basic Materials	-0.009	0.819**	0.088	0.117**	0.082**	0.899**	2.50
	(0.063)	0.063)	(0.063)	(0.042)	(0.021)	(0.024)	
Industrials	0.032	0.864**	0.193**	0.014*	0.062**	0.935**	2.33
	(0.046)	(0.025)	(0.045)	(0.008)	(0.013)	(0.013)	
Consumer Goods and Services	0.145	0.538**	0.352**	0.156*	0.054**	0.930**	3.26
	(0.089)	(0.041)	(0.086)	(0.070)	(0.013)	(0.017)	
Healthcare	0.164*	0.261**	0.089	5.010**	0.185**	0.000	2.47
	(0.077)	(0.024)	(0.067)	(0.451)	(0.017)	(0.017)	
Telecom, Media and IT	-0.078	1.181**	-0.093*	0.007*	0.032**	0.965**	1.57
	(0.041)	(0.013)	(0.038)	(0.005)	(0.005)	(0.005)	
Financial	0.122*	0.565**	0.199**	0.032*	0.054**	0.945**	1.96
	(0.059)	(0.025)	(0.057)	(0.012)	(0.009)	(0.007)	

Estimated GARCH (1,1) model, presented by equation (11) with modelled residual conditional variance estimated by the equation (13). The β_{1i} represents the coefficient parameter for the sector i for the exposure to market risk component and the β_{2i} for the currency risk exposure for the sector i over the market risk. The value in the parenthesis stands for the standard error of the parameter.
SER = Standard error of the regression
* = statistically significant at 5 % confidence level,
** = statistically significant at 1 % confidence level

Table 8 indicates the foreign trade statistics for year 2017. The used classification is NACE 2008, which is different to the one used in constructing the sector indices but is helpful when analysing the results from the GARCH (1,1) model estimation. As the Table 8 implies, Finland is in aggregate a net-importer in almost all of the sectors, but in Mining and quarrying, Manufacturing and Water Supply. The foreign trade statistics (Table 8) are largely parallel to the results in the Table 7, the coefficients being positive, except for Telecommunication, Media and IT.

Interestingly, the Basic Materials have a non-significant exposure to currency risk and Industrials are positively exposed although Table 8 would indicate the sector to be a net-exporter. In the same sense, Information and communication is a net-importer according to Table 8 although the results in Table 7 indicate the sector to be a net-exporter with a negative coefficient. The differences might be partially due to the construction of broader indices than in Table 8. Another explanation might include the financial derivatives usage and mitigation of exposure (e.g. Allyannis and Ofek, 2001). Also, Muller and Verschoor (2006) find that four industries, which in their work is Paper, Publishing and Printing, Utilities, Business support and other Industrials, having non-significant exposures. They posit rationale behind the finding to be in the use of financial hedging, which shields their exposure to exchange rate movements.

Table 8 Imports and Exports by the main industries in Finland, 2017 (Finnish Customs)

	Imports, thousand EUR	Exports, thousand EUR
A Agriculture, forestry and fishing	207,975	144,086
B Mining and quarrying	98,247	536,731
C Manufacturing	26,697,999	47,759,280
E Water supply; sewerage, waste management	68,588	245,462
F Construction	911,062	96,018
G Wholesale and retail	28,713,513	7,596,555
I Accommodation and food service activities	60,410	6,675
J Information and communication	1,050,574	174,014
K Financial and insurance activities	308,888	10,497
L Real estate activities	26,759	13,776
M Professional, scientific and technical activities	666,974	365,815
N Administrative and support service activities	392,559	108,232

The magnitude of the exposure coefficients in Table 9, indicating Swedish return effects of exchange rates, show a similar pattern and size as the Finnish parameters. Although there are some similar signs of coefficients (positive dominant), the magnitude of the parameters is lower than in Finnish results, in Table 7. For example, the magnitude of the pricing the exchange risk in Consumer Goods and Services sector is half of the Finnish parameter.

Patro et al. (2002) find the mean value of 0.881 for Swedish exchange rate exposure to be statistically significant. The value is higher than what my results indicate, but it is also worth of notice, that the investigation takes place in the pre-euro period. Also, other findings suggest the exposure to be diminished after the common currency (e.g. Gulati, Knif & Kolari, 2013 and Knif & Koutmos, 2011).

Table 9 GARCH (1,1) parameter estimates for sector returns in Sweden during 3.1.1999–28.2.2019

Sector index	β_0	β_1	β_2	α_0	α_1	α_2	SER
2) Sweden							
Basic Materials	0.049	0.922**	-0.049	0.073*	0.096**	0.888**	2.11
	(0.054)	(0.032)	(0.044)	(0.039)	(0.023)	(0.025)	
Industrials	0.058	1.079**	0.024	0.012*	0.061**	0.930**	1.42
	(0.030)	(0.020)	(0.031)	(0.005)	(0.013)	(0.013)	
Consumer Goods and Services	0.078	0.729**	0.124**	0.037*	0.063**	0.920**	1.68
	(0.041)	(0.041)	(0.034)	(0.015)	(0.014)	(0.017)	
Healthcare	0.112	0.599**	0.097	0.138*	0.069**	0.902**	2.18
	(0.074)	(0.064)	(0.050)	(0.059)	(0.019)	(0.027)	
Telecom, Media and IT	-0.122*	1.096**	0.250**	0.025*	0.044**	0.953**	2.56
	(0.058)	(0.031)	(0.047)	(0.011)	(0.007)	(0.006)	
Financial	-0.005	0.960**	-0.138**	0.029**	0.083**	0.902**	1.64
	(0.035)	(0.019)	(0.030)	(0.010)	(0.014)	(0.016)	

Estimated GARCH (1,1) model, presented by equation (14) with modelled residual conditional variance estimated by the equation (16). The β_{1i} represents the coefficient parameter for the sector i for the exposure to market risk component and the β_{2i} for the currency risk exposure for the sector i over the market risk. The value in the parenthesis stands for the standard error of the parameter.
SER = Standard error of the regression
* = statistically significant at 5 % confidence level,
** = statistically significant at 1 % confidence level

Another difference is that Telecommunication, Media and IT have a positive coefficient and the Financial sector has a negative coefficient. The sign of the Financial sector is in line with the exports reported by Table 10 – Financial sector is a net-exporter. The sign of the Telecommunication, Media and IT still somewhat contradicting to the export and import figures as the positive sign suggests Sweden to be a net-importer of the sector, but at the same time Table 10 indicates contrarily.

Also, in Sweden as in Finland the Industrials sector with Basic Materials seem not to be statistically significantly exposed to the exchange rate risk, which is again parallel to the findings of Muller and Verschoor (2006). The fact that the international trade in Manufacturing sector is generally balanced between exports and imports, could be a partial explanation to a non-significant exposure of the Basic Materials and Industrials. Another could be the financial hedging of those industries (e.g. Muller and Verschoor, 2006).

Table 10 Imports and Exports by the main industries in Sweden, 2017 (Statistika Centralbyrån)

	Imports, thousand SEK	Exports, thousand SEK
A Agriculture, forestry and fishing	55,686,786	33,888,559
B Mining and quarrying	80,449,708	29,432,615
C Manufacturing	1,310,645,122	1,347,015,891
D Electricity, gas, steam and air conditioning supply	3,918,406	9,531,179
E Water supply; sewerage, waste management	9,488,425	10,138,291
F Construction	15,246	7,274
J Information and communication	2,052,422	3,146,931
K Financial and insurance activities	25,052	38,088
M Professional, scientific and technical activities	21,987	3,887
N Administrative and support service activities	145,184	120,587

The Norwegian parameter coefficients continue to show similar magnitude of exchange rate effects on sector stock returns. The Basic Materials and Industrials remain having non-significant exposure coefficients. Consumer Goods and Services, Telecommunication, Media and IT and Financial sector have a similar economical magnitude and direction of the exposure as in Swedish data. Especially, Sweden and Norway seem to exhibit highly similar results in the estimation process.

The empirical findings from Norway are as rare as are in other Nordic countries, but Doidge et al. (2006), have found a non-significant but large coefficient of 1.79 for Norway in aggregate. This finding is a lot higher than the sector-specific results in Table 11 and would imply a 1 % unanticipated exchange rate increase to cause 1.79 % increase in the stock returns of Norwegian markets. Also, Patro et al. (2002) find a stark (but non-significant) exposure coefficient of 1.128, when investigating pre-euro period.

Table 11 GARCH (1,1) parameter estimates for sector returns in Norway during 3.1.1999–28.2.2019

Sector index	β_0	β_1	β_2	α_0	α_1	α_2	SER
3) Norway							
Basic Materials	-0.027	1.028**	-0.060	0.210**	0.111**	0.846**	2.23
	(0.058)	(0.028)	(0.051)	(0.063)	(0.022)	(0.029)	
Industrials	0.081	0.766**	0.036	0.035	0.057**	0.933**	1.74
	(0.048)	(0.025)	(0.041)	(0.020)	(0.014)	(0.017)	
Consumer Goods and Services	0.102	0.826**	0.160**	0.406*	0.087**	0.817**	2.04
	(0.062)	(0.029)	(0.048)	(0.169)	(0.025)	(0.056)	
Telecom, Media and IT	0.074	0.911**	0.205**	0.062**	0.037**	0.952**	2.54
	(0.070)	(0.033)	(0.057)	(0.024)	(0.007)	(0.007)	
Financial	0.082	0.962**	-0.117**	0.063**	0.072**	0.911**	1.96
	(0.049)	(0.026)	(0.042)	(0.026)	(0.019)	(0.022)	

Estimated GARCH (1,1) model, presented by equation (14) with modelled residual conditional variance estimated by the equation (16). The β_{1i} represents the coefficient parameter for the sector i for the exposure to market risk component and the β_{2i} for the currency risk exposure for the sector i over the market risk. The value in the parenthesis stands for the standard error of the parameter.
SER = Standard error of the regression
* = statistically significant at 5 % confidence level,
** = statistically significant at 1 % confidence level

When comparing the obtained results in Table 11 and the trade figures in Table 12, it is straightforward to conclude that there is nothing contradicting. Interestingly, it is challenging to obtain data of Financial sector among other sectors in Norway. The foreign trade is concentrated largely on Manufacturing and Mining and quarrying industries, which seem to mitigate the exposure well according to my non-significant exposure coefficient and parallel to Muller and Verschoor's findings.

Table 12 Imports and Exports by the main industries in Norway, 2017 (Statistik Centralbyrån)

	Imports, thousand NOK	Exports, thousand NOK
B Mining and quarrying	120,142,502	530,371,661
C Manufacturing	325,055,506	189,036,543
F Construction	2,747,000	694,000
G Wholesale and retail	18,184,000	5,120,000
H Transportation and storage	68,920,000	103,591,000
J Information and communication	29,785,000	25,361,000
M Professional, scientific and technical activities	22,141,000	29,484,000
N Administrative and support service activities	13,229,000	7,115,000

For Denmark, we obtain only two significantly exposed industries, which are Industrials and Healthcare. The obtained result is different to earlier results of Finland,

Sweden and Norway. First of all, Denmark seems to be the only Nordic country exhibiting both negative and statistically significant coefficient for Healthcare industry. This indicates Danish Healthcare sector to be a net-exporter – which is rather interesting. The data Danish data consists relatively higher number of Healthcare companies compared to other Nordic countries. Also, according to Table 14 the industry seems to be a net-exporter, which is in line with the found negative sing of the exposure. Industrials seem to be exposed in Danish markets positively to exchange rate movements, which in turn shows signs of the sector being a net-importer.

Patro et al. (2002) have studied pre-euro period obtaining an estimated coefficient of 0.770 for Danish equity index, which shows a larger magnitude for the exchange rate effect on stock returns. The coefficient is found to be statistically non-significant. Also, Doidge et al. (2006) find a non-significant exposure, but rather larger magnitude of the exposure compared to findings in Table 13. Also, both Patro et al. and Doige et al. find positive exposures, although Table 13 indicates Danish stock market having a negative mean exposure.

Table 13 GARCH (1,1) parameter estimates for sector returns in Denmark during 3.1.1999–28.2.2019

Sector index	β_0	β_1	β_2	α_0	α_1	α_2	SER
4) Denmark							
Industrials	-0.025	1.224**	0.141**	0.031*	0.052**	0.936**	1.57
	(0.044)	(0.041)	(0.051)	(0.015)	(0.011)	(0.013)	
Consumer Goods and Services	0.078	0.673**	0.014	0.105*	0.083**	0.890**	2.01
	(0.054)	(0.032)	(0.052)	(0.043)	(0.025)	(0.031)	
Healthcare	0.100*	0.896**	-0.238**	0.040*	0.059**	0.920**	1.44
	(0.040)	(0.220)	(0.038)	(0.018)	(0.016)	(0.023)	
Financial	0.152**	0.695**	0.037	0.033*	0.039**	0.949**	1.63
	(0.047)	(0.024)	(0.046)	(0.014)	(0.009)	(0.010)	

Estimated GARCH (1,1) model, presented by equation (14) with modelled residual conditional variance estimated by the equation (16). The β_{1i} represents the coefficient parameter for the sector i for the exposure to market risk component and the β_{2i} for the currency risk exposure for the sector i over the market risk. The value in the parenthesis stands for the standard error of the parameter.
SER = Standard error of the regression
* = statistically significant at 5 % confidence level,
** = statistically significant at 1 % confidence level

Table 14 Imports and Exports by the main industries in Denmark, 2017 (Statistics Denmark)

	Imports, thousand DKK	Exports, thousand DKK
B Mining and quarrying	55,567,500	57,709,100
C Manufacturing	40,205,700	35,518,500
F Construction	80,288,300	142,156,600
H Transportation and storage	159,590,700	198,779,400
J Information and communication	286,725,800	238,373,200
K Financial and insurance activities	303,119,300	276,976,900
Q Personal, Cultural and Recreational*	9,665,000	3,722,000
*= The share of Healthcare services	569,000	648,000

Noticed from the analysis of the results and foreign trade statistics of the countries, imports and exports are not necessarily the sole dominant factors affecting the sign and the significance of the exposure. For Finland, Sweden and Denmark in aggregate, some studies find negative signs of exposures, Hutson and Stevenson (2010) among others. For Norway in the other hand, they find positive exposure. This is contrary to my findings, when classified by industry rather than analysing total stock market averages.

Nevertheless, the negative signs for exposure are found, Hutson and Stevenson also study broad industries across boarders in the 23 developed countries. They conclude finding significant exchange rate exposure in high-technology and low-technology durables manufacturing, textile, clothing and footwear. All of the industries significantly exposed are articles of high cross-border competitiveness, which they state indirectly being the reason for exposure. This indirect exposure arising from competition is the reason for significant exposures among industries rather than the direct exposure from international transactions, which is relatively easier to mitigate using financial hedges (e.g. Dominiguez & Tesar, 2006).

The competitiveness perspective is closely related to the pass-through effect. The pass-through effect means that some firms in some specific sectors are able to increase the prices of their products and services in response to unexpected increases in costs, arising for example, from exchange rate movements. Intuitively, these industries face inelastic demand, substitutability and the firms do not face high competition (Bodnar et al., 2002). There is also evidence from U.S. automotive industry from Williamson

(2001), where there is a competition against Japanese auto imports and thus, depreciating yen causes trouble.

Compared to the presented findings, the statement of Hutson and Stevenson could be a partial explanation for deviations from international trade tables as Consumer Goods and Services are significantly exposed to exchange rate risk in all but Danish markets. Also, Telecommunication, Media and IT sector is significantly exposed in all markets, except in Denmark, where there were not enough of listed companies to observe. In addition to Telecom, Media and IT and Consumer Goods and services having a significant exposure creating a clear pattern (Denmark excluded), Financial sector seems to exhibit significant exposures also in all of the Nordics, but again – not in Denmark. As for exchange rate exposures, Denmark seems to be slightly divergent to other Nordic countries. This suggest some other industry characteristics than competitiveness, to be dominant in Danish markets, when looking for factors affecting the exposure.

Notably, Basic Materials and Industrials do not exhibit clear exposure trends consistently in all Nordic countries, which could be due to the formerly mentioned hedging argument. One could argue, these industries are more subject to direct exposure through international trade, which is proved also by the international trade tables in the earlier section 6.1.

The sector-specific coefficients presented are smaller than the ones Hutson and Stevenson find in the 23 developed countries during 1984–2003, which are supposedly due to the thesis concentrating only in Nordic countries. As stated before, the Nordic countries shift their trading into EMU countries after the euro was launched, which as one factor reduces the exchange rate exposure. After the shift to one currency regime, 1/3 of the trading partners (earlier having national currencies) now include to the same currency regime. This is proposed as one reason for the magnitude of the obtained coefficients in post-euro period.

As a conclusion, the Nordic countries (with the slight exceptions from Denmark), all exhibit quite equal economic exposures to exchange rate movements. The positive connectedness to European economy that Kiohos and Stoupos (2019) and of the Nordic countries is to some extent inadmissible. What they mean by the inter-

connectedness, are the spill over effects of euro currency volatility on the other Nordic currencies. Although, the recognition of openness, competition, interaction and other factors behind the exchange rate exposure occurs, the Nordic countries are missing attention in the empirical work.

6.2 The model and the other alternatives for modelling

The GARCH (1,1) parameters are generally statistically significant at least at 5 % confidence level, which indicates a good fit for modelling heteroskedasticity of the error terms (Tables 7, 9, 11 and 13). The stationarity of the variance of the error term seems to hold, which further proves allowing the time-varying variance to produce more reliable estimates with the used model. The stationarity of the variance can be noticed from the sum of α_1 and α_2 terms in Tables 7, 9, 11 and 13, which in all instances equals less than 1.

When evaluating the distribution of the error terms in Table 15, we are able to detect the rejection of normality from the Jarque-Bera test in every country. Additionally, even after the GARCH (1,1) process the error terms exhibit excess skewness and kurtosis affecting the non-normality of the distribution. The Ljung-Box Q-statistic also rejects the hypothesis of the error terms not being serial correlated. Nevertheless, the ARCH test exhibits almost in all instances rather good results indicating that the GARCH (1,1) model does well and the error term variance being conditional.

The standard errors of regression in the section 5.1. also exhibit rather moderate values, indicating the linear model captures quite well the variation in the observations on industry-level data. As we can see, the standard error of the regression is highest for Finnish Consumer Goods and Services -sector, being 3.26 %, but in the aggregate the values are less than 2.56 %.

Table 15 Basic statistics on the GARCH (1,1) error terms

	μ	σ	SK	Kurt	JB	Q(10)	ARCH
1) Finland							
Basic Materials	0.00	1.00	-0.53*	2.88*	413*	35*	1.69
Industrials	-0.02	1.00	0.02	1.36*	82*	44*	7.19
Consumer Goods and Services	-0.01	1.01	-0.63*	4.91*	1131*	62*	7.17
Healthcare	-0.01	1.00	-0.62*	3.84	716*	75*	7.23
Telecom, Media and IT	-0.01	1.00	-0.32*	2.19*	230*	75*	9.73
Financial	-0.02	1.00	0.75*	8.40*	3203*	35*	0.69
	μ	σ	SK	Kurt	JB	Q(10)	ARCH
2) Sweden							
Basic Materials	0.02	1.00	-0.12	0.85*	35*	82*	23.48*
Industrials	0.00	1.00	-0.29*	1.16*	75*	51*	4.19
Consumer Goods and Services	0.00	1.00	0.16*	1.07*	56*	67*	16.15
Healthcare	0.00	1.01	0.14	2.68*	321*	83*	9.09
Telecom, Media and IT	-0.01	1.00	-0.73*	6.80*	2129*	59*	5.52
Financial	-0.01	1.00	-0.05	0.96*	41*	49*	8.57
	μ	σ	SK	Kurt	JB	Q(10)	ARCH
3) Norway							
Basic Materials	-0.02	1.00	0.47*	6.22*	1738*	38*	2.65
Industrials	-0.01	1.00	-0.12	1.16*	62*	58*	4.4
Consumer Goods and Services	0.00	1.00	0.06	1.40*	88*	37*	7.95
Telecom, Media and IT	-0.01	1.01	0.13	3.30*	482*	64*	4.4
Financial	-0.02	1.00	0.75*	8.40*	3203*	35*	0.69
	μ	σ	SK	Kurt	JB	Q(10)	ARCH
4) Denmark							
Industrials	-0.01	1.00	0.11	1.10*	56*	36*	3.82
Consumer Goods and Services	-0.03	1.00	-0.43*	2.35*	276*	50*	2.19
Healthcare	0.00	1.00	-0.03	2.08*	190*	36*	7.19
Financial	0.03	1.00	0.23*	3.75*	629*	84*	7.05

μ = mean return, Min = minimum value of the time series, Max = maximum value of the time series, σ = standard deviation, SK = skewness, Kurt = Kurtosis, JB = Jarque-Bera test with the null hypothesis of the normality of sample, Q(10) = Ljung-Box test for autoregression with the lag of 10, * = statistically significant at 5 % confidence level

6.3 Similarities and differences among the Nordic countries and industries

Table 15 presents the mean coefficients of exchange rate exposure in Nordic countries. Although, it would have been expected that the countries are highly linked, there are

some important notions to make arising from the Table 15. Finland has the highest exposure coefficient of magnitude, which is logical as the industries were the most sensitive to exchange rate movements in Finnish markets compared to other countries. The high Finnish mean exposure is affected by the Consumer Goods and Services sector, which is assumedly due to the lowest number of constituents in Nordic countries but also as there are large index constituents in market value. Furthermore, for the past years, the United States has been the third or the fourth biggest importer of good in Finland (Finnish Customs, 2018), which is shown by the large mean exposure on the bilateral U.S. dollar exchange rate.

For the other Sweden and Norway seem to exhibit quite alike mean exposure of magnitude, whereas Denmark has a negative mean exposure. The other Nordic countries are more moderately exposed to U.S. dollar exchange risk as the United States is only fifth to eighth trading partner to them. The negative mean exposure of Denmark is driven by the export-driven Healthcare sector with other sectors being moderately positive. Also, Denmark has the lowest share of international trading with United States of all the studied countries.

Table 15 The mean coefficients of exchange rate exposure in Nordic countries

Nordic country	β_2
Finland	0.138
Sweden	0.051
Norway	0.045
Denmark	-0.012

The table presents the country-specific average exchange rate exposure coefficients β_2, which indicate the magnitude of the country exposures.

Table 16 includes the t-statistics for the null hypothesis of the mean coefficients being equal, i.e. not exhibiting statistically significant differences. With this hypothesis it is possible to test the question about countries exhibiting similar exchange rate sensitivities. Table 16 shows the rejection of the null hypothesis of equal sensitivity to exchange rate movements in all cases but between Sweden and Norway. The similarity of Sweden and Norway countries is also shown in the Table 15.

The results of similarity seem to be partly in line with empirical work of Kiohos and Stoupos (2019) highlighting the similarities of Nordics and linkages of Scandinavian

countries to euro currency movements. The magnitudes and the signs seem to differ from those obtained by Muller and Verschoor (2006). Muller and Verschoor find -0.0303 coefficient for Finland and 0.0064 for Denmark on average, which are different from the coefficients in Table 15. Assumedly, the differences arise due to smaller number of firms in sample of my thesis. This difference again, is due to the need of cutting out industries not including enough listed firms.

Comparison to work of Bartram and Bodnar (2012) the coefficients are quite equal of magnitude among the Nordic countries – for Finland it is the highest 0.787, Sweden 0.181, Norway 0.009 and Denmark 0.443. Also, Bartram and Bodnar divide portfolios of developed and emerging countries separately and test their exchange rate exposures. For developed countries the mean is 0.060, which is of magnitude equal to mine (mean coefficient of all of the countries 0.058).

The most interesting aspect in Table 16, is the statistical significance in the differences of the means. Although, the economic magnitude of the differences in mean exposures seems to be moderate (Table 15). Almost all of the Nordic countries vary statistically significantly from each other. This highlights the fact, that the monetary policy decisions might matter in the end. The high exchange rate exposure of Finland could be interpreted in the way that taking part in single currency would not have been as good decision as proposed in terms of currency exposure on the U.S. dollar. Nevertheless, the former claim would require more evidence from pre-euro period and currency exposures against other trading partners' currencies.

Table 16 T-test for the differences in mean exposures being equal

	t-values
H_0: $\beta_2 F = \beta_2 S$	7.09**
H_0: $\beta_2 F = \beta_2 N$	6.64**
H_0: $\beta_2 F = \beta_2 D$	9.59**
H_0: $\beta_2 S = \beta_2 N$	0.56
H_0: $\beta_2 S = \beta_2 D$	4.64**
H_0: $\beta_2 D = \beta_2 N$	3.70**

The table presents the t-values, for test of equal sensitivity for country stock markets constructed from the indexes.
H_0= null hypothesis of betas of the countries being equal,
F = Finland, S = Sweden, N = Norway, D = Denmark,
** = Statistically significantly different betas at 5 % confidence level

Thirdly, the aim is to detect similarities and differences between industries in Nordic countries. Studies state that the establishment of EU among other global integration, led to increasing competition between industries and firms rather than countries or regions (Knif and Koutmos, 2011 and Dominiguez and Tesar, 2006). Thus, it would be intuitive to expect to see smaller differences in the industry-specific sensitivities to exchange rates. The assumption is, that the industries would hedge their exposures to large extent in order to avoid the deterioration of the profitability caused by exposure to exchange rates.

In the Figure 2, the magnitude of the coefficients is expressed as bars indicating the sensitivities to exchange rate movements. The clear implication from the figure is that there are stark differences among industries and their sensitivities to exchange rate movements. Sweden and Norway, interestingly, seem to exhibit the most similar results as noticed also earlier. Finnish sectors as well as Danish, seem to behave more individually and exhibit stark differences. This result is largely different from expected.

Finnish sectors seem to behave most aggressively – all the bars being notably different from others, especially in Consumer Goods and Services. The suggested explanation for higher parameter value lays in smaller amount of index constituents and few large market participants. Also, the Telecommunication, Media and IT sector seem to exhibit a different sign in the exposure to other countries. The explanation for the sensitivity results of Telecom, Media and IT sector in Finland, is probably in large names as Nokia Corporation and others, who have engaged in international trade and interaction during my investigation period. For Denmark, Healthcare seems to exhibit excessively altering sensitivity to exchange rate movements. This could be due to the fact of Denmark possessing one of Europe's leading medical technology nations and high exports of Pharmaceuticals (Ministry of Foreign Affairs, Denmark, 2017).

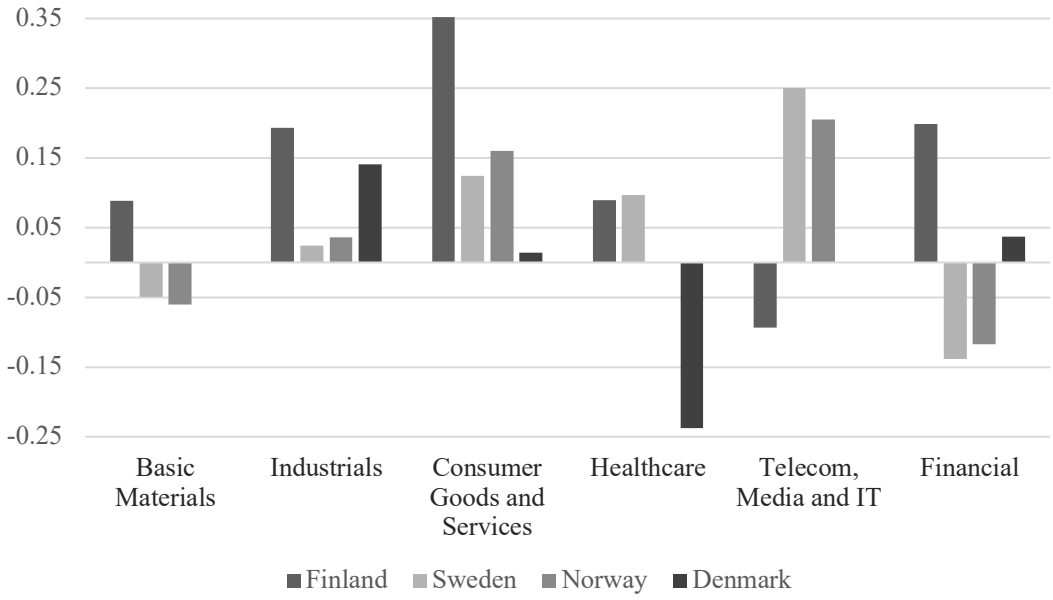

Figure 2 The sector-specific sensitivities to exchange rate movements, by country

Aligning with the findings of Dominiguez and Tesar, the varying signs of exposure between and among the industry categories is present. Because the study includes sector indices rather than firm-level data, it impossible to find an explanation of firm-level variation, which in turn could explain the individual firm behaviour and differences inside industry indices. The variation in the magnitude and the sign of the exposure is evident in other studies including Nordic countries into the investigation, too.

The Table 17 presents the significantly exposed industries in each country by industry category. As shown, there is no clear pattern in any sector, to be concluded as significant or insignificant for certain. The Basic Materials seem to have non-significant exposure as found by Muller and Verschoor (2007), which could be due to direct and well-hedged exposure from international trade. Telecom, Media and IT seem to exhibit pattern-alike and significant exposures, as well as Consumer Goods and Services and the Financial sector in Finland, Sweden and Norway.

Analysing the Table 17 by country, reveals that the exposures are alike in Nordic countries aside from Denmark. As suggested earlier, Denmark seems to be a clear exception to a rule of exchange rate exposure in Nordic countries. The reason for this

is probably due to the strong Healthcare sector and high export figures to United States (OEC, 2018).

Table 17 The significance of the exposures in each country and sector

	Finland	Sweden	Norway	Denmark
Basic Materials				--
Industrials	x			x
Consumer Goods and Services	x	x	x	
Healthcare			--	x
Telecom, Media and IT	x	x	x	--
Financial	x	x	x	

The table indicates the significantly exposed industries in each country by a shaded sell.
The blank sells represent non-significant exposures.
--= No exposure coefficient obtained

7 CONCLUSION

The aim of the thesis was to detect, whether there is exchange rate exposure sensitivity in Nordic sectors, which were Basic Materials, Industrials, Consumer Goods and Services, Healthcare, Telecommunication, Media and IT and Financial sector. The concentration in Nordic countries is new and yet undiscovered, although the countries provide an interesting test laboratory for small, open and inter-connected countries. The research questions concentrate in finding out, if the stock markets in Nordic countries exhibit exposure to exchange rate risk and how is the risk priced. Secondly, are there differences in exposure and pricing among the countries? Lastly, are there differences between industries rather than countries?

The main result of my investigation was that there is statistically significant exposure to exchange rate risk in Nordic stock markets between January 1999 and February 2019, which is contrary to some of the earlier empirical literature. The detected exposure seems to be also economically important, especially in Finnish sectors. The mean exposures between the countries are statistically significantly different from each other in the Nordic countries. The exceptions are Sweden and Norway, which exhibit statistically non-significant differences in mean exposures. Regardless from the statistical significance of the differences in means, the economical difference in mean coefficients among Nordic countries is not large.

The largest exposures are consistently found from the Finnish sectors – for example, Consumer Goods and Services seem to exhibit high positive exposure which is at least twice as large as in other Nordic countries. For Denmark Healthcare sector seems to exhibit stark negative exposure to exchange rate risk, which is characteristic of the general industry being one of the leaders in the Europe. The same negatively (and different from other Nordic peers) exposed industry is Finnish Telecommunication, Media and IT, which is also characteristic due to a large and international operator, Nokia.

The differences in mean exposures could be due to broad categorization of industries and the low number of the listed companies included in the industry indices. The inclusion of firm-specific investigation and unlisted companies could have brought a more specific perspective. The effect of firm-specific characteristics is noticed also in

earlier literature to affect the exposure (e.g. Allayannis and Ihrig, 2001; Dominiguez and Tesar, 2006; Chaieb and Mazotta, 2010).

Although, the concentration in Nordic countries is a fresh and yet lacks investigation, the results are generalizable as indications of the Nordic industry exposures. There are significant exposures to exchange rate movements in open and internationally engaged Nordic countries. The findings support others detecting exposures in industry- and firm-level data (Dominiguez and Tesar, 2006; Koutmos and Knif, 2011; Gulati et al., 2013 and Doige et al., 2006). The details of industry specific exposures, however, need some support from more specific firm-level approaches (discussed earlier).

Firstly, additional to detecting the firm-specific characteristics behind the exposures, the further research should concentrate more specifically to changes in the exposures over time and detect the asymmetries in the exposures over time. It hnoticed that the appreciations and depreciations have an asymmetric response in firm-level returns in different industries and thus, some events of economic turmoil are suggested to study further. Secondly, the importance of trading partners should be taken into account, when going further. That is, the use of effective exchange rates should be considered in order to detect more accurate descriptions of exposure in industry-indices.

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