FINNISH AND SWEDISH SECTORS DURING COVID-19 PANDEMIC

Evaluating the performance and modelling future index prices based on COVID-19 data

Lappeenranta–Lahti University of Technology LUT

Master's thesis in Strategic Finance and Analytics

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Examiners: Associate Professor Jan Stoklasa

Visiting Researcher Tomáš Talášek

ABSTRACT

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Finnish and Swedish sectors during COVID-19 pandemic - Evaluating the performance and modelling future index prices based on COVID-19 data

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Keywords: COVID-19, stock returns, performance measurement tools, linear regression, MCDM, TOPSIS

This study focuses on Finland´s and Sweden´s stock markets during COVID-19 period from March 2020 to April 2022. In addition of the whole period, three sub-periods 1) from 18 March 2020 to 30 September 2020, 2) from 1 October 2020 to 30 July 2021 and 3) from 2 August 2021 to 7 April 2022 are examined. This thesis examines if the performance was similar in same sectors in Finland and Sweden and try to provide answer if there were winners or losers among the sectors. Performance measurement tools, such as Treynor, Sharpe, Sortino, and Calmar ratio are used to assess the sector indices. Distance-based MCDM method TOPSIS will be used to rank the results.

There is a lack of studies, that focus on examining the COVID-19 variables and their relationship to stock prices if no other economic variables were used and were they the same during different waves. Even if there is a lot of research on price predictions, there is a lack of studies on if it would have been possible to predict the index price development in future waves based on previous waves´ data and models. Linear regression is used to identify the significant variables that affect the index prices and classical linear regression models are created to predict the following waves´ sector index prices.

The results indicate that some sectors, such as financial sector, did have similar performance in both countries, but the winner and loser sectors varied a lot depending on the time period. Similarly, the factors that affected the index prices varied depending on the time period and were somewhat different in both countries. CLRM models could predict index prices to some extent in the same wave, when using linear regression models and in-sample method but predicting future waves´ index prices is not possible.

TIIVISTELMÄ

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Kauppatieteet

Juuso Sandholm

Suomalaiset ja ruotsalaiset toimialat COVID-19 pandemian aikana – Arvio toimialojen suoriutumiskyvystä ja tulevien indeksihintojen mallintaminen COVID-19-tietojen perusteella

Kauppatieteiden pro gradu -tutkielma

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Tämä tutkielma perehtyy Suomen ja Ruotsin osakemarkkinoihin COVID-19 pandemian aikana maaliskuusta 2020 huhtikuuhun 2022 saakka, jonka lisäksi tarkastellaan kolmea osajaksoa. Tässä pro gradu -tutkielmassa tutkitaan, oliko suoriutuminen samoilla sektoreilla Suomessa ja Ruotsissa samankaltaista sekä pyritään antamaan vastaus, oliko toimialojen välillä voittajia tai häviäjiä. Toimiala-indeksien arvioinnissa käytetään suorituskyvyn mittaustyökaluja ja näiden tulosten luokittelussa käytetään etäisyysperusteista monikriteeristä päätöksentekomenetelmää nimeltään TOPSIS.

Aiempia tutkimuksia tärkeimmistä osakkeiden hintoihin vaikuttaneista COVID-19-muuttujista tai näiden muuttumisesta aaltojen välillä ei ole esitetty, kuten ei myöskään tulevien osakehintojen ennustamisesta edellä mainittujen tietojen valossa. Tässä tutkielmassa käytetään lineaarista regressiota indeksihintoihin vaikuttavien merkittävien muuttujien tunnistamiseen ja regressiomalleja hintaennusteiden tekemiseen.

Tulokset osoittavat, että jotkin sektorit, kuten finanssisektori, suoriutuivat molemmissa maissa samankaltaisesti, mutta voittajat ja häviäjät vaihtelivat suuresti ajanjaksosta riippuen. Samoin indeksihintoihin vaikuttaneet tekijät vaihtelivat ajanjakson mukaan ja erosivat jonkin verran molemmissa maissa. Regressiomallit kykenevät ennustamaan indeksihintoja jossain määrin saman aallon sisällä in-sample menetelmää käytettäessä, mutta tulevien aaltojen indeksihintojen ennustaminen ei ole mahdollista.

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“Started from the bottom, now we're here.” -Drake

It´s been such a long journey from the first grade until this moment. It has included many wonderful moments, but also long and hard days. Especially the last couple of years have been tough. However, the journey has come to an end and it´s time to say thanks. First, I would like to thank my mother and father that you encouraged and supported me on my first years of my journey. Second, I want to thank my friends for all the great times in high school. Finally, I would like to express my gratitude to my lovely wife, without whom this Master´s degree and thesis couldn´t be possible and to whom these last couple of years have been at least as tough.

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Juuso Sandholm

4th of March 2023, Helsinki, Finland.

SYMBOLS AND ABBREVIATIONS

Beta (β) = A measure of the volatility of an asset

CAPM = Capital Asset Pricing Model

CLRM = Classical Linear Regression Model

COVID-19 = Coronavirus Disease that broke out in 2019

GDP = Gross Domestic Product

GI =Gross Index, considering for instance dividends

MCDM = Multiple Criteria Decision-Making

NIS = Negative Ideal Solution

PIS = Positive Ideal Solution

PI = Price Index, considering only the development of the index price

TOPSIS = Technique for Order Preference by Similarity to Ideal Solution

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1. Introduction

December 31st in 2019, The World Health Organization China Country Office announced several pneumonia cases in Wuhan, Hubei Province. The cause of the cases was unknown, but there was one common factor – Huanan Seafood Wholesale Market in Wuhan. All the patients were somehow linked in the Market. January 7th in 2020, authorities in China successfully isolated and identified a novel coronavirus as a cause of those several previously unknown pneumonia case and three days later CDC (Centers of Disease Control and Prevention) published this information in their website. January 20th, CDC confirms the first COVID-19 cases in the U.S soil and January 22nd The world Health Organization confirms, that COVID-19 spreads human-to-human. February 23rd Italy became a global COVID-19 hotspot which led to lockdown. March 11th, The World Health Organization declared COVID-19 a pandemic. (Centers of Disease Control and Prevention 2022) These were the first weeks of the outbreak of the disease which became one of the deathliest pandemics in the history by causing over 6 million deaths worldwide (World Health Organization 2022) and led to strict restrictions and lockdowns all over the world (Think Global Health 2022).

The impact of COVID-19 to the global economy and stock market was huge and volatility rocketed upwards around the world in the first weeks of the pandemic, when uncertainty was at the highest. Restrictions, quarantines, social distancing, and market measures led to a crash of stock markets on every sector worldwide in February 2020. (Baker et al. 2020) However, just seven months later, nearly half of the sectors in the global portfolio of 5,000 companies had fully recovered from the crash and in February 2021 most of them were recovered with weighted average shareholder returns by industry used as a measure. (Bradly & Stumpner 2021). COVID-19 restrictions and policies varied from country to country, being strict in some countries and looser in other. Finland applied "hybrid strategy", which included quite strict nationwide and later partial lockdowns (Tiirinki et al. 2020) while Sweden imposed only a few travel and mobility restrictions (Sulyok & Walker 2021). This study aims to examine Finnish and Swedish stock market and stock returns during COVID-19 years 2020 and 2021. I will compare different sectors in Finland and Sweden to see if COVID-19 affected them differently, as Bradley and & Stumpner (2021) presented with the 5 000 world’s biggest companies and are there winners and losers among the sectors. Have the different COVID-19 strategies in Finland and Sweden led to different stock returns in these countries?

1.1. Background of the research

The COVID-19 pandemic was an unexpected event that no country or company was prepared for. To save lives, governments imposed travel restrictions and lockdowns as emergency actions. The purpose of these actions was to slow down and eliminate the spread of the virus. The downside of these actions was that they severely reduced the economic activity of societies, causing a negative shock to the stock market. (Ashraf 2020) Fiscal and monetary policies effected market reactions in European and US stocks and Heyden & Heyden (2021) identified, that country-specific measures in fiscal policy had negative effect to stock returns, while measures in monetary policy had calming effect to market. Ramelli (et al. 2020) suggested, that governments should limit the uncertainty in the market by presenting policy measures. They noted, that even if some decisions are hard to make, doing nothing or too little are neither good options. By September 1, 2020, the mortality rate and number of positive tested residents in Sweden was higher than in other Nordic countries, including Finland. The reason was that Sweden had no general lockdown, unlike in many other Nordic countries, and they generally imposed less and looser restrictions. Sweden´s strategy was to mitigate, but not isolate the virus and its spreading among the population. No enforced quarantines were exploited, facemask recommendation was used only in health care centres and physical distancing was mandatory only in restaurants and bars, and otherwise it was just recommended. (Ludvigsson 2020)

Emergency Powers Act was passed in the parliament on 17 March 2020 in Finland which hadn’t been used since the last war. The aim of the Act was to secure livelihood of the national economy and population, and it allowed government to restrict people’s everyday life and mobility and regulate labour markets. Finland used geographical restrictions and lockdowns, such as closing the Uusimaa border. Government also closed most of the public venues and banned gatherings of more than 10 people. The accommodation and restaurant sectors were most affected by the restrictions, due to the restaurants and bars being forced to close. (Moisio 2020)

COVID-19 pandemic had multiple waves, which had negative impact on stock market globally. When governments imposed hard restrictions or lockdowns, the effect to stock market was negative and on the contrary, when loosening of the lockdown restrictions was announced, the stock market reacted positively. However, market tended to overreact when new information was announced and, in some cases, reactions were contrary to what was expected. Some negative reactions were noticed on the stock market when earlier restrictions were loosened (between January – March 2020), but later reactions were positive, as expected. It was surprising, that number of COVID-19 infections worldwide or nationally didn´t significantly effect on returns of stock market. (Scherf & Rieger 2022)

It seems, that some sectors benefitted from COVID-19 more than others. Narayan (et al. 2022) studied Australian stock market returns and observed, that sectors such as consumer staples, health and information technology benefitted the most. Chaudhary & Bakhshi (2022) made similar conclusions with positive stock returns when they studied global IT sector performance during the COVID-19.

1.2. Research objectives

This research has two main focuses, to study sector index returns and performance and to study index price predictions that are based on COVID-19 data. Sector indices from Nasdaq Helsinki and Nasdaq Stockholm are used to examine how sector have developed in COVID-19 period from March 2020 to April 2022. Finland and Sweden have had different strategies on how they have imposed lockdowns and restrictions on mobility and industries. Therefore, one goal of this research is to also study, if same sectors have similar index performance in Finland and Sweden while the governments´ COVID-19 strategies have been dissimilar. The second main focus of this research is to examine COVID-19 data of Finland and Sweden and study what factors affected on sector index prices and were they the same in Finland and

Sweden. If there had been some clear relationships between COVID-19 variables and index performance, would it have been possible to predict the future index prices? If the results show that this is the case, this would open up an opportunity for investors to hedge a portfolio or short sell stocks in a particular sector in the future if a similar event occur again.

GDP, societies, sectors, and companies are quite similar in Finland and Sweden. When COVID-19 started, both countries chose different strategies on how to solve the problem of rapidly increasing number of infections which could possibly lead to death. This caused a great amount of discussion in both countries on which strategy is correct and what are the effects to the economy, infections and mortality rates. At that time, there were no real-world data available. Forecasts and simulations were made based on previous pandemics years ago, predictions and any other data or economic theories that were available. This and massive uncertainty of this new disease caused wild theories, accusations, and discussion not only among the people, but also among the scientists and politics. Now, almost three years after the COVID-19 started, there is real data available. It´s important to utilize this data and study this exceptional period of our history. The debate and discussion, whether the choices made were right or wrong will certainly take place on several occasions in the future and it should be based on real data and studies. Therefore, this study tries to provide new information on how pandemic and different COVID-19 strategies effected different sectors in Finland and Sweden and could this information be used to predict the sector index prices.

Research questions:

Question 1: “Is the performance similar in same sectors in Finland and Sweden?”

Question 2: “Are there any winners or losers among the sectors?”

Question 3: “What are the main COVID-19 factors that affected on the index prices?”

Question 4: "Can index prices be predicted based on COVID-19 data?"

1.3. Previous studies

Previous studies regarding stock returns during COVID-19 period are mostly geographically focused on US and Asia. Some comparisons of stock returns of different stock exchanges or countries have been made as well as sector comparison and if there are winners or losers among the sectors. Andersen (et al. 2022) recently published a study, in which they compared Nordic countries (Denmark, Finland, Norway and Sweden) strategies to mitigate the economic consequences of COVID-19. All four countries pointed significant economic support to firms, households, and labour markets. The packages were quite similar to each other and there were only some differences in details. There were significant differences on how COVID-19 impacted sectors and what was their capability to recover from it. The conclusion of the study was that Denmark, Finland and Norway managed to mitigate economic consequences better than most of the countries. Sweden´s COVID-19 strategy was not that successful and led to greater number of infections and deaths. Regardless, Sweden´s economic consequences were on the same level with other Nordic countries, thus it can be concluded, that looser restrictions didn´t have any positive effect to economy, as well as the high number of infections and deaths didn´t have negative impact to economy. This study will combine features of previous studies and focus only on index returns of Helsinki and Stockholm sector indices. One goal of this research is to study if there are winners or losers also in Finland and Sweden sectors. The research tries to provide an answer to if the chosen COVID-19 strategy led to better stock returns than another.

There are some previous studies regarding of stock and/or index price predictions during COVID-19. Razali & Nur-Firyal (2021) studied whether COVID-19 cases and deaths could explain and predict S&P 500, FTSE, Nikkei 225 and KLCI indices. They collected daily closing prices of these indices from the first 11 months of 2020. The data from January to October was used as an in-sample data to create a ARIMA and Linear Regression models and data from October as out-sample data. They found that COVID-19 deaths and cases had equivalent relationships and predictive abilities on the abnormal index prices. They concluded that Linear Regression model was able to predict index prices better than ARIMA. For further research, they recommended to include other COVID-19 variables, than new cases and deaths, and also some economic variables, such as economic growth, interest rate and inflation rate. Tuna (2021) studied, if COVID-19 deaths, COVID-19 case numbers and health news were good predictors for index prices. She approached the topic from another perspective and used Google Trend to obtain a search volume of these variables and regression analysis as a method. The results indicated that those variables had higher performance as predictors than historical return values in all sectors of both Islamic and conventional financial markets. For further studies, Tuna suggested to include more variables in the regression analysis, such as the number of intubated patients, the infection rate and intensive care unit patients. Also, Afees (et al. 2020) used Google searches and health news about COVID-19 cases and deaths to predict stock returns. They used panel data forecasting method and found, that health news had a negative and statistically significant effect on stock returns and that single predictor model outperformed the historical average model both for in-sample and out-sample. Even if there are studies about forecasting stock or index prices based on COVID-19 related data, the author of this thesis didn´t find any studies about stock or index price predictions based on models that are created from previous waves COVID-19 data and that time stock or index price development. The lack of these studies is a motivator for this research to study if it could be possible.

1.4. Structure of the study

This thesis follows a standard structure of the study and is divided into five sections. In the first section, there is an introductory of the topic and the study. This section introduces background and the motivation of this research, as well as research questions. It also provides a short description of beginning of the COVID-19 and how it has affected worldwide and what strategies governments have applied. The second section includes literature review, and some previous studies are presented. The third section introduces some theories and concepts that are used in this study. It includes introduction about the data and methodology and descriptive statistics is presented. The fourth section includes the results of this study. Empirical results of analysis are presented. The last section presents conclusions. It provides summary of the study, its results and answers the research questions. There is also discussion of reliability and limitations of this study and proposal for further research.

1.5. Limitations of the study

There are few limitations to this study. There was no data available of Helsinki (HX60PI) and Stockholm (SX60PI) Oil, Gas & Coal indices during the period between 13 July 2020 and 14 August 2020 and the missing data has been replaced with previous five days average prices of these indices. The selected COVID-19 days included this study and the chosen splitting points for the sub-periods can affect the results, especially to the performance measurements. Also, using Profitability Indices and not Gross Indices lead to different results, because there is no dividends included, especially when studying and assessing the index returns.

Only COVID-19 variables are included, when the relationships of the dependent and independent variables are studied, and index price predictions are done. Including, for instance, some economic variables in the model could have changed the results. Also, only one method, classical linear regression model, is used to predict next wave´s index prices. Using multiple methods would have increased the reliability. Using some other method than 7-day period smoothing may have led to another results.

2. Literature review

COVID-19 has been a shock to economies and societies all over the world. The COVID-19 pandemic era is not comparative with any other previous pandemics, since the world is more developed, connected and globalized than ever before. Previous experiences with financial crises could not be used as such and governments needed to apply different economic theories based on governments political trends and expert and public opinions.

This section of the study concentrates on previous studies and their findings on this topic. It mainly focuses on how COVID-19 has impacted stock markets and stock returns all over the world. Has the pandemic created winners or losers in some sectors and are there differences among the countries? Researchers published studies on the topic once there was data available and these studies have been published while the pandemic has developed. COVID-19 is not over yet, but now there is data from two full years and studies can assess impacts of the different phases and waves of the pandemic.

2.1. Impacts of COVID-19 to different sectors

Impacts of COVID-19 have been heterogeneous in different sectors - some companies have benefited from social distancing and travel restrictions, such as companies in technology sector, and some companies suffered, such as companies in travel and tourism and restaurant sectors. Early data from 65 countries in December 2019 to May 2020 indicated that travel and leisure industry is one of the sectors that were hit the hardest. The study provided results that COVID-19 deaths and confirmed infected cases had a remarkable negative effect on the sector´s stock returns. (Lee & Chen 2022) On the other hand, in USA, technology companies, such as Apple, Google and Microsoft outperformed the market by yielding market-adjusted returns of 19 %, 33 % and 12 % only in the first quarter of the 2020. On the contrary, travel and tourism companies, such as Marriot, Royal Caribbean and United Airlines underperformed with market-adjusted returns of -38 %, -66 % and -53 % at the same period. After the first shock, the market added a disaster premium to companies, that are so called pandemic-resilient when pricing their stocks and thus they expected lower excess returns in the future (Pagano et al. 2021). Carter (et al. 2022) noticed similar negative stock price reaction in airline, hotel, and tourism industry in the U.S.

Szczygielski (et al. 2022) had a different perspective and approach to the topic compared to previous studies. They used Google Trends search data and a sample of 68 industries to study uncertainty, returns and volatility during COVID-19 period. The results supported previous studies by indicating that the impact of COVID-19 varied on different sectors and industries. Impacts were smallest in such a sector that provided products or services that were necessity or hard to substitute, such as household products, food and staples retailing and telecommunications. On the contrary, airline, consumer finance and energy sectors were the most impacted. Szczygielski (et al. 2022) provide a hypothesis, that these sectors were significantly impacted by restrictions and global economic growth.

Stock market reacted differently on different phases of COVID-19 pandemic. Wielechowski & Czech´s (2021) study proved that the MSCI ACWI index (= global equity index, that includes stocks from 23 developed and 24 emerging markets in 11 different sectors (MSCI 2022)) lost approximately 30 % of its value between 20 February and 23 March 2020. Volatility was extremely high the whole year, and index recovered fully by the end of the third quartile. Volatility in 2021 was more stable and index increased 10 % by 30 September. 11 out of 12 main sectors (based on top five companies of each sector), including alternative energy sector, had yield a positive average weekly return in the period of January 2020–September 2021. Energy and financial sectors performed worst and alternative energy sector best in above mentioned period. Information technology and communication service sectors outperformed, as was pointed also in previous study. However, interesting was, that energy and financial sectors performed poorly in the first months of the pandemic but yielded the highest returns during the period of January–September 2021. On the contrary, alternative energy sector underperformed significantly in the same period.

Gradual loosening of COVID-19 restrictions had positive impact on stock markets. Qatar, as one of the richest countries in Arab world also had this experience. The effect of these measures was however different among sectors. Banking sector benefitted the most from gradual lifting of the restrictions, but it also had positive effect on real estate, telecoms, and transportation sectors. However, the effect was negative in insurance, consumer goods and services sectors. Tourism, restaurant or energy sectors were not observed in the research. (Elshqirat 2022)

2.2. Impacts of COVID-19 policies and restrictions to stock market

The new and confirmed daily COVID-19 cases and deaths had considerable effect on market returns in Ullah´s (2022) study with 30 emerging and developed countries during 2020. This implies that governments should act proactively with restrictions and aim to deceleration of the spread of the virus. By adapting these methods, governments could increase investors' confidence and thus increase market returns. Khilar (et al. 2022) obtained similar, but on the other hand, different results. They studied 34 emerging and developed countries from the first nine months of 2020 and founded the same negative connection with daily confirmed COVID-19 cases and lockdowns with stock market reactions. Unlike in Ullah´s (2022) study, stock market reacted positively with deaths in emerging countries, while the reaction was opposite in developed countries, as was in Ullah´s (2022) study.

Saito and Sakamoto (2021) examined lockdown policies and their impacts on asset prices in 22 developed countries, including Finland and Sweden, in the first months of the pandemic. Study showed that stock returns and increase in restrictions had negative correlation, meaning that imposing strict restrictions or lockdowns led to negative stock returns. Interesting is, that even if countries provided economic support, such as direct cash out, the negative impacts of strict restrictions and lockdowns exceeded the positive effects of economic support. Number of new COVID-19 infections had positive correlation with asset prices and Saito and Sakamoto (2021) provided theory that high number of new infections predicts future lockdowns, which decrease labour income. Thus, preparing for the future by increasing savings increases asset accumulation and asset prices. As a conclusion, they presented theory that rapid stock market recover would be achieved, if lockdown policies are not too strict and gives room for new infections.

COVID-19 didn´t only crash stock market, but economic activity also collapsed shortly after in 32 of 35 countries in Davis´ (et al. 2021) study. Their study showed, that not only global, but also national development of stock prices predicted the nation-wide collapse in economic activity and coming restrictions. Quick prevention of the spread of virus has led to better stock returns and economic performance in short term, than if the measures had been delayed. However, study shows, that strict lockdowns didn´t bring additional benefit, but the main factor was time. (Gnahe et al. 2022) studied COVID-19 pandemic effects on emerging economies´ stock markets and resulted that governments should mitigate deceleration of COVID-19 infections, due it has positive effect on stock market returns. Some countries were spared the worst loss of life, but still their stock market was impacted as harsh. This was the case in Rahman & Al Mamun research (2021) from Asia Pacific area. As previously proved, the first information about the new global health concern had negative impact, but the information about pandemic level disease led to tremendous negative shock in stock markets all over the world. In Japan and China, only later objective and well targeted measures were able to calm markets.

Multiple countries worldwide supported their economies with various instruments of monetary and financial policies. One of the most popular actions was stimulus packages. Shafiullah (et al. 2022) observed that the greater the fall in stock market was the larger the announced stimulus package was. Their study included emerging and developed countries, and this connection held only if country´s income level exceeded mean and/or median per capita GDP. Results also indicated that monetary policy had greater impact on stock markets than fiscal policy.

3. Data and Methodology

First positive COVID-19 case was confirmed in Finland in end of January 2020 with Chinese tourist who came from Wuhan, China. (Yle 2020) Positive cases started to increase more rapidly in March 2020 when the disease started to spread and new chain of infections was recognized. The first COVID-19 based death was on 20 March 2022. (Finnish Institute For Health And Welfare 2022) Similarly the first positive case in Sweden was confirmed with Chinese tourist in end of January 2020. (Krisinformation.se - Emergency information from Swedish authorities 2020) Also in Sweden the spreading of the disease started in March 2020 when tested and confirmed positive cases started to increase. The first COVID-19 based death in Sweden was on 11 March 2020. (The Public Health Agency of Sweden 2020) Government in Finland reacted quickly to the situation, and so-called Emergency Powers Act passed in the parliament on 17 March 2020. The act allowed the government to impose restrictions that limited and regulated everyday life and movement. At this time, first lockdowns were announced in Finland. (Moisio 2020) Sweden had different COVID-19 strategy. There were no strict restrictions or lockdowns, but Government did recommend social distancing and good hand hygiene. The Swedish Government did change the strategy during the second and the third wave. New measures included some restrictions in commercial areas and restaurants, using facemasks on public transport (only in rush hours) and household quarantine in case if a family member had COVID-19. (Ludvigson 2022)

3.1. Data

In this study, Excel and MATLAB are used to pre-process the data and creating the models and the graphs. The data used in this study is formed from two separate datasets – COVID-19 data and sector index data. The COVID-19 data is from Our World in Data (2022) and it includes daily data of Finnish and Swedish COVID-19 cases, deaths and other COVID-19 related information, that has been documented and reported during COVID-19 pandemic. Sector index data includes daily closing prices of eight different sectors from Finland and Sweden. The data is downloaded from Nasdaq Nordic (2022). Time period is from 18 March

2020 to 6 April 2022, when Multiple COVID-19 related variables had no information before 18 March 2020, thus no data from previous dates was selected to this study, even if positive cases and deaths occurred before that date. The explanation for why the latest data used in this study is from April 2022 is that this study was started in the same month. One goal of this paper was to study and model relationships between COVID-19 variables and index prices, I´ve selected data only from those dates when there were closing prices available from both countries. The entire data set included data from 518 days (=rows) and 31 variables, which are explained in more detail in the next chapter, and thus the total amount of observations was 16 058.

McConnell (2020) argues that COVID-19 analysis should be based on smoothed data due the raw data is noisy. Thus, observing trends without using the smoothed data is difficult. In most cases, Governments don´t report new cases and deaths every day, due to weekends, holidays, and corrections. Smoothing reduces the individual spikes, but still includes the information in the trend. McConnel (2020) recommends using a 7-day period to smooth, in which case it takes account above mentioned weekends, holidays and corrections. The COVID-19 data used in this study is smoothed to a 7-day period by using a rolling (moving) average by summing the observations for the previous seven days and dividing this by seven.

The data is also divided in three subperiods. The division is based on visual observations of three different COVID-19 variables that includes information of daily new deaths, hospital patients and number of patients in intensive care units. These three graphs (Figures 2, 5 & 6) present three clear waves in Sweden and two in Finland. The division is done based on waves of Sweden, because Finland didn´t have similar third wave as in Sweden. Time periods were chosen to include the entire wave and it has ´cooled down´ a bit, meaning that I´ve included some observations after the wave has ended. The subperiods are 1) from 18 March 2020 to 30 September 2020, 2) from 1 October 2020 to 30 July 2021 and 3) from 2 August 2021 to 7 April 2022.

3.2. Variables

In this section, the variables are presented from the entire data, not by subperiods. COVID-19 related variables will be presented first and then variables related to sector indices. Variable Date is simply used dates from 18 March 2020 to 6 April 2022. Variables FIN_new_cases and SWE_new_cases represent new daily confirmed cases of COVID-19 in Finland and Sweden. Counts can include probable cases, where reported. As previously mentioned, the COVID-19 related variables are smoothed to 7-day periods. From Figure 1 you can see the difference of the magnitude of new COVID-19 cases in Finland and Sweden. During the first wave, in spring 2020, the number of cases were quite similar in both countries. In later waves the difference was significant and in spring 2022 highest number of new daily cases in Finland was between 11 000 and 15 000 while in the same period in Sweden the number reached over 60 000.

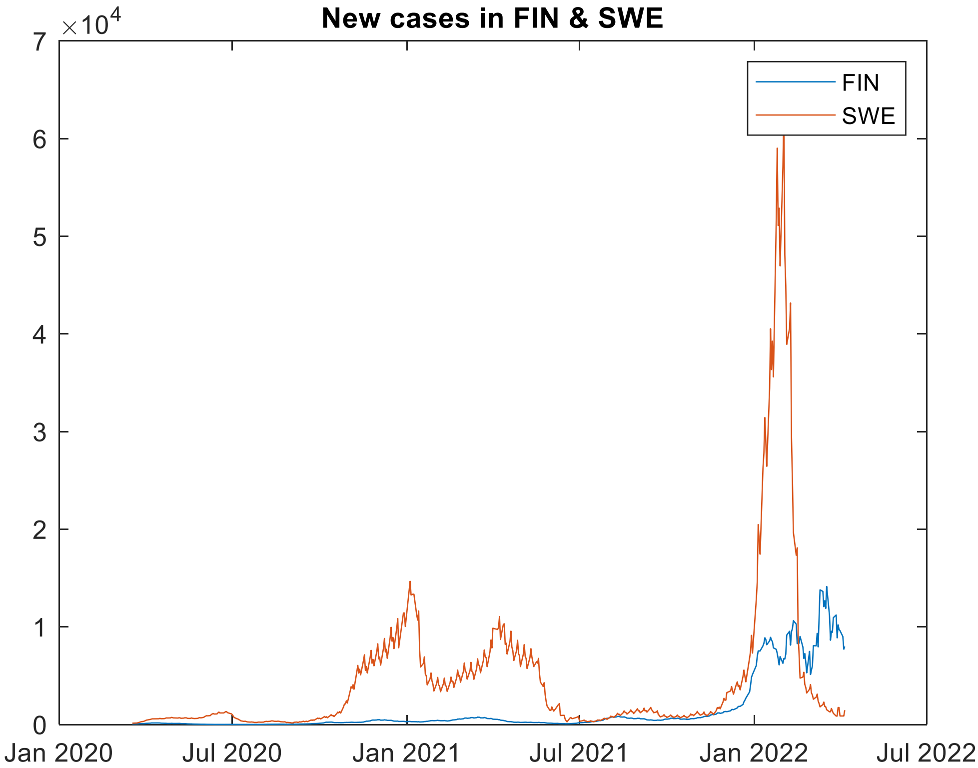


Figure 1. New daily COVID-19 cases in Finland & Sweden.

FIN_new_deaths and SWE_new_deaths represent new daily deaths of COVID-19 in Finland and Sweden. Counts can include probable cases, where reported. In addition to new cases, the difference in the number of new deaths was also significant in Finland and Sweden as can be seen from Figure 2. At worst, there were over 210 deaths in a day in January 2021 in Sweden, while at the same time there were only four deaths in Finland. This means that there were 52,5 times more deaths in Sweden, even if the population is only 1,84 times greater in Sweden (10,25 million) than in Finland (5,56 million). (Worldometer 2022) Maximum deaths in Finland were reported in during the first wave.

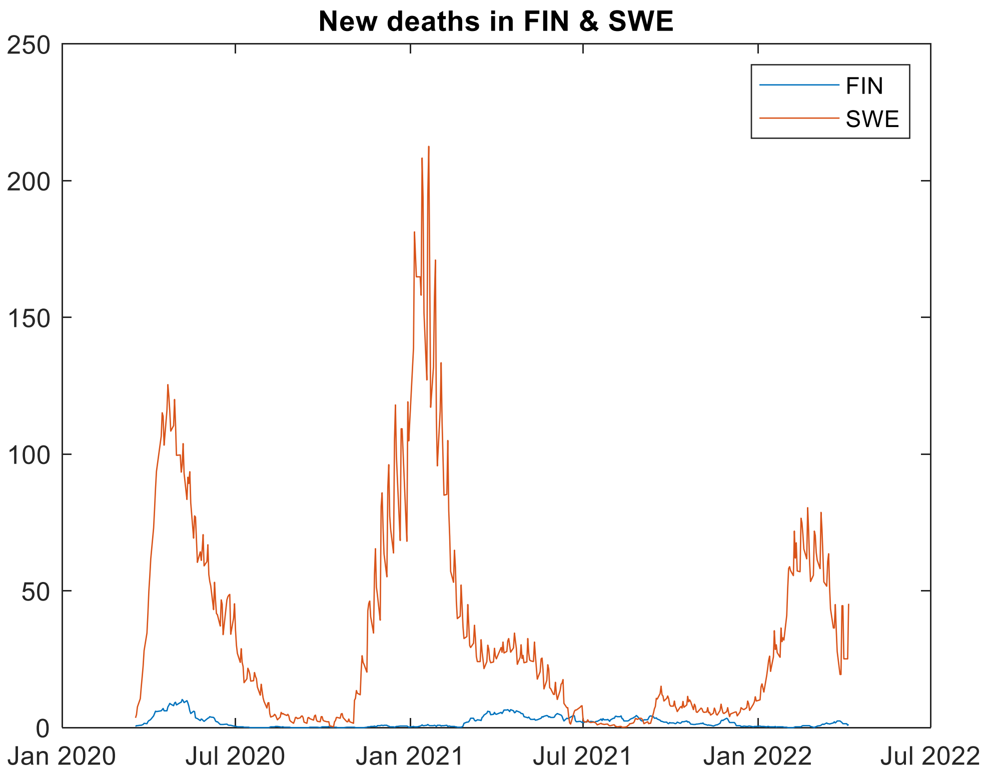


Figure 2. New daily COVID-19 deaths in Finland & Sweden.

Variables FIN_positive_rate and SWE_positive_rate represent the share of COVID-19 tests that are positive, given as a rolling 7-day average (Figure 3). The positive rate is dependent on how many tests were performed. If only few tests were performed in hospitals with patients that had COVID-19 symptoms, also the positive rate was high. High positive rate did not only indicate that COVID-19 infection rates were high, but Governments should've performed more testing and add restrictions to slow the spread of COVID-19. WHO recommended, that loosening restrictions could be considered, if for at least two weeks, the positive rate had been less than 5 %. (Dowdy & D'Souza 2020) Positive rate remained under 10 % in Finland until the last wave in spring 2022, when it rapidly increased approximately to 50 %. In Sweden, the volatility has been greater, but the highest percent (almost 80 %) was reported also during the last wave.

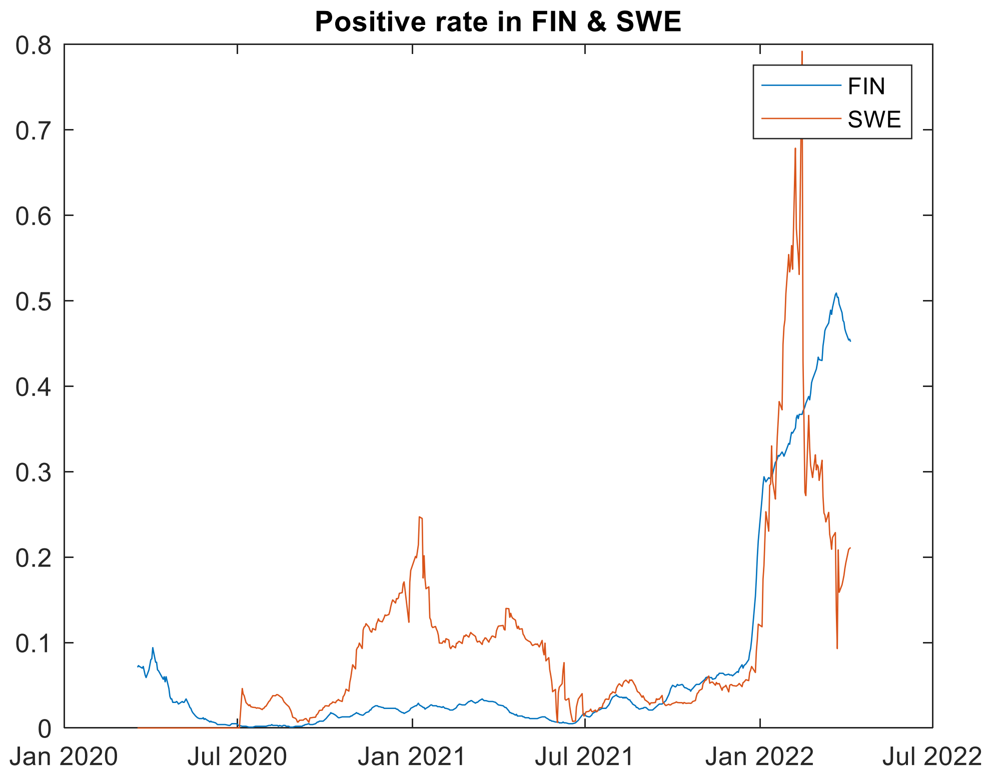


Figure 3. Positive rate of COVID-19 in Finland & Sweden.

Variables FIN_reproduction_rate and SWE_reproduction_rate represent real-time estimate of the effective reproduction rate (R) of COVID-19. Reproduction rate (R) tells how many, on average, one infected person infects in the population. The reproduction rate is based on mathematical models and illustrates the spread rate of the COVID-19. If the R <1, the diseases fades and if R >1 the diseases spreads. For instance, in Finland this was one of the key measures that were used, when the Government decided to add or lift the restrictions. (Auranen & Leino 2020) It´s interesting, that number of new cases and deaths were significantly higher in Sweden than in Finland, but trend and magnitude of the reproduction rate was quite similar in both countries (Figure 4). Mean in Finland from the entire period was 1,07 and from Sweden 1,15.

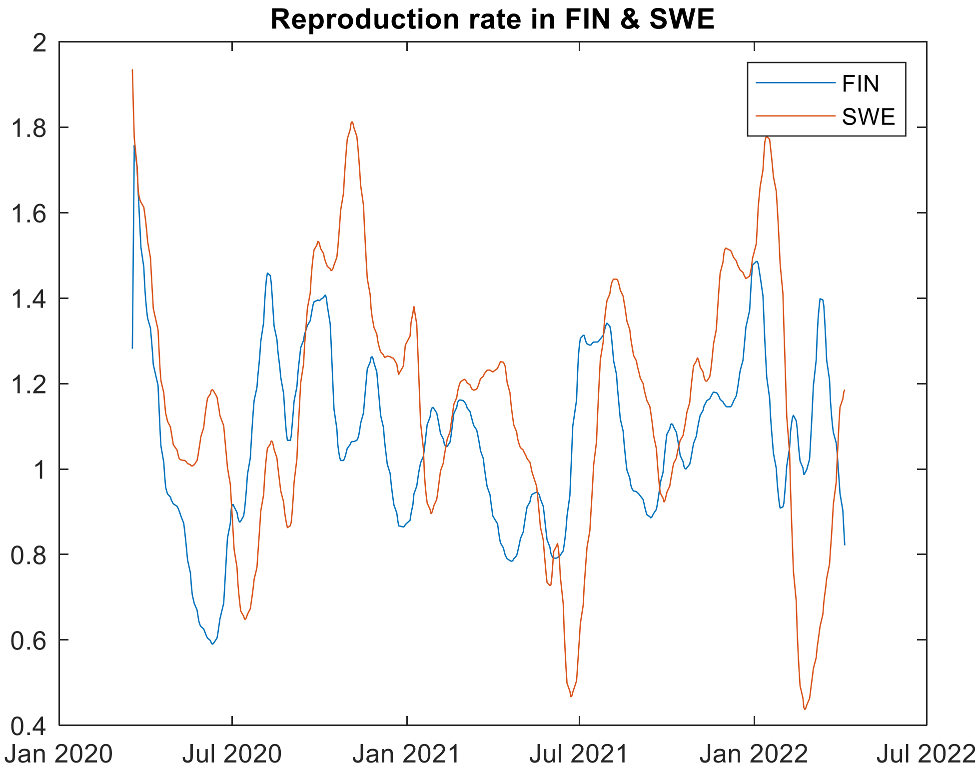


Figure 4. Reproduction rate (R) of COVID-19 in Finland & Sweden.

Variables FIN_hosp_patients and SWE_hosp_patients represent number of COVID-19 patients in hospital on a given day. The trend of the number of the hospital patients were similar during waves one and two, but during the last wave there were no reported hospital patients in Finland (Figure 5). Despite the similar trend during waves one and two, the magnitude was very different. In wave one there were maximum under 230 hospital patients in Finland while in Sweden there were almost 2.270. During December 2020 to April 2021, the hospital patients in Finland remained under 300 while in Sweden they were nearly 2.900. It is noteworthy, that these numbers are the peaks of the waves, and the actual trend value is much lower. During the last wave the peak reached over 2.100 hospital patients in Sweden, while there were no reported COVID-19 patients in Finland. Similarly, variables FIN_icu_patients and FIN_icu_patients represent number of COVID-19 patients in intensive care units (ICUs) on a given day (Figure 6). Trends of hospital patients and ICU patients were quite similar (Figures 5 and 6), only the number of ICU patients is much lower.

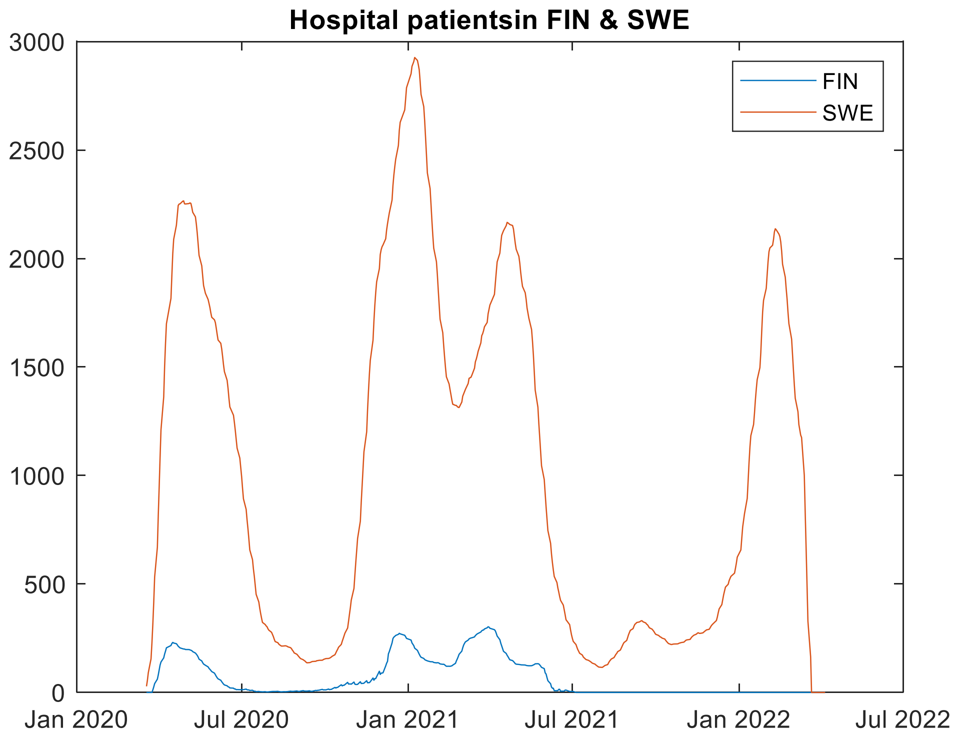


Figure 5. Number of COVID-19 patients in hospital in Finland & Sweden.

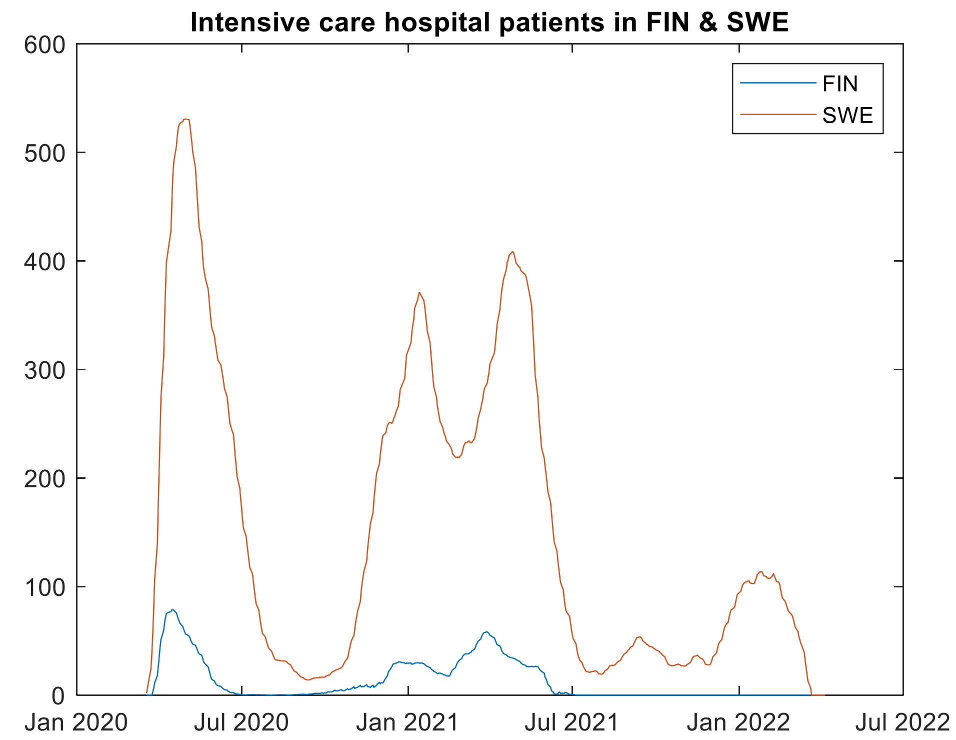


Figure 6. Number of COVID-19 patients in intensive care units Finland & Sweden.

Variables FIN_stringency_index and SWE_stringency_index represent Government Response Stringency Index composite measure, which is based on nine response indicators. Those indicators are school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls. For each indicators, a value is created on a scale of 0-100, which considers, for example, whether the restrictions are applied locally or generally. The stringency index value is formed by calculating additive score of nine indicators measured on an ordinal scale and then rescaled to vary from 0 to 100, in which 100 is the strictest response (Figure 7). (Mathieu et al. 2020) Even if the stringency index was on quite the same level in Finland and in Sweden during the first wave, the social distancing measures were less strict in Sweden, but they banned the gatherings of more than 500 people and didn´t closed air boarders but advised to avoid unnecessary travel. Especially, imposing effective air border closures could have reduced new cases and deaths. Due to the high level of new cases during wave two, Sweden imposed more stringent social distancing measures than Finland. (Gordon et al. 2021)

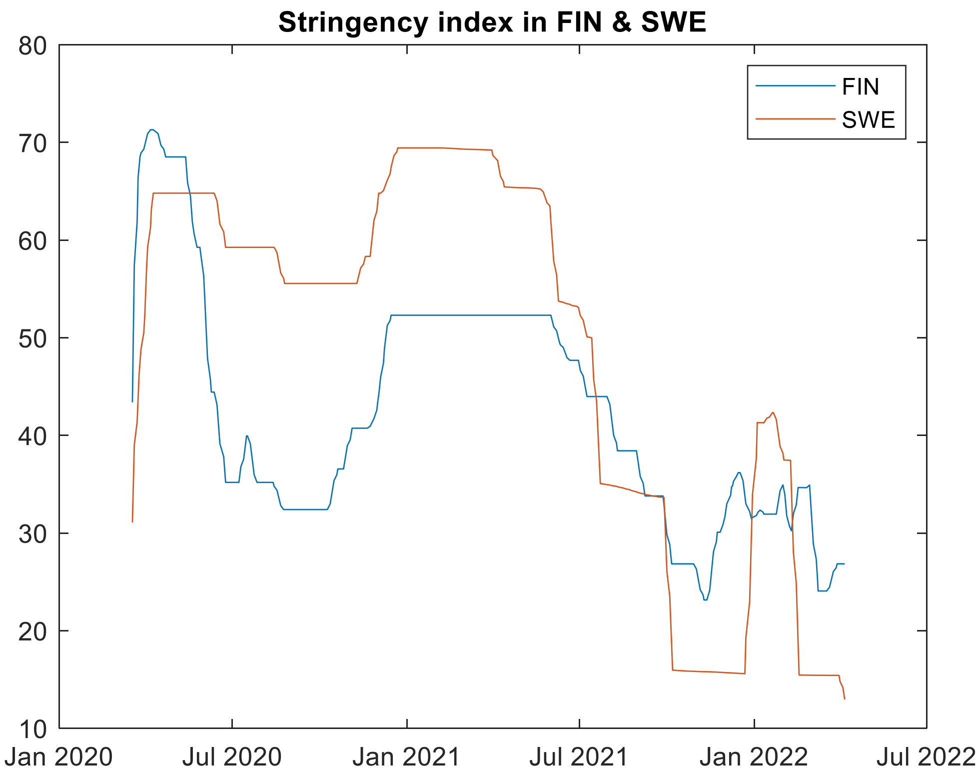


Figure 7. Government Response Stringency Index in Finland & Sweden.

Below, in the Table 1 are listed eight sector indices from both countries. Indices are Profitability Indices (PI), therefore they reflect only changes of stock prices, that are included in the index and ignore possible dividends (=Gross Index / GI). (Nasdaq 2022) The reason to use PI and not GI is, that dividends would bias the models and price development predictions. For instance, European Central Bank recommended banks in 2020 to refrain from or limit dividends until September 2021. (ECB 2020) As a result, creating a model based on 2020 data could not predict, even in theory, correct price development in financial sector in 2022.

Table 1. Sector Indices.

Variable	Sector Index	Figure
HX55PI	Helsinki Basic Materials	Figure 8.
HX30PI	Helsinki Financials	Figure 9.
HX50PI	Helsinki Industrials	Figure 10.
HX60PI	Helsinki Oil & Gas	Figure 11.
HX10PI	Helsinki Technology	Figure 12.
HX15PI	Helsinki Telecommunications	Figure 13.
HX65PI	Helsinki Utilities	Figure 14.
HX20PI	Helsinki Health Care	Figure 15.
SX55PI	Stockholm Basic Materials	Figure 8.
SX30PI	Stockholm Financials	Figure 9.
SX50PI	Stockholm Industrials	Figure 10.
SX60PI	Stockholm Oil & Gas	Figure 11.
SX10PI	Stockholm Technology	Figure 12.
SX15PI	Stockholm Telecommunication	Figure 13.
SX65PI	Stockholm Utilities	Figure 14.
SX20PI	Stockholm Health Care	Figure 15.

Trends of price development of Helsinki (HX55PI) and Stockholm (SX55PI) Basic Material indices are very similar, even if the starting price of HX55PI is higher than SX55PI (Figure 8). The rises and falls of indices occur at the same time. Based on visual observation, the HX55PI has developed better than SX55PI (Figure 9). Similarly trends of price development of Helsinki (HX30PI) and Stockholm (SX30PI) Financial indices look quite same, of course prices are different.

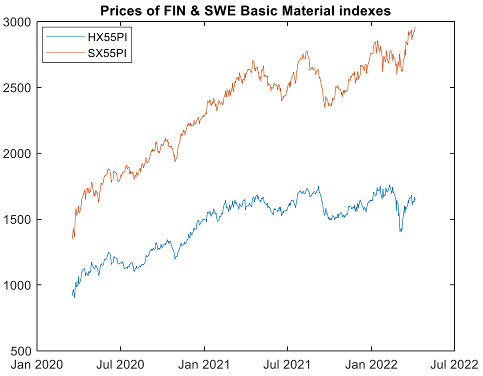


Figure 8. Index prices of Basic Material indices in Finland & Sweden.

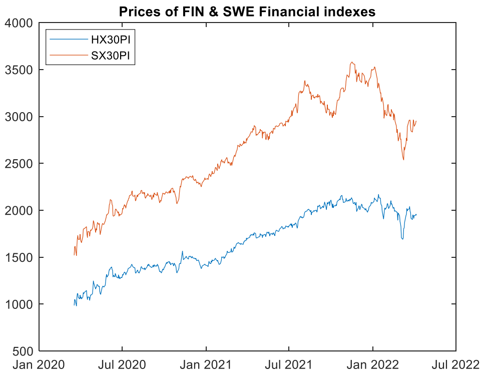


Figure 9. Index prices of Financials indices in Finland & Sweden.

Even if the starting prices of Helsinki (HX50PI) and Stockholm (SX50PI) Industrial indices were close to each other's, the spread has increased during COVID-19 years and SX50PI ended up being much higher than HX50PI (Figure 10). Unlike with previous indices, the starting prices of Helsinki (HX60PI) and Stockholm (SX60PI) Oil, Gas & Coal were far away from each other's (Figure 11), HX60PI being much higher. Volatility of HX60PI has been high whereas SX60PI has remained quite stable. There was no data available on time period 13 July 2020 – 14 August 2020 and the missing data has been replaced by previous five days average price.

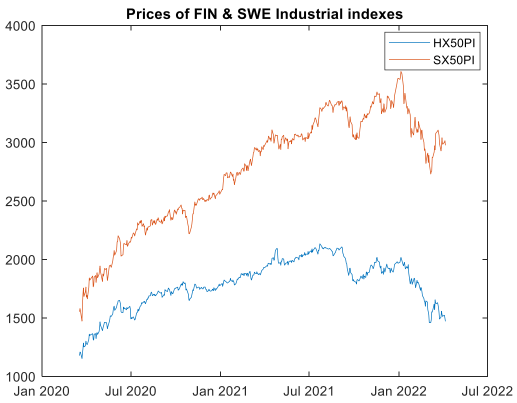


Figure 10. Index prices of Industrial indices Finland & Sweden.

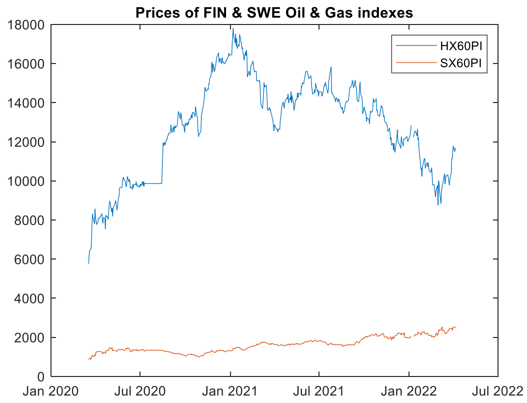


Figure 11. Index prices of Oil, Gas & Coal indices in Finland & Sweden.

Helsinki (HX10PI) and Stockholm (SX10PI) Technology indices have developed quite similarly, yet the difference of the prices has grown in SX10PI´s favour over time (Figure 12). Helsinki (HX15PI) and Stockholm (SX15PI) Telecommunication indices don´t have similar trend (Figure 13). Volatility of HX15PI has been higher than SX15PI and in the end of the period the price is much higher than in the beginning of the period. Whereas SX15PI trend is flat, and volatility is low.

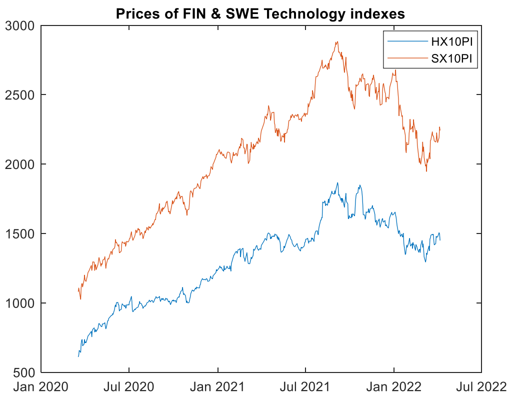


Figure 12. Index prices of Technology indices in Finland & Sweden.

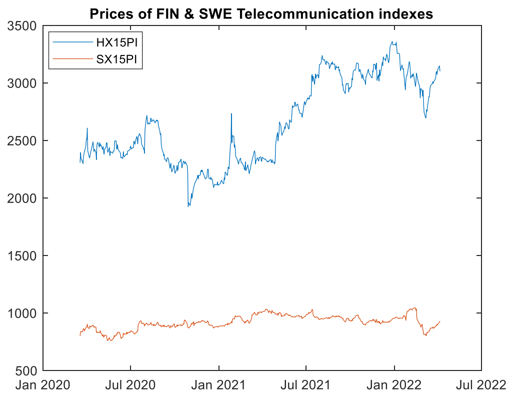


Figure 13. Index prices of Telecommunication indices in Finland & Sweden.

Trends of Helsinki (HX65PI) and Stockholm (SX65PI) Utilities indices are interesting (Figure 14). They don´t resemble any previous indices, but neither do they resemble each other. The trend of SX65PI was upward until summer 2021 it collapses close to starting price. Similarly, HX65PI has over doubled its value until spring 2022 it collapses to a little over its starting price. Helsinki (HX20PI) and Stockholm (SX20PI) Health Care indices´ prices has developed at the same trend in spring 2020, but after that HX20PI´s trend is somewhat flat and there is no significant price development (Figure 15).

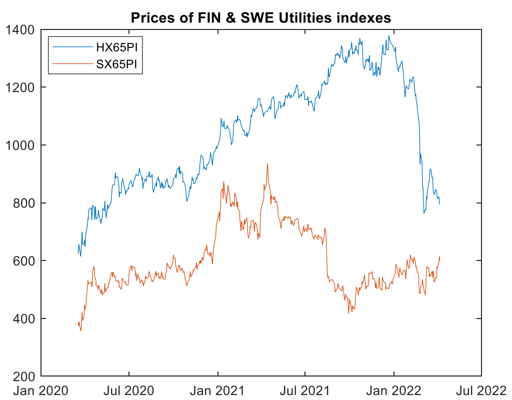


Figure 14. Index prices of Utilities indices Finland & Sweden Care.

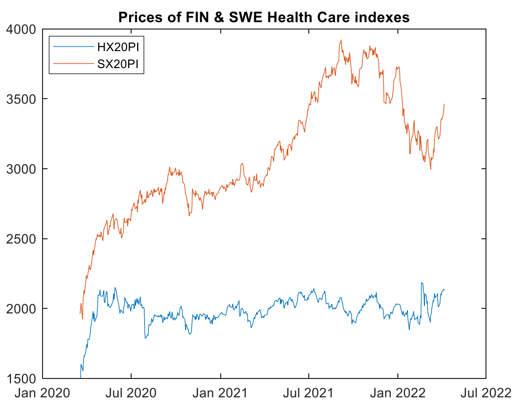


Figure 15. Index prices of Health indices in Finland & Sweden.

3.3. Descriptive statistics

In previous chapter, the variables were reviewed, and they were also visually presented. This chapter presents the variables in more detail using descriptive statistics. Time period was from 18 March 2020 to 6 April 2022 and only dates when Helsinki and Stockholm stock exchanges were available included in the data. Thus, 518 days were included, which is also the number of observations for each variable. Since the variables are smoothed, there are rarely integers, and most numbers are decimals. Due to the reason, the number of new cases or deaths can also be a decimal number, even if it is not possible in reality. Table 2 presents summary of descriptive statistics of COVID-19 variables of Finland. The first positive COVID-19 infections had already been confirmed in February 2020, before the first observation date and new cases were confirmed since then and thus minimum number of new cases in Finland was 5,71. The number of new deaths was small in relation to the number of new cases, due to the mean of new deaths was 4,71 while the mean of new cases was 1 457,00, meaning that on average, the death rate was 0,32 % on those who were infected. Maximum number of new deaths was only 44 while the new cases was 14 130,57. The number of hospital patients was greater than intensive care unit hospital patients (ICU) during the entire period (Figures 5 & 6). Similarly, maximum numbers and means were higher. The minimum number is zero for both variables, due there were no reported hospital or ICU patients after summer of 2021. On average, death rate of hospital patients was 7,45 % and ICU patients 38,23 %.

As described previously, the reproduction rate was an important measurement Finland, when the Government decided to add or lift the restrictions. Mean and median of the reproduction rate was 1,07 and kurtosis and skewness were close to zero. At worst, reproduction rate rose to 1,76. Positive rate was quite low, the maximum number was only 51 and mean was 0,07. During the time period, the stringency index was on average 42,20 and at the most stringent it was 71,30.

Table 2. Descriptive analysis of COVID-19 variables of Finland.

Finland	New cases	New deaths	Reproduc tion rate	ICU patients	Hospital patients	Positive rate	Stringency index
Minimum	5,71	0,00	0,59	0,00	0,00	0,00	23,15
Maximum	14 130,57	44,00	1,76	79,14	302,86	0,51	71,30
25th %tile	109,82	0,57	0,93	0,00	0,00	0,01	32,41
75th %tile	686,75	5,43	1,21	23,29	127,00	0,05	52,31
Mean	1 457,01	4,71	1,07	12,32	63,25	0,07	42,20
Median	345,71	2,29	1,07	0,86	8,50	0,02	39,05
Std. Dev.	2 890,02	7,21	0,20	18,49	86,81	0,13	11,92
Kurtosis	4,69	9,62	-0,04	1,76	0,07	3,67	-0,37
Skewness	2,42	2,98	0,07	1,58	1,18	2,26	0,59
Count	518,00	518,00	518,00	518,00	518,00	518,00	518,00

Table 3 presents summary of descriptive statistics of COVID-19 variables of Sweden. Maximum number of new cases was much higher in Sweden than in Finland, being 62 730. Noteworthy is, that even the minimum number was high 134,86. Mean was 4 762,43, being 2,27 times higher than in Finland. Mean number of new deaths in Sweden was 34,26 which was 6,28 times higher than in Finland and maximum number was 212,57. On average, the death rate of those who were infected in Sweden was 0,72 %, over double compared to Finland. Similarly in Sweden the number of hospital patients was higher than ICU patients. Maximum number of hospital patients was 2926,57 and ICU patients 530,71. Mean values were quite high, 1 002,17 on hospital and 151,13 on ICU patients. On average, death rate of hospital patients was 3,42 % and ICU patients 22,67 %, which were much lower than in Finland.

Reproduction rate in Sweden was 1,15 on average, and on highest it was 1,94. These numbers are slightly greater than in Finland. Maximum positive rate value was 0,79, meaning that almost eight of ten people had confirmed positive test result, which was very high. However, the mean value was 0,09, which was only a bit higher than in Finland. On the most stringent, the stringency index was 0,79 and on the least stringent it was 12,96. On average, during the time period from 18 March 2020 to 6 April 2022 the stringency index was mildly higher in Sweden (48,62) than in Finland (42,20).

Table 3. Descriptive analysis of COVID-19 variables of Sweden.

Sweden	New cases	New deaths	Reproduction rate	ICU patients	Hospital patients	Positive rate	Stringency index
Minimum	134,86	0,14	0,44	0,00	0,00	0,00	12,96
Maximum	62 730,00	212,57	1,94	530,71	2 926,57	0,79	69,44
25th %tile	671,50	5,29	0,96	31,82	240,25	0,02	34,30
75th %tile	5 460,82	51,75	1,36	251,36	1 733,07	0,12	64,81
Mean	4 762,43	34,26	1,15	151,13	1 002,17	0,09	48,62
Median	1 323,14	20,71	1,17	92,36	710,36	0,05	55,56
Std. Dev.	8 944,56	39,44	0,31	142,18	822,23	0,11	19,04
Kurtosis	16,84	3,22	-0,28	-0,30	-1,16	8,12	-0,99
Skewness	3,91	1,75	-0,08	0,91	0,48	2,57	-0,68
Count	518,00	518,00	518,00	518,00	518,00	518,00	518,00

Table 4 presents summary of descriptive statistics of Finnish sector index variables. All other variables than Helsinki Health Care index (HX20PI / kurtosis 5,37), had negative kurtosis, meaning that more observations were located near the mean. Similarly, all the variables, but Helsinki Telecommunications index (HX15PI) had negative skewness, meaning that on those variables, the curve is skewed on right, leaving the tail on its left. Standard deviation was high on Helsinki Oil, Gas & Coal index (HX60PI), being 2 462,65, but also the mean was high 12 728,07. The mean value of other indices was between 1 300 and 2 700. Helsinki Oil, Gas & Coal index (HX60PI) and Helsinki Technology index (HX10PI) had the greatest difference between the minimum and maximum value (HX60PI / 209,15 % and HX10PI / 205,93 %). Smallest difference was on Helsinki Health Care index (HX20PI), being 45,49 %.

Table 4. Descriptive analysis of Index variables of Finland.

Finland	HX55PI	HX30PI	HX50PI	HX60PI	HX10PI	HX15PI	HX65PI	HX20PI
Minimum	904,24	980,15	1 154,55	5 761,33	610,19	1 923,44	614,92	1 502,99
Maximum	1 762,19	2 168,69	2 134,92	17 811,29	1 866,76	3 360,04	1 377,79	2 186,70
25th %tile	1 267,45	1 401,39	1 663,72	10 299,49	1 022,35	2 332,41	871,91	1 940,54
75th %tile	1 625,12	1 989,36	1 957,36	14 521,28	1 494,50	3 042,79	1 203,33	2 047,00
Mean	1 458,71	1 663,25	1 791,27	12 728,07	1 302,20	2 653,13	1 043,19	1 986,09
Median	1 546,36	1 683,02	1 810,84	13 203,05	1 379,05	2 559,63	1 066,86	1 991,35
Std. Dev.	212,73	317,01	208,91	2 462,65	292,19	367,78	192,53	91,39
Kurtosis	-0,98	-1,24	-0,07	-0,69	-0,91	-1,37	-1,22	5,37
Skewness	-0,61	-0,11	-0,62	-0,36	-0,19	0,20	-0,05	-1,52
Count	518,00	518,00	518,00	518,00	518,00	518,00	518,00	518,00

Table *5* presents summary of descriptive statistics of Swedish sector index variables. Kurtosis is negative on every index and skewness is positive on Stockholm Oil, Gas & Coal (SX60PI), Utilities (SX65PI) and Health Care indices (SX20PI). Greatest difference between minimum and maximum value was on Stockholm Oil, Gas & Coal (SX60PI), being 196,26 %. Overall, the differences were higher in Sweden than Finland. Smallest difference was on Stockholm Telecommunication index (SX15PI), being only 37,60 %.

Table 5. Descriptive analysis of Index variables of Sweden.

Sweden	SX55PI	SX30PI	SX50PI	SX60PI	SX10PI	SX15PI	SX65PI	SX20PI
Minimum	1 350,25	1 517,43	1 474,37	858,74	1 025,30	759,27	356,45	1 925,04
Maximum	2 959,67	3 579,79	3 608,24	2 544,08	2 883,41	1 044,77	935,31	3 920,91
25th %tile	2 016,23	2 176,90	2 348,61	1 325,39	1 679,10	887,02	524,54	2 818,98
75th %tile	2 621,78	3 059,59	3 141,29	1 923,18	2 421,79	965,84	698,73	3 468,32
Mean	2 329,83	2 634,70	2 758,66	1 619,88	2 056,11	920,83	601,80	3 097,29
Median	2 447,59	2 706,75	2 919,42	1 607,68	2 123,94	923,22	561,66	2 994,84
Std. Dev.	366,57	520,94	486,04	377,51	458,38	59,84	111,41	425,35
Kurtosis	-0,84	-1,14	-0,77	-0,75	-0,94	-0,21	-0,31	-0,60
Skewness	-0,55	-0,07	-0,50	0,40	-0,29	-0,38	0,70	0,09
Count	518,00	518,00	518,00	518,00	518,00	518,00	518,00	518,00

3.4. Performance measurement tools for evaluating sector development

There are multiple ways to measure and compare returns of stocks and indices. The simplest way is to calculate and compare returns, but this ignores the risk element. In case of two assets having the same return, the investor should prefer the one with lower risk. Total risk can be divided in two parts: systematic risk and diversifiable risk. The first one is also called a market risk or non-diversifiable risk, because it can´t be diversified. Factors of systematic risk are political or economic, such as inflation. Even if the risk is non-diversifiable, some assets, such as stocks, are more sensitive to systematic risk than others. This risk can be measured as a beta (1). Beta measures the risk of certain asset and compares it to whole market and it notices both asset´s volatility but also the market volatility. Market´s beta is considered to be 1 and a single asset´s beta can be either 1 or exceed or be below the 1. Asset, that has beta of 1 is strongly correlated with the market. If asset´s beta exceeds 1, it is considered to be a positive beta and it has a positive correlation with the market and it is in generally more volatile than the market. The asset´s beta indicates how much more volatile the asset is compared to the market. For instance, beta 1,1 assumes that the asset is 10 % more volatile than the market. On the contrary, if the beta is less than 1, it´s called negative beta and it has a negative correlation with the market. For instance, if beta is 0,90, the asset is -10 % less volatile than the market. Diversifiable risk, the second part of the total risk, can be lowered by diversifying investments on different assets or sectors. Factors of diversifiable risk are based on the company and its actions. (Spaulding 2022).

$$Beta\ coefficient\ (\beta) = \frac{Coveriance(R_e, R_m)}{Variance(R_m)} \tag{1}$$

Where,

R_e = return of an asset

R_m = return of the market

There are five ratios used in this thesis to measure index’s return, that also accounts the risk factor: Treynor, Sharpe, Sortino, Calmar and Sterling ratios. Five ratios have been chosen because it improves the reliability of the results compared to, for example, the use of two ratios, which minimizes the effect of possible calculation errors in some ratios on the overall result. Jack L. Treynor (1965) developed reward-to-volatility ratio, also known as a Treynor ratio (2), which measures relationship of asset´s excess return and risk taken. Difference between Treynor ratio and Sharpe ratio is, that Sharpe ratio uses standard deviation to adjust asset´s systematic risk while Treynor ratio uses asset´s beta. There are no scale or indicative grades on how to compare Treynor ratios´ results. Treynor ratio can be used to compare assets, but it doesn´t indicate how much better one asset is to another, since it´s ordinal. However, when comparing to similar investments, higher Treynor ratio value is better. Treynor ratio can be high if asset´s beta is low, or returns are high.

$$Treynor\ ratio = \frac{R_p - r_f}{\beta_p} \quad (2)$$

Where,

R_p = return of the asset

r_f = risk-free rate

β_p = beta of the asset

The Sharpe ratio (3) was developed by William F. Sharpe (1966) to assess asset´s performance compared to risk-free rate which results risk-adjusted return. Sharpe ratio´s equation is quite simple. It´s formed from subtraction of the asset´s return and the risk-free rate, which is then divided by standard deviation of the asset´s excess return. The higher the Sharpe ratio of the asset is, the better the risk-adjusted return is. If the Sharpe ratio is between 1-1.99, it is interpreted as adequate/good, 2-2.99 as very good and >3 is excellent. If Sharpe ratio is <1 portfolio´s return is expected to be negative or risk-free rate is greater than the portfolio´s return. (CFI 2023)

Sharpe ratio has some limitations. It´s based on historical returns and volatility and thus can´t be used as a very trustworthy measurement when predicting future performance. The time period used should be carefully selected and any associated risks identified due the portfolio returns might vary quite significantly in different periods. Thus, there should be arguments why certain time period is used to comparison. The Sharpe ratio uses volatility and thus notices upsides and downsides, but not in which directions the movement has been. The assumption is, that the returns of the asset are normally distributed, but in real life they are often skewed from the average. (Mistry & Shah 2013)

$$Sharpe\ ratio = \frac{R_p - r_f}{\sigma_p} \quad (3)$$

Where,

R_p = return of the asset

r_f = risk-free rate

σ_p = standard deviation of the asset´s excess return

The Sortino ratio (4) (Sortino & Price 1994) is a variation of the previously presented Sharpe ratio. Sharpe ratio uses the standard deviation of the asset´s excess return whereas Sortino ratio uses the standard deviation of negative asset´s returns or in the other words, downside deviation. It´s formed from subtraction of the asset´s return and the risk-free rate which is then divided by standard deviation of the downside. Similar to Treynor ratio, there are no scale or indicative grades on how to compare Sortino ratios´ results. It can be used to compare assets, but it doesn´t indicate how much better one asset is to another, since it´s ordinal. The higher the Sortino ratio of the asset is, the better the risk-adjusted return is. Upside volatility is rather hoped by investors, unlike the downside volatility, which however assesses the actual negative risk and which investors usually want to avoid.

$$Sortino\ ratio = \frac{R_p - r_f}{\sigma_d} \quad (4)$$

Where,

R_p = return of the asset

r_f = risk-free rate

σ_d = standard deviation of the downside

The Sterling ratio (5) is the last performance measure. There are multiple variations of the Sterling ratio, but the common factor is, that they all use average drawdown to measure the risk-adjusted returns. The higher the ratio´s value, the better the performance. Similar to Calmar ratio, the timeframe is usually 36 months and monthly data is used if data is available for a longer period. (Bacon 2008)

$$Sterling\ ratio = \frac{R_p - r_f}{Avg\ Max\ D} \tag{5}$$

Where,

R_p = return of the asset

r_f = risk-free rate

$Avg\ Max\ D$ = the average maximum drawdown for the period

The Calmar ratio (6) was developed by Terry W. Young (1991) and it is a modification of the Sterling ratio. It uses a maximum drawdown, the maximum loss from a peak-to-trough the given period, to measure a risk. It ignores general volatility, which is its strength but also weakness. The formula is the same as Sharpe ratio´s, only difference is, that the maximum drawdown is a divisor instead of the standard deviation of the downside. The Calmar ratio smooths out under and over achievements and is thus a good tool for measuring performance of the investment alongside other ratios. A high ratio indicates higher risk-adjusted returns. Ratio from 1 to 3 is considered good, from 3 to 5 excellent and over 5 awesome. If data is available for a longer period, the timeframe is usually 36 months and monthly data is used.

$$Calmar\ ratio = \frac{R_p - r_f}{Max\ D} \tag{6}$$

Where,

R_p = return of the asset

r_f = risk-free rate

$Max\ D$ = the maximum drawdown for the period

3.4.1. TOPSIS – distances-based MCDM method

When there is only one or two performance measures and the result of them are clear, it´s easy to determine which assets outperformed others. However, in real life, several performance metrics may be used, but the results are vague and determining and organizing superiority is much more difficult. In these cases, it´s preferable to use some multiple criteria decision-making (MCDM) method to solve or at lease ease the decision-making. There are various of MCDM methods, and they are based on different techniques. One of the methods is Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) which was developed by Hwang and Yoon (1981). TOPSIS is a distance-based MCDM method, which can be used to determine the maximum distance from a Negative Ideal Solution (NIS) and the minimum distance from a Positive Ideal Solution (PIS) and then utilising these results to order the alternatives. In this study, the TOPSIS is used to order the results of Treynor, Sharpe, Sortino, Calmar and Sterling ratios to determine the best alternatives for the best and the worst performing indices. There are six steps in the method if a matrix of evaluated alternatives is already constructed. The first step is *normalization* (7), since the used alternatives e_{ij} are typically on a different scale, they need to be normalized to same scale r_{ij}.

$$r_{ij} = \frac{e_{ij}}{\sqrt{\sum_{i=1}^{l} e_{ij}^2}} \tag{7}$$

The second step is *weighting*, in which the weights w_j will be chosen and then those are multiplied with each column of the normalized alternatives of step one r_{ij} to construct the matrix of weighted normalized alternatives q_{ij}. In the third step, *Positive-Ideal and Negative-Ideal Solutions* are determined. If the chosen alternatives are benefit-type, meaning that the higher the value, the more preference, then the positive-ideal solution is the largest value of each column of q_{ij} and the similarly the negative-ideal solution consist of the smallest value of each column of q_{ij}. The fourth step is *calculating separation measures*, in the other words, calculating the Euclidean distance d_i^N (8) and d_i^P (9) of alternatives from NIS and PIS.

$$d_i^N = \sqrt{\sum_{j=1}^{k}(q_{ij} - q_i^N)^2} \tag{8}$$

$$d_i^P = \sqrt{\sum_{j=1}^{k}(q_{ij} - q_i^P)^2} \tag{9}$$

The fifth step is *calculating similarities S_i^P of each alternative to Positive-Ideal Solution (PIS)* (10).

$$S_i^P = \frac{d_i^N}{(d_i^P + d_i^N)} \tag{10}$$

The sixth and the final step is to *Preference Rank.* In this step, the alternatives will be ranked by using S_i^P and the higher S_i^P value means a higher preference.

3.5. Linear regression

One of the most important methods in econometrics is regression analysis. It´s relatively simple and quick to use. However, the downside of the linear regression is that the real-world data might not actually be linear. Regression evaluates and describes the relationships between two or more variables. In other words, it tries to explain in what quantity dependent variable *y* is affected by independent variables $x_1, x_2, \ldots, x_k$. If there are only variables *y* and *x* and based on a financial theory, and *x* impacts to *y*, then this relationship should be possible to visually observe, for instance from scatter plot. In this case, increase in independent variable x will lead to increase of dependent variable y. Placing a straight line through observations, one can notice that there is a positive linear relationships between dependent and independent variables. Equation for this relationship would be $y = \alpha + \beta x$, in which α and β are the coefficients. However, it rarely occurs, that the line fits all the observations perfectly, and thus there is a need to add u to the equation, to reflect a random disturbance. Due to this, there are multiple observations, there is also needed to add t to equation to reflect them. Now, the equation, or a model, would be following $y_t = \alpha + \beta x_t + u_t$. By adding more variables into model and trying to explain how variables $x_1, x_2, \ldots, x_t$ affect on variable y, the model can be transformed to multiple linear regression model (11). (Brooks 2008, 27-30, 89)

Multiple linear regression model $$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t \quad (11)$$

Where,

y_t = dependent variable

β_0 = constant term

x_i = independent variable

β_i = variable coefficients

u_t = error term

3.5.1. Model assessment

One of the most used methods to measure the goodness of fit of the model, is to use the coefficient of determination or better-known R-squared (R^2). The R^2 (12) indicates how well regression line fits the actual data or, in other words, how much variation of a dependent variable is explained by the independent variables. Range of the scale is from 0 to 1, in which higher value indicates better results. The limitation of R^2 is, that when adding more variables in the model, it tends to increase. This might cause a problem, due there is no previous information about the variables and which are important and which not. (Pardo 2020, 64-66)

$$R^2 = 1 - \frac{\Sigma(y_i - \hat{y}_{i)}{}^2}{\Sigma(y_i - \bar{y}_{i)}{}^2} \tag{12}$$

Where,

y_i = actual value

$\hat{y}_i$ = forecasted value

$\bar{y}_i$ = mean of the actual values

One way to assess model accuracy is visually examine graphs, for instance plotting the linear regression model, calculating errors of actual and predicted values and then using histograms or plotting predicted and actual values. It is quite easy to notice, if model performs well and predicted values are close to actual values or if the model performs very bad and the spread is huge. However, most of the time, the results are somewhere between these two examples and then it´s necessary to use numerical assessment. Root Mean Square Error (RMSE) (13) is relatively simple method for model accuracy assessment. It presents the standard deviation of the residuals and measures how spread out these residuals are from the regression line. The higher the value, the worse the accuracy of the model is. (Glen 2022)

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \tag{13}$$

Where,

$\hat{y}_i$ = forecasted value

y_i = actual value

n = number of observations

4. Results

In this chapter, the empirical results are presented. The chapter is divided in multiple subchapters, in which results of performance measurements and multiple linear regressions models are reviewed.

4.1. Performance of the sector indices

Five performance measurements were used in this study to assess performance of eight different Finnish and Swedish sector indices during COVID-19 period from 18 March 2020 to 6 April 2022. The performance measurements were Sharpe, Treynor, Sortino, Calmar and Sterling ratios. Sharpe and Treynor ratios are a bit more traditional measurements and their weights in TOPSIS were 35 % each. Also, Sortino, Calmar and Sterling ratios were included due their nature to stress standard deviation of negative asset´s return and their weights in TOPSIS were 10 % each. The risk-free rate used in the calculations for entire period and for the first wave was Finland´s 10-year bond yield of 0,29 % dated on March 18, 2020, for the second wave -0,34 % dated on 1 October 2020 and for the third wave -0,31 % dated on August 2, 2021. (Investing.com 2022) All ratios were annualized, meaning that factors, such as returns and standard deviations, used in the calculations were annualized. Beta (β) used in the Treynor ratio was 1, due the sector indices themselves represented the meaningful benchmark for assets.

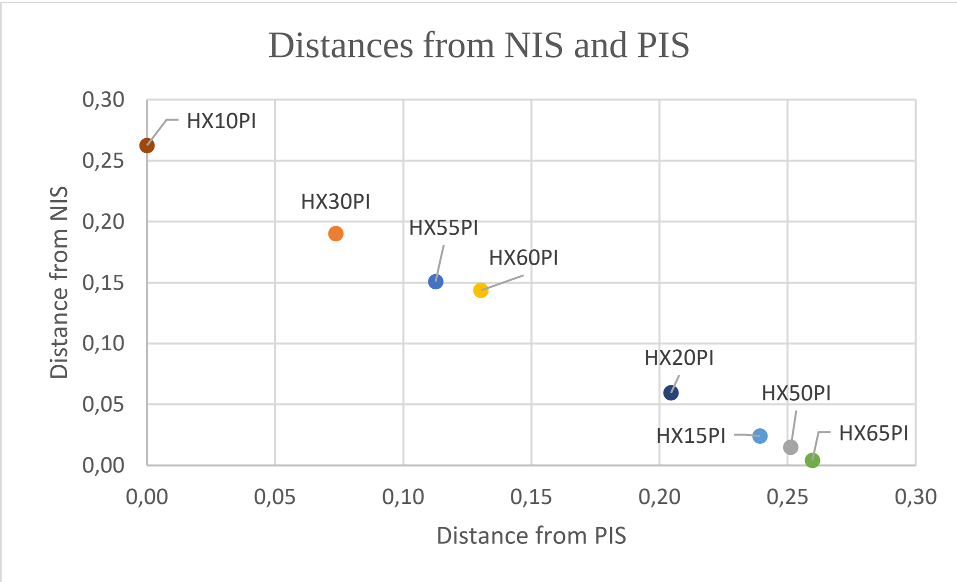
4.1.1. The entire period

Results of performance measurements for the entire period is presented on Table 6 Helsinki Technology index (HX10PI) had the highest measured values in all ratios and thus its performance was the best of all Finnish sector indices. The results of the rest of the Finnish indices varied depending on the ratio.

Table 6. The results of performance measurements of Finnish sector indices for the entire period.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
HX55PI	1,23	32,63 %	0,37	4,98	62,92
HX30PI	1,43	39,06 %	0,68	5,74	78,41
HX50PI	0,48	11,14 %	-0,72	2,12	23,56
HX60PI	0,96	40,44 %	-0,05	3,83	52,07
HX10PI	1,76	52,16 %	1,18	8,47	92,00
HX15PI	0,52	15,21 %	-0,71	1,18	28,26
HX65PI	0,39	12,18 %	-0,84	1,28	18,89
HX20PI	0,75	18,23 %	-0,36	2,35	41,12

For ranking the results, TOPSIS was used. Graph 1 presents the distances of Finnish alternatives from Negative-Ideal Solutions (NIS) and Positive-Ideal Solutions (PIS). As Table 6 indicated, the Helsinki Technology index (HX10PI) had the minimum distance to PIS and maximum distance to NIS, being the best alternative. The second best was Helsinki Financials (HX30PI) and the third best Helsinki Basic Materials (HX55PI). Three worst alternatives were Helsinki Utilities (HX65PI), Helsinki Industrials (HX50PI) and Helsinki Telecommunications (HX15PI) due their distance were furthest from the PIS and closest to NIS.



Graph 1. Distances of Finnish alternatives of entire period from NIS and PIS.

In this case, ranking the alternatives visually was quite easy. However, Table 7 represents the similarities of alternatives to PIS and the results are ranked in descending order, with the highest number indicating the best result. The results confirm previous visual indications of the best and the worst alternatives.

Table 7. Similarities of Finnish entire period alternatives to PIS.

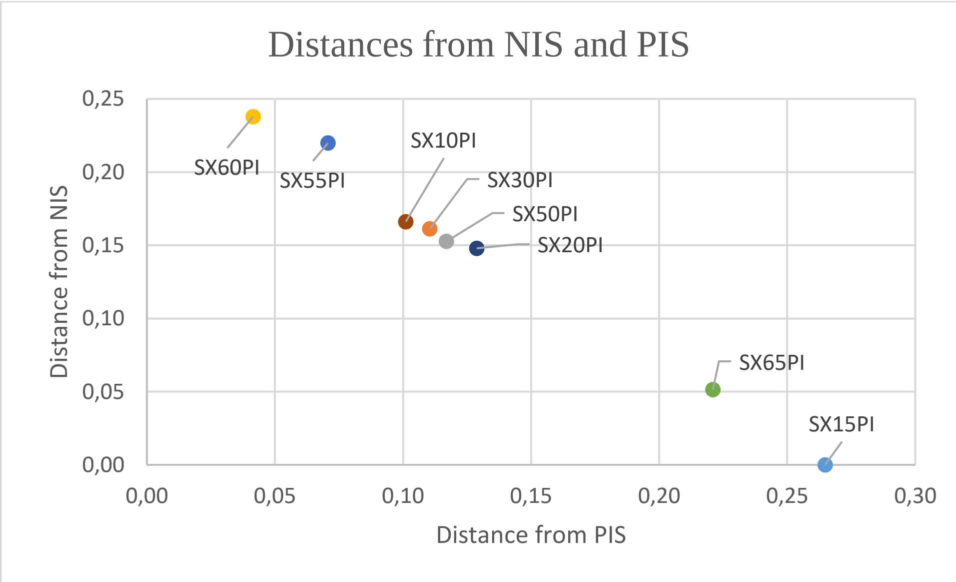
Index	S_i^P
HX10PI	1,00
HX30PI	0,72
HX55PI	0,57
HX60PI	0,52
HX20PI	0,23
HX15PI	0,09
HX50PI	0,06
HX65PI	0,02

The results of performance measurements of Swedish sector indices varied from the Finnish results (Table 7). On average, most of the ratios were higher in Sweden than in Finland. Stockholm Basic Materials (SX55PI) and Stockholm Oil, Gas & Coal (SX60PI) seemed to perform better than other but based on the Table 7 it´s difficult to say which was better. However, similarly to Finland, Telecommunication index (SX15PI) had the worst performance.

Table 8. The results of performance measurements of Swedish sector indices for the entire period.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
SX55PI	1,98	46,31 %	1,60	9,13	108,63
SX30PI	1,53	37,78 %	0,82	6,12	82,36
SX50PI	1,44	36,99 %	0,69	6,71	75,38
SX60PI	1,62	69,49 %	1,03	6,82	92,52
SX10PI	1,48	42,48 %	0,71	7,49	72,86
SX15PI	0,33	7,27 %	-0,94	0,84	16,74
SX65PI	0,48	23,43 %	-0,78	1,07	23,15
SX20PI	1,50	31,65 %	0,79	5,72	77,26

Graph 2 presents the TOPSIS results and distances from NIS and PIS. It also confirms that Stockholm Oil, Gas & Coal (SX60PI) was a better alternative to Stockholm Basic Materials (SX55PI). The worst alternatives were already mentioned Stockholm Telecommunication index (SX15PI) and Stockholm Utilities (SX65PI).



Graph 2. Distances of Swedish alternatives of entire period from NIS and PIS.

Table 9 summarizes S_i^P values of Swedish alternatives. Like in Finnish results, also S_i^P values confirm previous visual indications of the best and the worst alternatives. The best alternatives, and in this case, the best performing sector indices were different in Finland and Sweden. However, Basic Materials index (H/SX55PI) was in top three in both rankings. Also, Utilities index (H/SX65PI) was the worst in Finland and the second worst in Sweden.

Table 9. Similarities of Swedish entire period alternatives to PIS.

Index	S_i^P
SX60PI	0,85
SX55PI	0,76
SX10PI	0,62
SX30PI	0,59
SX50PI	0,57
SX20PI	0,53
SX65PI	0,19
SX15PI	0,00

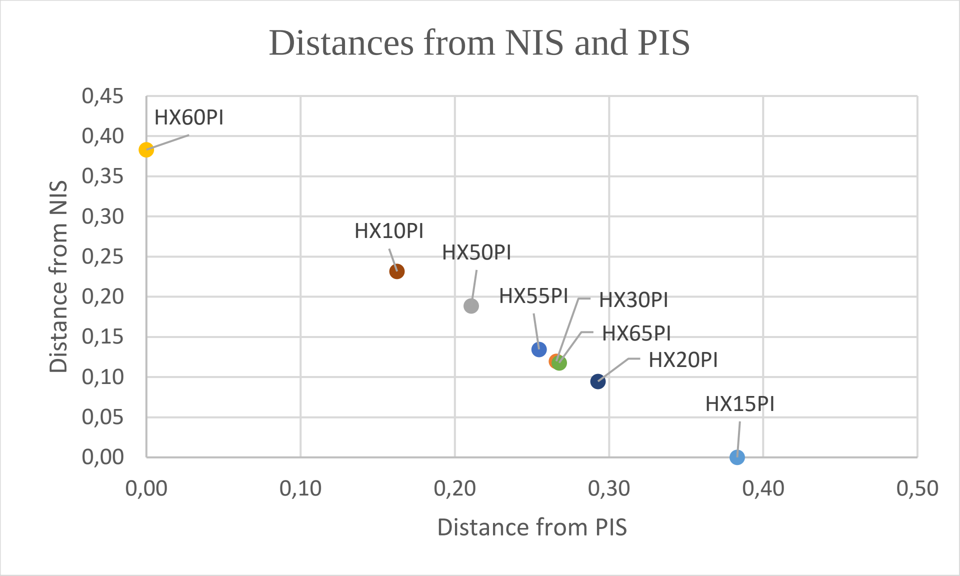
4.1.2. The first wave

Results of performance measurements for the first wave is presented on Table 10. Overall, all the ratios of indices were higher in the first wave compared to entire period, except Helsinki Telecommunications (HX15PI) which had negative ratios. The highest Sharpe and Treynor ratios were with Helsinki Oil, Gas & Coal (HX60PI) index.

Table 10. The results of performance measurements of Finnish sector indices for the first wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
HX55PI	2,79	86,08 %	3,04	13,13	177,84
HX30PI	2,31	85,00 %	2,23	13,35	137,89
HX50PI	4,12	109,20 %	5,16	20,79	269,10
HX60PI	6,25	322,99 %	12,42	48,09	527,68
HX10PI	4,69	158,26 %	6,39	25,69	324,26
HX15PI	-0,10	-2,95 %	-1,76	-0,39	-5,45
HX65PI	2,26	84,35 %	1,96	14,42	122,63
HX20PI	1,97	58,63 %	1,60	7,57	116,40

Helsinki Oil, Gas & Coal (HX60PI) index had the minimum distance from the PIS and maximum distance from NIS (Graph 3) and therefore was the best alternative. This time, Helsinki Telecommunications (HX15PI) had the maximum distance from the PIS and minimum distance from the NIS and therefore it was the worst alternative. However, other results were closer to each other compared to the entire period.



Graph 3. Distances of Finnish alternatives of the first wave from NIS and PIS.

In Table 11 below the similarity values of Finnish first wave alternatives to PIS are summarized. The results clarify the order of the alternatives, due the several of them were quite close to each other. Noteworthy exception is, that Helsinki Financials (HX30PI) and Helsinki Utilities (HX65PI) had the same value 0,31.

Table 11. Similarities of Finnish first wave alternatives to PIS.

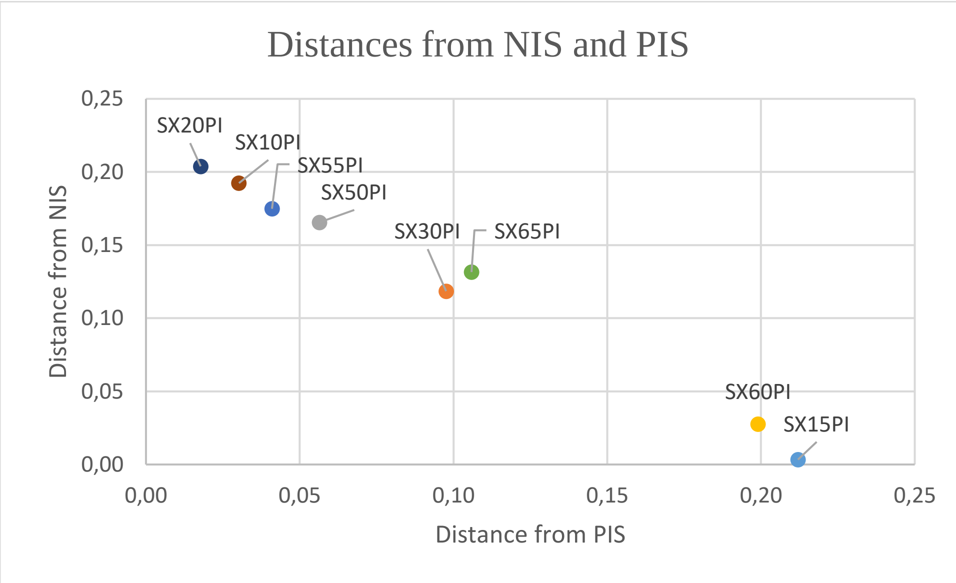
Index	S_i^P
HX60PI	1,00
HX10PI	0,59
HX50PI	0,47
HX55PI	0,35
HX30PI	0,31
HX65PI	0,31
HX20PI	0,24
HX15PI	0,00

Like Finland, also in Sweden the performance measurements indicated better results from the first wave than from the entire period (Table 12). Based on these results, it´s hard to assess which index had the best performance. The worst performance seemed to be with either Stockholm Oil, Gas & Coal (SX60PI) or Stockholm Telecommunication (SX15PI) indices.

Table 12. The results of performance measurements of Swedish sector indices for the first wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
SX55PI	4,10	119,85 %	5,73	23,64	286,86
SX30PI	3,01	95,01 %	3,22	15,38	188,49
SX50PI	3,70	125,57 %	4,57	22,77	231,88
SX60PI	0,91	49,42 %	-0,16	4,85	56,90
SX10PI	4,35	136,30 %	5,48	24,04	266,88
SX15PI	0,99	25,71 %	0,00	4,92	53,22
SX65PI	2,49	122,80 %	2,75	15,49	145,90
SX20PI	4,99	121,41 %	7,32	21,94	341,53

Distances from NIS and PIS confirm that Stockholm Oil, Gas & Coal (SX60PI) or Stockholm Telecommunication (SX15PI) indices indeed were the worst alternatives and therefore had the worst performance (Graph 4). Based on the Graph 4, top three indices were Stockholm Health Care (SX20PI), Technology (SX10PI) and Basic Materials (SX55PI) indices.



Graph 4. Distances of Swedish alternatives of the first wave from NIS and PIS.

Table 13 confirms the visual indications of the top three and the worst alternatives. It also represents, that Stockholm Utilities (SX60PI) and Financials (SX30PI) had the same similarity value 0,55 to PIS. The best alternative in Finland and Sweden was different, but the second best (Technology (H/SX10PI) index) and the worst Basic Materials (H/SX55PI) were the same.

Table 13. Similarities of Swedish first wave alternatives to PIS.

Index	S_i^P
SX20PI	0,92
SX10PI	0,86
SX55PI	0,81
SX50PI	0,75
SX65PI	0,55
SX30PI	0,55
SX60PI	0,12
SX15PI	0,02

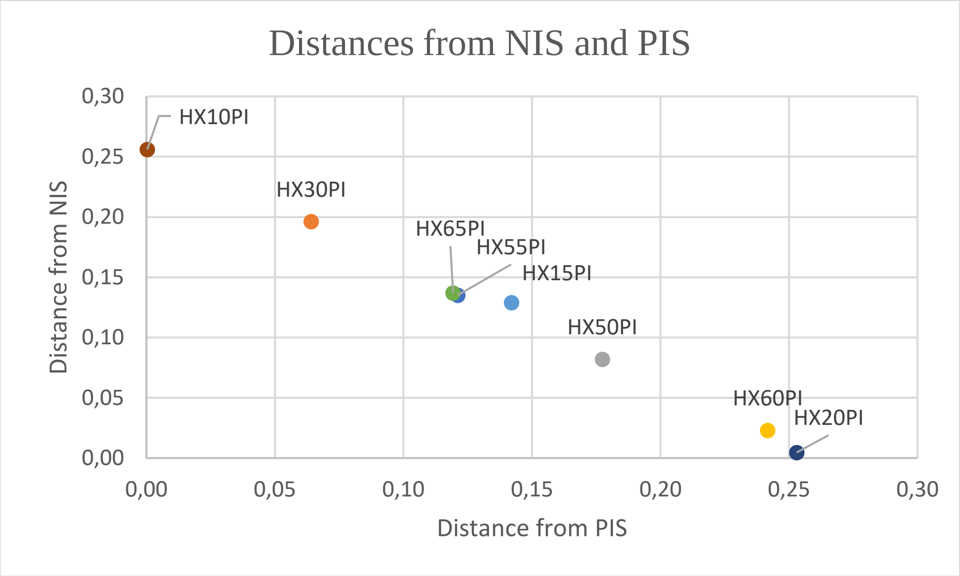
4.1.3. The second wave

The performance of most of the Finnish indices was good or excellent during the second wave (Table 14). The weakest performance was on Helsinki Oil, Gas & Coal (HX60PI) and Helsinki Health Care (HX20PI) indices, both had for instance negative Sortino ratio. Again, the strongest performance seemed to be on Helsinki Technology (HX10PI) index. Overall, performance was better than during the entire period, but weaker than in the second wave.

Table 14. The results of performance measurements of Finnish sector indices for the second wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
HX55PI	1,92	41,65 %	1,57	9,00	108,09
HX30PI	2,55	50,47 %	2,95	16,69	178,16
HX50PI	1,54	24,24 %	0,90	6,64	97,15
HX60PI	0,60	19,08 %	-0,63	2,32	30,23
HX10PI	3,08	68,14 %	3,67	16,59	192,12
HX15PI	1,46	49,15 %	0,71	3,82	102,09
HX65PI	1,90	42,78 %	1,51	9,60	115,18
HX20PI	0,65	11,27 %	-0,58	2,22	39,16

Graph 5 represents the distances of Finnish indices from NIS and PIS. Even if Helsinki Financials (HX30PI) and Helsinki Telecommunications (HX15PI) Treynor ratios were quite close to each other, other ratios of Helsinki Financials (HX30PI) had higher values and hence the distance from PIS was shorter and from NIS longer. Also, it seemed that indices with lower Treynor ratio, but for instance higher Sharpe ratio, such as Helsinki Utilities (HX65PI) and Helsinki Basic Materials (HX55PI) were closer to PIS than Helsinki Telecommunications (HX15PI).



Graph 5. Distances of Finnish alternatives of the second wave from NIS and PIS.

Alternatives for the best and the worst performed indices were quite clear when observing only Table 14 and Graph 5. But ranking the alternatives by the similarity values (Table 15) shows, that Helsinki Utilities (HX65PI) and Helsinki Basic Materials (HX55PI) actually had the same similarity value 0,53, being equally good alternatives.

Table 15. Similarities of Finnish second wave alternatives to PIS.

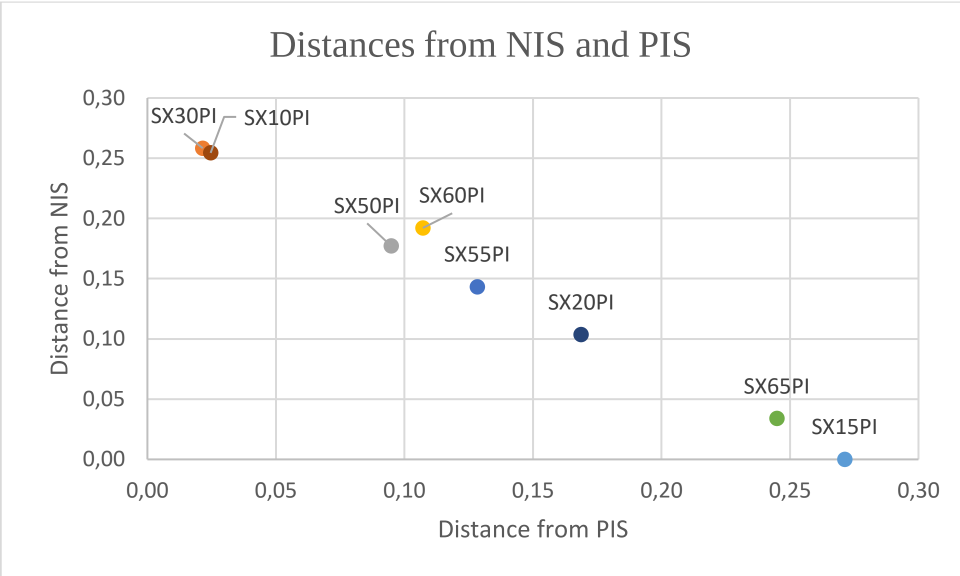
Index	S_i^P
HX10PI	1,00
HX30PI	0,75
HX65PI	0,53
HX55PI	0,53
HX15PI	0,48
HX50PI	0,32
HX60PI	0,09
HX20PI	0,02

Some Swedish sector indices had better performance during the second wave (Table 16) compared to the entire period but weaker compared to the first wave. The results were to some extent similar with Finnish second wave results. There were differences between values of the ratios, but couple of the indices, such as Financials (H/SX30PI) and Technology (H/SX10PI) performed much better in both countries than other indices in the same period.

Table 16. The results of performance measurements of Swedish sector indices for the second wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
SX55PI	2,10	40,09 %	1,91	12,63	126,98
SX30PI	3,65	63,08 %	4,89	21,36	270,84
SX50PI	2,57	46,57 %	2,83	16,05	163,04
SX60PI	1,96	67,90 %	1,78	13,75	119,64
SX10PI	3,34	71,47 %	4,07	21,14	207,45
SX15PI	0,29	5,38 %	-1,19	1,26	16,76
SX65PI	0,43	18,11 %	-1,00	3,00	21,00
SX20PI	1,69	27,22 %	1,27	9,87	107,66

Even if the indices that had the best performance were the same in both countries, the worst performed indices were different. In Sweden, those were Stockholm Telecommunication (SX15PI) and Stockholm Utilities (SX65PI) indices. By observing only Graph 6 and the distances from NIS and PIS, it was difficult to assess which alternative, Stockholm Industrials (SX50PI) and Stockholm Oil, Gas & Coal (SX60PI) was better.



Graph 6. Distances of Swedish alternatives of the second wave from NIS and PIS.

Table 17 confirms that the difference of the similarity values of Stockholm Industrials (SX50PI) and Stockholm Oil, Gas & Coal (SX60PI) were extremely small, only 0,01, and the former had slightly higher value and hence being better alternative. Also, The difference of the two best alternatives, Stockholm Financials (SX30PI) and Stockholm Technology (SX10PI) was only 0,01, the latter alternative being slightly better.

Table 17. Similarities of Swedish second wave alternatives to PIS.

Index	S_i^P
SX30PI	0,92
SX10PI	0,91
SX50PI	0,65
SX60PI	0,64
SX55PI	0,53
SX20PI	0,38
SX65PI	0,12
SX15PI	0,00

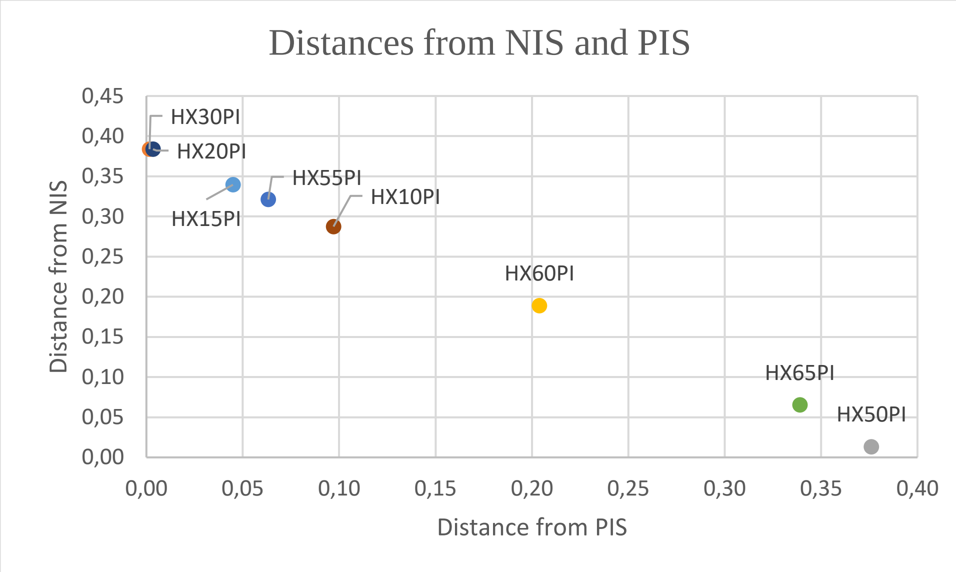
4.1.4. The third wave

The performance of Finnish sector indices was poor during the third wave (Table 18). The performance was worse than in previous waves or the entire period. Only Helsinki Financials (HX30PI) and Helsinki Health Care (HX20PI) had positive results from all the other ratios, except Sortino ratio. However, their performance was still poor, for instance Sharpe, Treynor and Calmar ratios were only slightly positive.

Table 18. The results of performance measurements of Finnish sector indices for the third wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
HX55PI	-0,17	-4,66 %	-1,48	-0,79	-6,61
HX30PI	0,10	2,50 %	-1,15	0,37	3,77
HX50PI	-1,53	-39,55 %	-3,01	-7,90	-49,97
HX60PI	-0,61	-26,31 %	-2,18	-2,49	-24,40
HX10PI	-0,29	-9,47 %	-1,69	-1,54	-10,74
HX15PI	-0,10	-2,26 %	-1,41	-0,48	-3,75
HX65PI	-1,22	-41,96 %	-2,60	-4,39	-44,69
HX20PI	0,10	2,48 %	-1,34	0,51	4,25

From Graph 7 and distances from NIS and PIS it´s difficult to assess which one of Helsinki Financials (HX30PI) and Helsinki Health Care (HX20PI) was the better alternative. The worst alternative was Helsinki Industrials (HX50PI) and the second worst Helsinki Utilities (HX65PI). It´s good to remind, that even if the Graph 7 presents, that multiple alternatives had quite short distances from PIS and long distances from NIS, it didn´t mean that they performed well, but due they have been standardized and then Positive-Ideal and Negative-Ideal Solutions were determined, and the distances are calculated from those values.



Graph 7. Distances of Finnish alternatives of the third wave from NIS and PIS.

The difference of the similarity values of best alternatives (Helsinki Financials (HX30PI) and Helsinki Health Care (HX20PI)) were extremely small, only 0,01. The fact that they were the only indices with the most positive ratios indicated that they were the best options, and that small difference only underlines the difference of their performance to the other indices.

Table 19. Similarities of Finnish third wave alternatives to PIS.

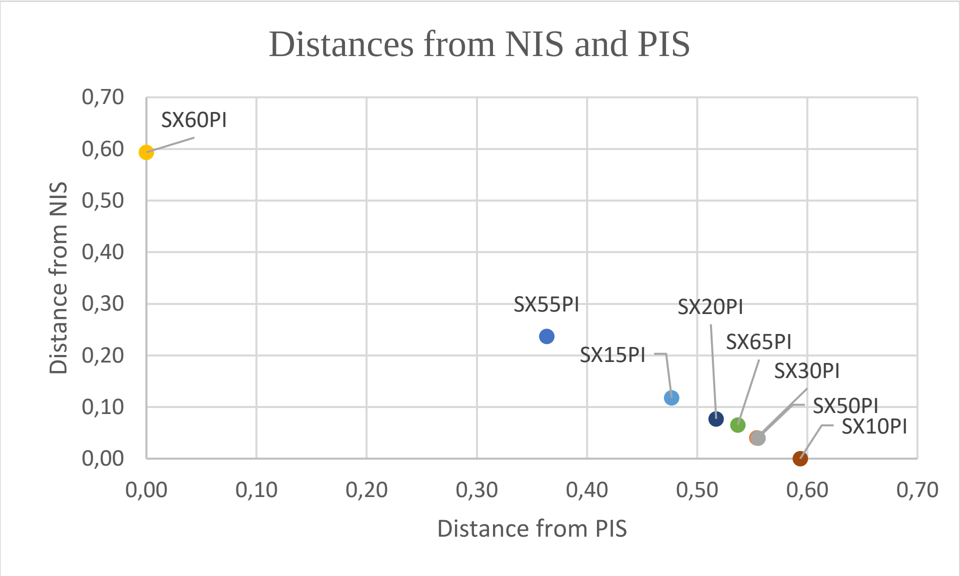
Index	S_i^P
HX30PI	1,00
HX20PI	0,99
HX15PI	0,88
HX55PI	0,84
HX10PI	0,75
HX60PI	0,48
HX65PI	0,16
HX50PI	0,03

Also, the performance of the Swedish indices was poor during the third wave. Only indices, that had most of the ratios positive, were Stockholm Basic Materials (SX55PI) and Stockholm Oil, Gas & Coal (SX60PI) (Table 20). However, the latter one actually performed well and had, for instance, Treynor ratio 90,47 % and Sterling ratio 102,87, while these ratios were negative in most of the other indices.

Table 20. The results of performance measurements of Swedish sector indices for the third wave.

	Sharpe ratio	Treynor ratio	Sortino ratio	Calmar ratio	Sterling ratio
SX55PI	0,62	13,53 %	-0,52	3,29	23,95
SX30PI	-0,52	-13,01 %	-1,91	-2,80	-18,76
SX50PI	-0,53	-13,19 %	-1,88	-2,71	-18,94
SX60PI	2,15	90,47 %	1,61	8,96	102,87
SX10PI	-0,67	-22,00 %	-2,12	-4,23	-23,80
SX15PI	-0,08	-1,83 %	-1,30	-0,21	-3,43
SX65PI	-0,29	-16,63 %	-1,67	-0,76	-12,57
SX20PI	-0,33	-7,27 %	-1,61	-1,50	-11,38

The same conclusion can be seen from Graph 8. Stockholm Oil, Gas & Coal (SX60PI) is the only index in the left on the axis, while all the other indices, expect previously mentioned Stockholm Basic Materials (SX55PI), are on the right side of the axis.



Graph 8. Distances of Swedish alternatives of the third wave from NIS and PIS.

Table 21 summarize the difference of the performance of the alternatives. While the best one had similarity value 1,00, the second best had 0,39 and all the other had values 0,20 or below. Even if the Finnish sector indices performed poorly during the third wave, the differences of similarity values were not as radical as in Sweden.

Table 21. Similarities of Swedish third wave alternatives to PIS.

Index	S_i^P
SX60PI	1,00
SX55PI	0,39
SX15PI	0,20
SX20PI	0,13
SX65PI	0,11
SX30PI	0,07
SX50PI	0,07
SX10PI	0,00

4.2. Classical linear regression models and price predictions

Classical linear regression models have been constructed in a way, that dependent variable y is the sector index price, during the time period from 18 March 2020 to 6 April 2022 and independent variables x_k are previous 7-day period smoothed COVID-19 variables. The regression results are based on the data of the previous seven days, which is why their events affect the aforementioned results. There is a total of eight sector indices from both countries, thus total 16 linear regression results are presented for the entire time period. Linear regression results include coefficients and their p-values. Also, models´ R-squared and P-values are presented. Significance level used is 5 %.

4.2.1. The entire period

Table 22 summarizes R-squared and P-values of linear regression models of Helsinki sector indices and Table 23 Stockholm sector indices. P-values are close to 0,000 in every model in Finland and Sweden, thus can be said, that models are significant. R-squared of all Helsinki Sector Indices models is low. Only models that had R-squared value higher than 0,40 were Helsinki Financials (HX30PI) 0,430, Helsinki Oil, Gas & Coal (HX60PI) 0,438, and Helsinki Telecommunication sector (HX15PI) 0,489. Thus, can be interpreted, that these models could explain some of the development of the index prices. In Sweden, four sectors had R-squared value over 0,400 but less than 0,700. Those were Stockholm Basic Materials (SX55PI) 0,472, Stockholm Financials (SX30PI) 0,551, Stockholm Industrials (SX50PI)

0,447, and Stockholm Health Care (SX20PI) 0,541. Stockholm Oil, Gas & Coal (SX60PI) had R-squared value 0,794, which can be interpreted as a good explaining power.

Table 22. R-squared and P-values of Helsinki sector index models.

Index	R-squared	P-value
HX55PI	0,290	0,000
HX30PI	0,430	0,000
HX50PI	0,281	0,000
HX60PI	0,438	0,000
HX10PI	0,272	0,000
HX15PI	0,489	0,000
HX65PI	0,210	0,000
HX20PI	0,255	0,000

Table 23. R-squared and P-values of Stockholm sector index models.

Index	R-squared	P-value
SX55PI	0,472	0,000
SX30PI	0,551	0,000
SX50PI	0,447	0,000
SX60PI	0,794	0,000
SX10PI	0,362	0,000
SX15PI	0,341	0,000
SX65PI	0,382	0,000
SX20PI	0,541	0,000

In Table 24 is summarized P-values of coefficients of linear regression models of Helsinki sector indices. Variables New cases, Reproduction rate and Stringency index were significant, with 5 % significance level used, in seven out of eight models. Variable Hospital patients were significant in six out of eight models. Worst significance ratio was with variable New deaths, being significant in only half of the models.

Table 24. P-values of coefficients of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	0,000	0,000	0,000	0,000	0,489	0,007	0,028	0,001
HX30PI	0,000	0,869	0,761	0,002	0,306	0,097	0,001	0,000
HX50PI	0,000	0,000	0,000	0,000	0,041	0,000	0,401	0,000
HX60PI	0,000	0,000	0,000	0,009	0,009	0,000	0,035	0,013
HX10PI	0,000	0,009	0,166	0,134	0,199	0,136	0,000	0,000
HX15PI	0,000	0,000	0,000	0,043	0,014	0,346	0,038	0,015
HX65PI	0,000	0,340	0,886	0,000	0,728	0,000	0,004	0,000
HX20PI	0,000	0,000	0,028	0,027	0,001	0,003	0,000	0,058

P-values of coefficients of linear regression models of Stockholm sector indices are summarized in Table 25. Variables New deaths and Reproduction rate were significant, with 5 % significancy level, in every model. Variables New cases and Stringency index were significant with same significancy level, in 7 out of 8 models. However, the one model where they were not significant, were not the same. Variable ICU patients was significant only in two models. Overall, the results of significant variables varied between Finland and Sweden.

Table 25. P-values of coefficients of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	0,000	0,744	0,017	0,182	0,000	0,000	0,037	0,000
SX30PI	0,000	0,039	0,317	0,000	0,000	0,299	0,003	0,000
SX50PI	0,000	0,023	0,967	0,004	0,000	0,772	0,001	0,000
SX60PI	0,000	0,000	0,000	0,000	0,004	0,000	0,000	0,000
SX10PI	0,000	0,002	0,303	0,029	0,000	0,211	0,037	0,000
SX15PI	0,000	0,372	0,433	0,003	0,000	0,010	0,002	0,138
SX65PI	0,000	0,932	0,079	0,004	0,010	0,000	0,001	0,000
SX20PI	0,000	0,262	0,831	0,000	0,000	0,001	0,000	0,000

In Table 26 coefficient estimates of Helsinki sector index models are summarized. Symbol * indicates, that coefficient estimate is significant with 5 % significancy level. Coefficient estimates were positive in all other models, except Helsinki Telecommunication (HX15PI) and Helsinki Health Care (HX20PI), meaning that the variable effected negatively on the price development of the indices only in these two models. However, variable ICU patients had positive effect on index price development of the these very same models, while the effect was negative in all the other models. All coefficient estimates of variable New Cases were positive in every model. Coefficient estimates of variable New deaths were negative only in Helsinki Industrials (HX50PI) and Helsinki Utilities (HX65PI) models. Only positive coefficient estimate of variable Reproduction rate was on model Helsinki Oil, Gas & Coal (HX60PI). Coefficient estimates of variables Positive rate and Stringency index were negative in every model.

As previous chapters have proved, most of the indices developed positively when time period was examined. This combined with low R-squared value might explain why some variables, such as Hospital patients, New cases and New deaths seemed to have positive effect on index prices. However, for instance Stringency rate had a negative effect on the price development in every model and Reproduction rate in all but one model. These two variables were also significant variables in all, but one model. Thus, although the time period contained three waves, it could be interpreted that these two variables actually had a negative effect on most indices.

Table 26. Coefficient estimates of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	*1665,18	*1,64	*-5,97	*0,06	1,45	*-740,48	*-91,12	*-4,08
HX30PI	*2391,19	0,05	-0,53	*0,05	2,86	-607,28	*-183,23	*-13,43
HX50PI	*2100,63	*1,08	*-4,66	*0,08	*-4,25	*-2022,45	-34,43	*-5,46
HX60PI	*13134,56	*38,21	*-161,75	*0,32	*56,75	*-16086,58	*903,72	*-32,02
HX10PI	*2046,08	*0,90	-2,55	0,02	3,75	-569,23	*-209,16	*-13,18
HX15PI	*3043,10	*-3,56	*8,11	*0,04	*7,54	*-378,54	*-126,16	*-4,46
HX65PI	*1491,09	0,23	-0,18	*0,05	-0,70	-1368,39	*-114,40	*-7,40
HX20PI	*2262,27	*-0,39	*1,28	*0,01	*3,07	*-358,88	*-212,10	-1,04

Table 27 summarizes coefficient estimates of Stockholm sector index models. Symbol * indicates, that coefficient estimate is significant with 5 % significancy level. Results were somewhat similar with Finnis sector index models. Striking difference was with variables New death and Positive rate. Coefficient estimates were positive in all but two Finnish sector index models, but they were negative in all Swedish models. Also, the variable was significant in every model. Results of Positive rate were also interesting. All the coefficients, that were significant, had negative estimates in every model but in Stockholm Health Care (SX20PI), while the estimates were negative in every model. Similarly, as in Finnish models, variables Reproduction rate and Stringency index were significant and had negative coefficient estimates in almost every model.

Table 27. Coefficient estimates of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	*2670,47	0,02	*0,64	0,00	*-3,38	*1883,71	*-90,22	*-8,01
SX30PI	*3704,65	*0,16	0,35	*0,02	*-5,69	-404,35	*-167,45	*-19,33
SX50PI	*3596,06	*0,19	-0,02	*0,01	*-5,49	116,59	*-194,59	*-13,87
SX60PI	*2653,95	*-0,19	*1,78	*0,01	*-1,05	*1038,02	*-359,68	*-16,52
SX10PI	*2832,17	*0,26	-0,38	*0,01	*-4,88	-511,35	*-124,57	*-13,65
SX15PI	*933,89	0,01	0,04	*0,00	*-0,96	*140,74	*-24,43	0,25
SX65PI	*464,03	0,00	0,15	*0,00	*-0,47	*490,50	*-49,05	*3,23
SX20PI	*4171,80	0,07	-0,06	*0,02	*-3,10	*-1079,53	*-221,98	*-15,44

4.2.2. The first wave

Based on visual observation (Figures 2, 5 & 6), the first wave was during 18 March 2020 - 30 September 2020. Table 28 summarizes R-squared and P-values of Helsinki sector index models. P-values were close to 0,000 and thus can be said, that models were significant. R-squared values of wave 1 were considerably better than in similar models, when entire period data was used (Table 6). All models, excluding Helsinki Telecommunication index model (HX15PI / P-value 0,471), had R-squared value over 0,780. Thus, can be said that there was a high level of correlation in the models, and independent variables explained well the variance of dependent variable. The highest R-squared was in model Helsinki Technology (HX10PI), being 0,917.

In Table 29 is summarized P and R-squared valuer of Stockholm Sector index models. Again, all P-values were close to 0,000. Also, R-squared values of Swedish wave 1 models were remarkably higher than models based on the entire data. All R-squared values were 0,650 or over and the highest value was in Stockholm Financials (SX30PI), being 0,879.

Table 28. R-squared and P-values of Helsinki sector index models.

Index	R-squared	P-value
HX55PI	0,782	0,000
HX30PI	0,861	0,000
HX50PI	0,869	0,000
HX60PI	0,794	0,000
HX10PI	0,917	0,000
HX15PI	0,471	0,000
HX65PI	0,856	0,000
HX20PI	0,847	0,000

Table 29. R-squared and P-values of Stockholm sector index models.

Index	R-squared	P-value
SX55PI	0,699	0,000
SX30PI	0,879	0,000
SX50PI	0,856	0,000
SX60PI	0,838	0,000
SX10PI	0,753	0,000
SX15PI	0,821	0,000
SX65PI	0,650	0,000
SX20PI	0,726	0,000

The variable-specific P-values of Helsinki sector index models are collected in Table 30. Variable Hospital patients was insignificant in all models. Also, variables ICU patients and New deaths were insignificant in every model, but Helsinki Financials (HX30PI). Variable Positive rate was significant in all models but Helsinki Telecommunication (HX15PI) and variable New cases in models Helsinki Financials (HX30PI) and Helsinki Utilities (HX65PI).

Table 30. P-values of coefficients of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	0,00	0,73	0,64	0,00	0,26	0,00	0,00	0,00
HX30PI	0,00	0,11	0,04	0,44	0,01	0,00	0,48	0,13
HX50PI	0,00	0,30	0,63	0,00	0,16	0,00	0,03	0,00
HX60PI	0,00	0,37	0,70	0,00	0,50	0,00	0,10	0,04
HX10PI	0,00	0,67	0,53	0,04	0,97	0,00	0,43	0,00
HX15PI	0,00	0,15	0,48	0,00	0,89	0,39	0,00	0,79
HX65PI	0,00	0,21	0,05	0,13	0,59	0,00	0,90	0,11
HX20PI	0,00	0,61	0,09	0,02	0,07	0,00	0,00	0,39

There were somewhat similar results in P-values of variables of Stockholm sector index models (Table 31). Variables ICU patients was insignificant in every model but Stockholm Telecommunication model (SX15PI). Also, variable New death was insignificant in every model, but models Stockholm Oil, Gas & Coal (SX65PI) and Stockholm Telecommunication (SX15PI). The biggest difference in results of these variable-specific P-values in Helsinki and Stockholm sector index models was with variable Hospital patients, which were insignificant in every model in Finland, but only two in Sweden.

Table 31. P-values of coefficients of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	0,01	0,00	0,23	0,03	0,28	0,00	0,43	0,00
SX30PI	0,00	0,03	0,77	0,14	0,10	0,79	0,00	0,00
SX50PI	0,00	0,00	0,42	0,00	0,26	0,22	0,00	0,00
SX60PI	0,00	0,07	0,59	0,20	0,05	0,01	0,00	0,00
SX10PI	0,07	0,00	0,05	0,02	0,16	0,00	0,03	0,00
SX15PI	0,00	0,00	0,00	0,34	0,00	0,10	0,03	0,00
SX65PI	0,11	0,16	0,86	0,04	0,20	0,34	0,49	0,00
SX20PI	0,00	0,00	0,08	0,04	0,27	0,76	0,01	0,00

Table 32 presents variable-specific coefficient estimate values of Helsinki sector index models. Symbol * indicates, that coefficient estimate is significant with 5 % significancy level. New cases was the only variable, which had positive effect in most of the models and in addition had significance in most of the models. On the contrary, variable Positive rate was also significant in all, but one model, but had harsh negative effect to index price development in all models. Also, in those models, in which variable Stringency index was significant, the effect to the index price was negative.

Table 32. Coefficient estimates of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	*1409,90	-0,20	-0,77	*2,26	-4,91	*-2256,61	*-135,92	*-3,19
HX30PI	*1425,24	-1,11	*4,12	0,23	*-13,55	*-3507,36	21,79	-2,02
HX50PI	*1745,47	0,87	-1,19	*1,12	-9,06	*-4595,65	*84,30	*-5,92
HX60PI	*12730,75	-10,60	-13,21	*44,85	-61,47	*-55431,95	-871,91	*-45,71
HX10PI	*1135,95	-0,20	0,87	*0,43	-0,12	*-3259,71	-16,40	*-3,37
HX15PI	*2133,20	1,80	2,54	*-4,63	1,36	-904,48	*422,03	-0,64
HX65PI	*934,38	-0,52	2,32	-0,28	1,72	*-2398,68	-2,22	-1,26
HX20PI	*2117,36	-0,39	3,77	*0,80	-10,44	*-4887,53	*-185,35	1,23

Similar variable-specific coefficient estimates of Stockholm sector index models are summarized in Table 33. Unlike in Finnish models, variable Hospital patients was significant in six out of eight models, and it had negative effect to the dependent variable in all of those six models. Variable Reproduction rate had a negative effect in every model, but in Stockholm Telecommunication (SX15PI). Interesting is, that variable Stringency index was significant and had a positive effect in every model.

Table 33. Coefficient estimates of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	*463,82	*-0,44	0,96	*0,10	-1,52	*-2872,15	-31,85	*27,94
SX30PI	*789,84	*-0,25	0,18	0,05	-1,80	-202,09	*-106,70	*26,42
SX50PI	*614,89	*-0,50	0,71	*0,16	-1,73	-1338,85	*-161,97	*33,90
SX60PI	*881,78	0,16	-0,25	0,03	*-1,61	*1509,61	*-173,70	*8,66
SX10PI	312,06	*-0,61	1,61	*0,12	-2,06	*-3134,51	*-90,85	*26,09
SX15PI	*602,39	*-0,28	*0,64	0,01	*1,31	-371,73	*20,48	*5,45
SX65PI	89,42	-0,07	-0,05	*0,03	0,62	320,60	-9,39	*8,08
SX20PI	*927,94	*-0,74	2,09	*0,15	-2,35	-453,44	*-151,17	*37,12

4.2.3. The second wave

The second wave occurred 1 October 2020 – 30 July 2021 and from Figures 2, 5 & 6 can be noticed, that it included two peaks when measured in New deaths, Hospital patients and ICU patients. R-squared values were quite high in all Helsinki sector index models (Table 34), 0,648 being the lowest in Helsinki Health Care index model (HX20PI) and highest 0,854 in Helsinki Oil, Gas & Coal index (HX60PI) model. P-values in all models were close to 0,000. Similarly, R-squared values of Stockholm sector index models were quite high (Table 35) and fairly close to R-squared values of wave one. The lowest R-squared value was 0,661 in model Stockholm Telecommunication (SX15PI) and the highest 0,883 in Stockholm Health Care (SX20PI).

Table 34. R-squared and P-values of Helsinki sector index models.

Index	R-squared	P-value
HX55PI	0,786	0,000
HX30PI	0,676	0,000
HX50PI	0,714	0,000
HX60PI	0,854	0,000
HX10PI	0,818	0,000
HX15PI	0,678	0,000
HX65PI	0,773	0,000
HX20PI	0,648	0,000

Table 35. R-squared and P-values of Stockholm sector index models.

Index	R-squared	P-value
SX55PI	0,703	0,000
SX30PI	0,824	0,000
SX50PI	0,792	0,000
SX60PI	0,802	0,000
SX10PI	0,767	0,000
SX15PI	0,661	0,000
SX65PI	0,776	0,000
SX20PI	0,883	0,000

Variable-specific P-values of Helsinki sector index models are presented in Table 36. In addition to high R-squared values of the models, also P-values of the variables were low in most of the models. Variables New deaths and Stringency index were significant in all models. Variables Hospital patients, ICU patients and New cases were significant in seven out of eight models and variable Positive rate was significant in six out of eight models. Also, there were models, in which all variables were significant.

Table 36. P-values of coefficients of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	0,137	0,000	0,003	0,007	0,000	0,331	0,000	0,000
HX30PI	0,000	0,000	0,090	0,000	0,000	0,000	0,131	0,000
HX50PI	0,000	0,000	0,044	0,001	0,000	0,019	0,009	0,000
HX60PI	0,000	0,531	0,000	0,000	0,000	0,000	0,190	0,000
HX10PI	0,530	0,000	0,026	0,000	0,000	0,034	0,057	0,000
HX15PI	0,538	0,017	0,021	0,000	0,000	0,003	0,000	0,000
HX65PI	1,000	0,000	0,031	0,006	0,000	0,024	0,001	0,000
HX20PI	0,000	0,000	0,025	0,222	0,000	0,103	0,000	0,000

Almost as good results with P-values were with Stockholm sector index models (Table 37). Variables Hospital patients, ICU patients and Stringency index were significant in all models. Variable reproduction rate was insignificant only in Stockholm Technology index model (SX15PI). Variable Positive rate was significant in six out of eight models and New deaths in five out of eight models. All the variables were significant in Stockholm Telecommunication model (SX15PI).

Table 37. P-values of coefficients of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	0,000	0,000	0,000	0,271	0,148	0,008	0,000	0,000
SX30PI	0,000	0,000	0,000	0,102	0,003	0,008	0,000	0,000
SX50PI	0,000	0,000	0,000	0,057	0,150	0,004	0,000	0,000
SX60PI	0,000	0,000	0,000	0,088	0,005	0,000	0,000	0,004
SX10PI	0,530	0,000	0,026	0,000	0,000	0,034	0,057	0,000
SX15PI	0,538	0,017	0,021	0,000	0,000	0,003	0,000	0,000
SX65PI	0,000	0,000	0,000	0,136	0,000	0,111	0,000	0,001
SX20PI	0,000	0,000	0,000	0,103	0,599	0,331	0,000	0,000

Estimated coefficient values were more in line from model to model in Helsinki sector indices (Table 38). Variable Hospital patient, had negative effect in every model, in which it was significant. Also, variables New death and Positive rate had clear negative effect on index price development. However, variables ICU patients, New cases, Reproduction rate and Stringency index had positive effect in every, or almost in every model. Helsinki Oil, Gas & Coal index model (HX60PI) had interesting results, when almost every coefficient estimates´ sign, positive or negative, was opposite than almost in every other model.

Table 38. Coefficient estimates of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	128,38	*-0,79	*3,15	*0,18	*-26,94	-1518,04	*255,61	*24,67
HX30PI	*578,08	*-1,57	2,75	*0,65	*-47,91	*-8874,39	127,72	*22,80
HX50PI	*945,77	*-1,06	*2,38	*0,25	*-40,41	*-4054,86	*161,74	*19,54
HX60PI	*7882,31	1,03	*-64,33	*-4,98	*434,39	*112760,52	-577,21	*149,66
HX10PI	-59,20	*-1,17	*2,60	*0,39	*-43,29	*-3636,65	115,76	*28,53
HX15PI	141,02	*-1,33	*-6,58	*0,79	*-78,58	*-12581,18	*575,14	*44,26
HX65PI	0,03	*-0,69	*2,00	*0,16	*-29,04	*-3077,81	*166,68	*20,68
HX20PI	*1380,52	*-0,63	*1,64	-0,06	*-11,00	-1743,96	*169,78	*11,48

There were similarities with the coefficient estimates Stockholm and Finnish sector index models and the results of Swedish models are presented in Table 39 below. For instance, variable Hospital patients had a negative effect in every model and variable New deaths almost in all the models in both countries. Also, variable ICU patients had positive effect in almost all models in Finland and Sweden. On the contrary, variables Reproduction rate and Stringency index had opposite effect in Finland and Sweden. Those variables affect negatively in every model, excluding Stockholm Technology (SX10PI) and Stockholm Telecommunication (SX15PI).

Table 39. Coefficient estimates of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	*3265,00	*-0,25	*2,10	0,01	-0,50	*1850,43	*-346,03	*-12,07
SX30PI	*4720,51	*-0,29	*2,30	0,02	*-1,21	*2129,94	*-636,50	*-27,30
SX50PI	*4447,36	*-0,35	*2,42	0,02	-0,56	*2261,42	*-593,64	*-20,35
SX60PI	*2463,78	*-0,36	*1,36	0,01	*-0,94	*3842,49	*-733,94	*-4,62
SX10PI	-59,20	*-1,17	*2,60	*0,39	*-43,29	*-3636,65	115,76	*28,53
SX15PI	141,02	*-1,33	*-6,58	*0,79	*-78,58	*-12581,18	*575,14	*44,26
SX65PI	*853,66	*-0,16	*1,12	0,01	*1,01	447,12	*-110,02	*-2,33
SX20PI	*4934,81	*-0,17	*1,22	0,01	0,13	501,96	*-448,46	*-24,48

4.2.4. The third wave

The third wave in this study was defined for period 2 August 2021 – 7 April 2022. R-squared values of Helsinki sector index models (Table 40) were on average lower than in the second wave models. Half of the models had R-squared values below 0,700 and Helsinki Health care index model (HX20PI) had the lowest value of 0,2650. The highest R-square value was 0,8330 for the Helsinki Industrials sector model (HX50PI). However, the R-squared values of Swedish models (Table 41) were somewhat similar to the second wave´s results. The lowest value was 0,604 for model Stockholm Telecommunication (HX15PI) and the highest value was 0,848 for model Stockholm Oil, Gas & Coal (SX60PI). All the P-values of Finnish and Swedish models were below 0,000.

Table 40. R-squared and P-values of Helsinki sector index models.

Index	R-squared	P-value
HX55PI	0,6360	0,000
HX30PI	0,4510	0,000
HX50PI	0,8330	0,000
HX60PI	0,7790	0,000
HX10PI	0,7520	0,000
HX15PI	0,4700	0,000
HX65PI	0,7360	0,000
HX20PI	0,2650	0,000

Table 41. R-squared and P-values of Stockholm sector index models.

Index	R-squared	P-value
SX55PI	0,713	0,000
SX30PI	0,776	0,000
SX50PI	0,759	0,000
SX60PI	0,848	0,000
SX10PI	0,856	0,000
SX15PI	0,640	0,000
SX65PI	0,604	0,000
SX20PI	0,816	0,000

The variable-specific P-values of the third wave Finnish models are summarized in Table 42. Even if New cases increased and Positive rate rose during the third wave, there were no Hospital or ICU patients in Finland, meaning that the variables can´t affect index prices. Therefore, those variables were NaN in every Helsinki sector index model. Variable Positive rate was significant in every model, excluding Helsinki Health Care (HX20PI). Variables New cases and Reproduction rate were significant in six out of eight models, New deaths in three and Stringency index only in the half of the models.

Table 42. P-values of coefficients of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	0,000	NaN	NaN	0,000	0,001	0,000	0,009	0,000
HX30PI	0,000	NaN	NaN	0,000	0,005	0,000	0,833	0,000
HX50PI	0,000	NaN	NaN	0,000	0,135	0,000	0,000	0,000
HX60PI	0,000	NaN	NaN	0,000	0,890	0,000	0,000	0,374
HX10PI	0,000	NaN	NaN	0,676	0,019	0,000	0,023	0,069
HX15PI	0,000	NaN	NaN	0,155	0,000	0,000	0,000	0,000
HX65PI	0,000	NaN	NaN	0,000	0,061	0,000	0,803	0,842
HX20PI	0,000	NaN	NaN	0,000	0,000	0,099	0,024	0,999

Unlike in Finland, in Sweden there were almost as many Hospital patients and some ICU patients during the third wave as were during the first and the second waves. Thus, those variables were significant in some models. Variables New Cases, New deaths and Reproduction rate were significant in seven models and Hospital patients and Stringency index in six models. The variable-specific P-values are presented in Table 43 below.

Table 43. P-values of coefficients of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	0,000	0,021	0,117	0,000	0,000	0,000	0,000	0,000
SX30PI	0,000	0,004	0,414	0,001	0,000	0,989	0,000	0,000
SX50PI	0,000	0,860	0,001	0,000	0,012	0,617	0,000	0,291
SX60PI	0,000	0,000	0,000	0,000	0,000	0,000	0,289	0,000
SX10PI	0,000	0,010	0,482	0,002	0,000	0,021	0,029	0,000
SX15PI	0,000	0,005	0,225	0,012	0,000	0,010	0,000	0,001
SX65PI	0,000	0,000	0,000	0,000	0,059	0,000	0,000	0,000
SX20PI	0,000	0,819	0,518	0,788	0,000	0,092	0,000	0,205

The variable specific coefficient estimates of Finnish sector index models are compiled in Table 44. Symbol * indicates, that coefficient estimate is significant with 5 % significancy level. Variable New cases had again positive effect to every index price, excluding Helsinki Health Care index (HX20PI), which was similar during the second wave. Also, New deaths had positive effect on index prices, in every model in which it was significant. Variable Positive rate had a negative effect in every model, but in Helsinki Health Care (HX20PI) in which it was insignificant. The results of the variables Reproduction rate and Stringency index varied by model.

Table 44. Coefficient estimates of Helsinki sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
HX55PI	*1300,27	0,00	0,00	*0,03	*2,29	*-529,77	*-73,98	*11,78
HX30PI	*2233,14	0,00	0,00	*0,02	*2,23	*-894,23	-6,99	*-4,94
HX50PI	*1482,94	0,00	0,00	*0,04	-1,39	*-1509,10	*157,79	*11,00
HX60PI	*16226,12	0,00	0,00	*0,21	-1,40	*-12615,19	*-1758,29	-12,42
HX10PI	*1895,28	0,00	0,00	0,00	*2,23	*-866,66	*-92,47	-2,36
HX15PI	*2435,36	0,00	0,00	0,01	*7,51	*-764,27	*312,37	*10,57
HX65PI	*1333,66	0,00	0,00	*0,04	-2,18	*-1638,36	12,35	0,32
HX20PI	*1913,76	0,00	0,00	*-0,02	*5,17	155,83	*71,98	0,00

There didn´t seem to be any clear patterns in Swedish sector models´ coefficient estimates (Table 45). Variable hospital patient had positive effect in most of the models, such as Stringency index. For instance, almost every variable of Stockholm Oil, Gas & Coal index model (SX60PI) had positive coefficient estimates, excluding Hospital patients and Stringency index. On the contrary, those variables were the only ones, that had positive coefficient estimates in Stockholm Technology index model (SX10PI).

Table 45. Coefficient estimates of Stockholm sector index models.

Index	Intercept	Hosp. patients	ICU patients	New cases	New deaths	Positive rate	Reprod. rate	String, index
SX55PI	*1871,03	*-0,11	-1,00	*-0,01	*7,54	*934,18	*488,20	*3,70
SX30PI	*2754,89	*0,20	0,74	*-0,01	*-6,36	-2,61	*497,85	*-6,04
SX50PI	*2732,89	0,01	*2,33	*-0,01	*-2,29	74,00	*354,88	1,04
SX60PI	*2210,41	*-0,70	*6,74	*0,01	*9,05	*882,33	55,03	*-22,31
SX10PI	*2566,60	*0,15	-0,53	*0,00	*-9,16	*-362,67	*-107,53	*9,88
SX15PI	*995,32	*0,05	-0,28	*0,00	*-2,77	*122,73	*-60,22	*1,10
SX65PI	*272,02	*0,12	*-2,45	*0,00	0,67	*227,32	*185,73	*2,94
SX20PI	*4018,51	0,02	0,58	0,00	*-11,05	-315,98	*-242,58	1,59

4.2.5. The second and the third wave index price predictions

This chapter will include various models and results of index price predictions. The goal of these models was to test if it´s possible to predict future index prices. As previous chapters showed, the results of the sector index models in both countries varied from wave to wave. Linear regression models were first fitted with the first wave COVID-19 data and sector index prices. Then, the second wave COVID-19 data was filled into the model to predict the second wave index prices. Similarly, the third wave COVID-19 data was filled into the model to predict the third wave index prices. In addition, the second wave COVID-19 data and index prices were used to create linear regression models and then the third wave COVID-19 data was filled into the models to predict the third wave index prices. The model accuracy was assessed with RMSE.

The results of Helsinki sector index price predictions are presented in Table 46. Overall, the prediction accuracy was poor and the RMSE values were high. The second wave index price predictions based on the models of the first wave data were better than the third wave prediction based on the same data, due their RMSE values were significantly lower. However, the third wave index price predictions based on the models, which were created by using the second wave data, were more accurate, than using the models based on the first wave data. It seems, that the most recent data gives better prediction accuracy. The lowest

RMSE value 230,00 was on the prediction of Helsinki Health Care index model (HX20PI), that was based on the first wave data and predicted the second wave index prices.

Table 46. RMSE values of predicted Helsinki sector index models.

Waves to predict	1 → 2	1 → 3	2 → 3
HX55PI	415,11	11 664,00	424,17
HX30PI	361,43	602,22	967,71
HX50PI	245,93	4 965,30	443,53
HX60PI	9 585,20	235 340,00	9 314,10
HX10PI	322,13	1 380,20	833,99
HX15PI	1 349,50	26 382,00	1 375,00
HX65PI	357,58	2 267,00	650,49
HX20PI	230,06	3 106,60	963,92

The results of Stockholm sector index price predictions were quite similar as were Finnish models´ predictions and RMSE values were high. (Table 47). Models based on the first wave data predicted the second wave index prices better than the third wave´s. Also, the third wave index price predictions were more accurate when the second wave models were used than if the first wave models were used. Even though, the results were poor. The lowest RMSE value was 45,32 on Stockholm Telecommunication (SX15PI) model, that was created by using the second wave data and it predicted the third wave index prices.

Table 47. RMSE values of predicted Stockholm sector index models.

Waves to predict	1 → 2	1 → 3	2 → 3
SX55PI	558,12	1 830,00	361,31
SX30PI	587,05	1 836,30	810,05
SX50PI	526,23	2 436,70	727,00
SX60PI	383,86	963,57	566,47
SX10PI	686,13	1 995,30	880,68
SX15PI	187,17	307,97	45,32
SX65PI	134,56	507,21	236,24
SX20PI	530,97	2 377,50	614,44

Some models predicted to some extent the trend of the price development of the index (Figures 16 & 17). For instance, previously mentioned Stockholm Telecommunication model, which had RMSE 45,32 predicted the trend quite well, even the peak and the drop of the price (Figure 16). Also, the predicted movement occurred before the actual peaks and drops and thus investor could have had a chance to benefit from the predictions. In addition of intra-country predictions, also contra-country predictions were tested. Some models were build based on Finnish data and then filled with Swedish COVID-19 data to predict Swedish index prices. The results were, not so surprisingly, very bad.

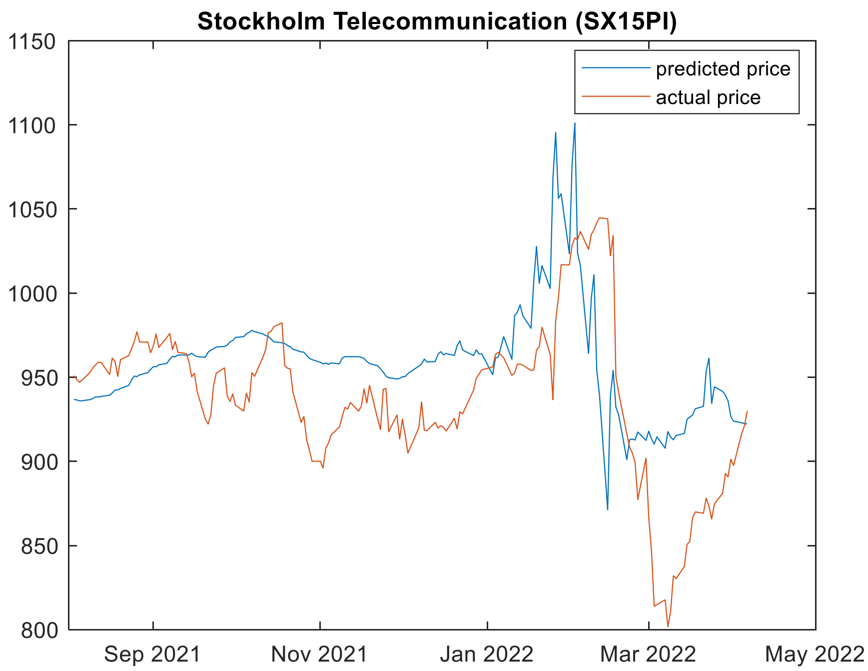


Figure 16. The third wave predicted (2 → 3) and actual prices of Stockholm Telecommunication (SX15PI) index.

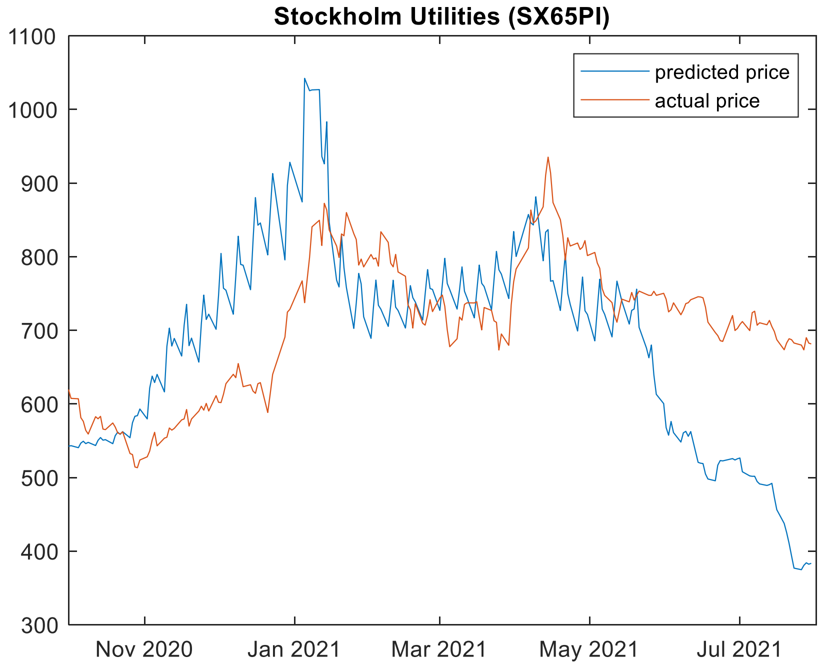


Figure 17. The second wave predicted (1 → 2) and actual prices of of Stockholm Utilities (SX65PI) index.

5. Conclusions

This thesis examined the impact of COVID-19 on the Finnish and Swedish sector indices, what were the main COVID-19 factors that affected the index price development and could it have been possible to predict future index prices based on previous COVID-19 waves. The research was conducted with the data from Nasdaq Nordic and Our World in Data. Time period was from 18 March 2020 to 6 April 2022 and the data was divided in to the following three sub-periods 1) from 18 March 2020 to 30 September 2020, 2) from 1 October 2020 to 30 July 2021 and 3) from 2 August 2021 to 7 April 2022. To assess sector indices´ performance, Sharpe, Treynor, Sortino, Sterling and Calmar ratios were used, and the results of the ratios were ordered by TOPSIS method. Linear regression was used to identify the significant variables that affected the index prices and classical linear regression models were created to predict the following waves' sector index prices. The motivation for this research is the topicality and the exceptionality caused by the pandemic. This research started from the author's interest in the subject and the lack of similar studies.

There were number of previous studies, that examined stock returns of different sectors during COVID-19 pandemic. The results of these studies were quite similar throughout the stock exchanges and same winner and loser sectors stood out from the studies. Some studies focused only on winners, to find the specific variables to predict the future prices and returns. There were also several studies of stock price and return predictions with different methods and models and how these models performed. Some studies used COVID-19 variables, such as new cases or deaths to predict stocks´ development. However, there was a lack of studies that focused on examining what were the main COVID-19 variables, that affected to stock prices, if no other economic variables were used and were they the same during different waves. Even if there were a lot of research on price predictions, there was a lack of studies if it could be possible to predict the price development of future waves based of previous waves´ data and models.

5.1. Discussion of the findings and the research questions

In this chapter, there will be a short discussion on the findings of this study and answers to the research questions presented in chapter 1. Also, there will be a brief discussion of the results of this study compared to other studies.

Question 1: *"Is the performance similar in same sectors in Finland and Sweden?"*

To find out the answer for the first research question, the five different annualized performance measures, Sharpe, Treynor, Sortino, Calmar and Sterling ratios, were calculated for the entire period and for the three waves. When evaluating the entire period from 18 March 2020 to 6 April 2022 it can be said that performance of financial sectors in both countries were very similar. Helsinki and Stockholm Financials indices had quite identical performance. Sharpe ratios were 1,43 and 1,53, Treynor ratios 39,06 % and 37,78 %, Sortino ratios 0,68 and 0,82, Calmar ratios 5,74 and 6,12 and Sterling ratios 78,41 and 82,41. In addition, Technology, Telecommunication, and Utilities indices had somewhat similar results in some ratios in both countries and hence it can be said to some extent that the performance of these sectors were similar in both countries. The results of other indices varied so much that it can be stated that these sectors did not have similar performance.

When evaluating only the first wave from 18 March 2020 to 30 September 2020, it can be stated that the performance of all sectors, excluding Helsinki Telecommunications, was remarkably good. Also, Stockholm Telecommunications index clearly lagged the performance of other indices, but still having, for instance, Sharpe ratio 0,99 and Treynor ratio 25,71 %, while several indices reached Sharpe ratio over 3,00 and Treynor ratio over 100 %. The performance of all the indices of the first wave was so exceptional, that the differences of the results of the ratios were quite high compared to the entire period. However, the closest similar performance was with Financial, Industrial and Technology sectors.

The performance of all indices was good when evaluating the second wave from 1 October 2020 to 30 July 2021. Basic Materials, Financials, and Technology indices performed better, than other indices in both countries. In addition, Basic Materials and Technology indices had quite similar results from the ratios, for instance Basic Materials´ Sharpe ratios were 1,92 and 2,10 and Treynor ratios 41,65 % and 40,09 % whereas Technology´s Sharpe ratios were 3,08 and 3,34 and Treynor ratios 68,14 % and 71,47 %. Thus, can be stated that the performance of these two sectors was similar and Financials sector had somewhat similar performance in both countries.

The performance was poor for almost all indices, with some exceptions, during the third wave from 2 August 2021 to 7 April 2022. Telecommunication indices in both countries had almost identical performance (Sharpe ratios -0,10 and -0,08, Treynor ratios -2,26 % and -1,83 %, Sortino ratios -1,41 and -1,30, Calmar ratios -0,48 and -0,21 and Sterling ratios -3,75 and -3,43) and thus can be stated that the performance was similar in this sector. Also, Industrials, Technology and Utilities had all negative ratios, but the magnitude varied. However, it can be stated that the performance of these sectors was much weaker than other sectors and in that sense the performance was similar.

Davis´ (et al. 2021) study showed, that quick prevention of the spread of virus has led to better stock returns and economic performance in short term, than if the measures had been delayed. Quick prevention of the spread of virus has led to better stock returns and economic performance in short term, than if the measures have been delayed. Finland's and Sweden's COVID-19 strategies differed quite a lot in the early stages of the pandemic. Sweden had looser reaction to the pandemic, and it imposed its restrictions and lockdowns later than Finland. Due to the above, it was by no means self-evident that the sectors would behave in the same way in Finland and Sweden, although the societies and economies are very similar. In very short term, during the first wave, sectors performed mostly similarly in both countries. However, with a couple of exceptions, the performance was better in Sweden. During the second wave, the sectors performance began to differ from each other in Finland and Sweden, but approximately half of the sectors performed quite similarly. During the third wave, the performance was negative in almost every sector, and there was a great difference in only one sector and smaller differences in two other sectors. When evaluating the entire period, the trend performance of the sectors is similar, but the overall performance is better in Sweden.

Question 2: *“Are there any winners or losers among the sectors?”*

To answer the second research question, the results of the first research questions were utilized. The results of Sharpe, Treynor, Sortino, Calmar and Sterling ratios were ordered by using multiple criteria decision-making (MCDM) method called Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Method included, depending on the calculation method, six or seven steps, such as normalizing the alternatives, adding weights (Sharpe and Treynor ratios 35 % and Sortino, Calmar and Sterling ratios 10 % each), determining the Positive-Ideal (NIS) and Negative-Ideal Solutions (PIS), calculating separation measures, calculating similarities S_i^P of each alternative to Positive-Ideal Solution (PIS) and finally conducting the preference rank.

When evaluating the entire period from 18 March 2020 to 6 April 2022, the clear winner in Finland was Technology sector. Also, in the winners could be included Financials, Basic Materials and Helsinki Oil, Gas & Coal sectors. Whereas losers were Utilities, Industrials, Telecommunications and Health Care sectors. It´s still good to remind, that all Finnish sectors performed well when the entire period was evaluated. In Sweden, the performance was overall good through sectors. However, the clear winner was Oil, Gas & Coal sector and the second was Basic Materials sector. The clear loser was Telecommunication sector and also Utilities sector could had been counted as a loser, even though the performance was slightly better and similarity value was much higher than Telecommunication sector.

As previously mentioned, the performance of almost all sectors in both countries were remarkably good during the first wave. Hence, all the sectors could have been evaluated as winners in Finland, except Telecommunication sector. However, the Oil, Gas & Coal index was the overwhelming winner among the Finnish indices. Similarly, all the other sectors, except Telecommunication and Oil, Gas and Coal sectors could be stated winners.

The performance of all the sectors was strong during the second wave in Finland and Sweden. Many of the Finnish and Swedish sectors could have been stated as winners, due to their ratios being good. Based on the results of the TOPSIS, Technology and Financials were the two clear winners and similarly Health Care and Oil, Gas & Coal were the losers in Finland. In Sweden, the winners were the same, but the losers were Telecommunication and Utilities sectors.

During the third wave, the performance was poor in almost all sectors in both countries. The winners of the period were Health Care and Financials, and clear losers were Industrials and Utilities sectors in Finland. In Sweden, the Oil, Gas & Coal sector performed remarkably well, being the clear winner. Also, Financials sector performed ok, and thus can be counted as a winner. The rest of the indices were losers.

Multiple previous studies showed that impacts of COVID-19 have been heterogeneous in different sectors around the world. Pagano (et al. 2021) presented results, that in USA technology sector outperformed the market in the first quarter of the 2020. The market added a disaster premium to companies, that are so called pandemic-resilient when pricing their stocks and thus they expected lower excess returns in the future. Results of this study also implicate somewhat similar observations as Pagano (et al. 2021) presented. In both countries, Technology sector performed excellent during the first wave, which was the shortest period observed in this study. However, Technology sector also had outstanding performance when the entire period was observed.

Szczygielski (et al. 2022) obtained similar results regarding performance differences in different sectors than Pagano (et al. 2021). Their results showed that impacts were smallest in such a sector that provided products or services that were necessity or hard to substitute, such as household products, food and staples retailing and telecommunications. On the contrary, airline, consumer finance and energy sectors were the most impacted. The results of this study were partially parallel to the previous study. There were no big movements in Telecommunication sector in Sweden and the yield was “flat”. In Finland, the performance was slightly better, but not outstanding. The results were different for the Financials and Energy sectors. In both countries, Financials indices performed well when the entire period was observed, especially during the first and the second wave. Also, Oil, Gas & Coal indices, representing the energy sector in this study, performed well in both countries when observing the entire period and the first two waves. It´s good to remind, that Szczygielski (et al. 2022) and Pagano (et al. 2021) used different time period(s) in their studies. Also, in this study, the first weeks of the pandemic were left out due to the missing COVID-19 data, but also the time period is much longer, even if it´s divided to sub-periods. Which comes to Wielechowski & Czech´s (2021) study, which showed that sectors reacted differently on different phases of COVID-19 pandemic. Results of this study highly support Wielechowski & Czech´s (2021) hypothesis that sectors´ performance were dependent on phases of COVID-19 pandemic. For instance, Oil, Gas & Coal sector in Finland had quite high volatility and the performance varied depending on the time period.

Question 3: *“What are the main COVID-19 factors that affected on the index prices?”*

To find the answer to the third research question, classical linear regression models were created, where the COVID-19 variables were x_k and the sector index prices were *y*. Models´ R-squared values varied from 0,21 to 0,79 when the entire time period from 18 March 2020 to 6 April 2022 was observed. Thus, the reliability of the results varied from almost none to quite reliable. Variables Hospital patients, New cases, Positive rate, Reproduction rate and Stringency index were the variables, that were significant in most of the Finnish and Swedish models. In addition, the variable New deaths was significant in all Swedish models. From those variables, Hospital patients and New cases had positive effect on index prices when all the others had negative effect in both countries, except Positive rate which had also positive effect on some of the Swedish sectors. However, the R-squared values were mostly low and most of the indices developed positively during this period. Therefore, these results cannot be considered very reliable, and it is more reasonable to study the results in waves.

R-squared values increased significantly, when observing the results from the first wave from 18 March 2020 to 30 September 2020. In Finland, variables New cases and Positive rate were clearly significant almost in every model and Reproduction rate and Stringency index in half of the models. New cases had a positive effect on index prices whereas Positive rate, Reproduction rate and Stringency index had clear negative effect. In Sweden, the results differed a bit and variables Hospital patients, New cases, Reproduction rate and Stringency index were significant in most of the models. Noteworthy is, that Stringency index had positive effect to all Swedish indices.

R-squared values were almost similar in the second wave than in the first wave. The greatest difference is that almost all the variables were significant in every model. Only exception was variable New cases, which was significant only in two Swedish models. Variables ICU patients and new cases had a positive effect almost in every model in both countries, whereas variables Hospital patients, New deaths had a negative effect. The most interesting differences were with variables Positive rate, Reproduction rate and Stringency index. The first one had clear negative effect to Finnish index prices (except in one model) and positive effect in all but two models in Sweden. The last two had a clear positive effect to Finnish models and negative to Swedish models.

During the third wave, COVID-19 didn´t have similar effect on Finland as on Sweden. There were no hospital and ICU patients in that period in Finland and thus they couldn´t have any relationships with index prices. The R-squared values were still quite high in all models and most of the variables were significant in all models. This time, only Positive rate still had negative impact in all index prices in Finland and Reproduction rate and Stringency rate in half of the indices. The results of Swedish models were mixed and only pattern was, that New cases and New deaths impacted more negatively than positively to index prices.

Overall, the factors affecting index prices varied during waves. Variable Positive rate can be said to be the main factor that affected the index prices consistently, negative way, in every wave in Finland. New deaths variable was similar in Sweden.

Razali & Nur-Firyal (2021) studied COVID-19 cases and deaths and S&P 500, FTSE, Nikkei 225 and KLCI indices and found that COVID-19 deaths and cases had contemporary relationships and predictive abilities on the abnormal index prices. Tuna (2021) studied if COVID-19 deaths, COVID-19 case numbers and health news had relationship with index performances. The results indicated that those variables had higher performance as predictors than historical return values in all sectors of both Islamic and conventional financial markets. Similarly, Afees (et al. 2020) showed in his study, that COVID-19 cases and deaths had a negative and statistically significant effect on stock returns. The results of this study are somewhat consistent with the aforementioned studies, but there are also differences. As mentioned, the factors affecting index prices varied during waves. Variable New deaths had clear negative effect on index prices in Sweden, but not in Finland, at least in all waves. Variable New cases had positive effect on Finnish sector indices in most cases, even if the variable was clearly significant. However, New cases had negative effect on indices in most of the cases and the waves. Based on results of this study, can be said, that only two COVID-19 variables, such as New cases and New deaths, is not enough, due there seems to be more significant health related variables also.

Question 4: *"Can index prices be predicted based on COVID-19 data?"*

As already discussed in the previous section, linear regression models were used to examine which COVID-19 factors affected sector index prices. Same linear regression models and in-sample method were used to test if those variables could predict the prices. R-squared values were low, when the entire time period from 18 March 2020 to 6 April 2022 was observed. In Finland, the lowest value was 0,210 and highest 0,489 and in Sweden the lowest value was 0,341 and the highest 0,79. The model with 0,794 R-squared was Stockholm Oil, Gas & Coal (SX60PI) index and it was the only model, which could be said to have some kind of predicting power. The R-squared values for all other models were so low that they cannot be said to have reliable predictive power when observing the whole sample.

Models based on the first and the second wave data had significantly higher R-squared values than models that based on the whole data. The R-squared values varied over the models, but in general, the values were between 0,700 and 0,900. The R-squared values decreased both, in Finnish and Swedish third wave models, being between 0,265 and 0,856. However, the majority of models had R-squared values between 0,700 and 0,856. Can be said, that those models could predict index prices to some extent in the same wave, when using linear regression models and in-sample method.

Razali & Nur-Firyal (2021) studied whether COVID-19 cases and deaths could explain and predict S&P 500, FTSE, Nikkei 225 and KLCI indices. They created ARIMA and Linear Regression models and found that COVID-19 deaths and cases had contemporary relationships and predictive abilities on the abnormal index prices and concluded that linear regression model was able to predict index prices better than ARIMA. Tuna (2021) studied if COVID-19 deaths, COVID-19 case numbers and health news were good predictors for index prices and using regression analysis as a method. The results indicated that COVID-19 variables had higher performance as predictors than historical return values. Tuna also suggested to include more variables in the regression analysis, such as the number of intubated patients, the infection rate and intensive care unit patients. Similar results presented also Afees (et al. 2020), when they used Google searches and health news about COVID-19 cases and deaths to predict stock returns. Their findings were, that single predictor model outperformed the historical average model both for in-sample and out-sample. The results of this study are similar to some extent with previous studies. Time period used in the regression analysis and model should be short enough to have proper reliability and that it wouldn´t capture too high volatility. Based on the results it seems, that predicting index prices to some extent is possible in the short period and in the same wave.

Linear regression models were also used to test the ability to predict the price development of indices in future waves of COVID-19. Those models were fitted with the previous waves´ data and then new, next wave´s COVID-19 data was filled in the model. Results were poor almost in all models. RMSE values were high and can be said, that the waves were so different that models fitted with the one wave data can´t be used to predict the following waves´ index prices. However, some models (Figures 16 and 17) were able to predict the trend of the index, including the peaks and the drops, to some extent. Also, the predicted movement occurred before the actual peaks and drops and thus investor could have a chance to benefit from the predictions. It was also tested that Swedish index prices couldn´t be predicted with models. Some models were first trained on Finnish data and then tested on Swedish data, with poor results due to the very different magnitude of the COVID-19 variables.

5.2. Reliability of the results and suggestions for further research

The study has a few limitations and areas for improvement. The time period used in this study has a significant effect on performance results. The biggest stock crash at the beginning of the pandemic is missing from the data as there was no COVID-19 data available, and this led to better performance of the indices than if the data used would be from the beginning of February 2020. Recognizing this shortcoming, comparing the results with previous research results from the beginning of the pandemic is not entirely meaningful. However, this research also studied sectors´ performances with different time and this way tried to assess how sectors performed with different waves. Due to the nature of ratios used as the performance measurement tools, the index returns were annualized, not the actual returns of the period. The results were used to compare the performance of the different sector indices, not study the returns themselves. There are multiple performance measurement tools and tools used in this study were chosen by their nature to consider risk and this risk-adjusted return. Beta (β) used in the Treynor ratio was 1, due the sector indices themselves represented the meaningful benchmark for assets. Using, for instance, S&P 500 index as a beta, different time periods and not, for instance, daily data would have led to different results. Similarly, using Gross Indices (GI), which consider for instance dividends, would have led to better sector performances than Profitability Indices (PI).

Linear regression was used as a method to assess the COVID-19 variables that most affected index performances. However, the regression did not include other factors, such as financial or economic factors. Therefore, it is very simplified to assume, that only COVID-19 variables themselves had affected the index performance. However, there were clear indications, that some variables actually had significant effect on some indices´

development. A factor that reduces the credibility of the study is the lack of reporting of OLS results.

Only classical linear regression models were used in this research to study if it could have been possible to predict future index prices based on previous COVID-19 data and index development. Using other methods and comparing their results would have been recommendable, as some have done in some previous studies, even if their results showed, that linear regression model was able to predict index prices better than, for instance, ARIMA. Using out-sample method in the study would have increased reliability and enabled comparison of the results. Model assessment was made only based on R-squared (R^2) and using other model assessment methods would have also increased the reliability. Similarly, reporting only some information from regression analysis, such as P-value and R^2, decreased the reliability and the transparency of the results. The reason was the large amount of data, models and results, and reporting the entire regression result table would have led to dozens of pages being added to the work, in which case the readability would not have been pleasant or meaningful.

The results of this study can be used in case of possible future pandemics or other similar special situations. For example, investors can get excess returns by following the development of certain COVID-19 variables and thus anticipate the development of different sectors. In the same way, companies and business leaders can also take advantage of the results in case of possible new pandemics or similar events since the performance of stocks often correlates with the outlook of companies and the industry. In this case, if necessary, they could anticipate possible future liquidity needs in the direction of the financiers or, for example, by starting to adapt operations. If new restrictions are needed in the future, the authorities can use the results of this report when evaluating the effects of the restrictions on different industries, as the Stringency Index, for example, was a significant factor in the development of most indexes. In addition, this study serves as a good basis for further studies. If the models were changed slightly and economic and financial factors were added to them, it would be somewhat possible to predict the development of the economy in a short time, if a similar exceptional situation were to occur.

The suggestions for future research are based on above mentioned observations and limitations of this study. The future research should contain economic and financial factors, such as GDP, inflation rate, interest rate, companies´ key figures, etc. It would be recommendable to focus on only some sectors, indices or stock and not to study as many sector indices as has been done in this study. Focusing on fewer assets could enable them to be more closely examined and compared among other Nordic countries. As previously mentioned, using variety of methodologies and methods, would also be advisable.

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