Master's thesis

NTNU
Norwegian University of Science and Technology
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Department of Economics

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Passive portfolio management of Statens Pensjonsfond Norge

A simulation of passive portfolio mangement of Statens Pensjonsfond Norge from 2014 to 2022.

Master's thesis in Master of Science in Financial Economics
Supervisor: Joakim Kvamvold
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Abstract

This master's thesis investigates a possible transition of Statens Pensjonsfond Norge (SPN) from active to passive fund management.

Historic data from 2014 to 2023 is utilized to analyze the effects of three case studies involving different trade restrictions, which are compared against the current SPN portfolio. The evaluation includes an assessment of weighted overlap, market impact, and portfolio value.

The findings indicate that SPN successfully replicates the returns of the Oslo Stock Exchange. The simulations fail to replicate the value of the Oslo Stock Exchange to the same extent, primarily due to the notable market impact, which ranges between 3.9% and 6.0% annually. The average portfolio value of SPN is 121.82 billion, which is from 6.29 to 15.36 billion higher than the passive portfolios. Based on these findings, it is not recommended to transition SPN to passive management.

Sammendrag

Denne masteroppgaven undersøker en mulig overgangen av Statens Pensjonsfond Norge (SPN) fra aktiv til passiv fondsforvaltning.

Historiske data fra perioden 2014 til 2023 blir brukt for å analysere effektene av tre casestudier som involverer ulike handelsrestriksjoner, og som blir sammenlignet med dagens SPN-portefølje. Vektet overlapp, markedseffekt og portføljeverdi blir studert.

Resultatene indikerer at SPN replikerer avkastningen til Oslo Børs. Simuleringene replikere ikke verdien av Oslo Børs i samme grad, hovedsakelig på grunn av den betydelige markedseffekten og som varierer mellom 3.9% og 6.0% årlig. Den gjennomsnittlige portføljeverdien for SPN er 121.82 milliarder, som er fra 6.29 til 15.36 milliarder høyere enn for de passive porteføljene. Basert på disse funnene, anbefales det ikke å overføre SPN til passiv forvaltning.

Preface

This master's thesis is a part of the Master of Science in Financial Economics at the Norwegian University of Science and Technology (NTNU). The study is written on behalf of Folketrygdfondet.

This study offers a evaluation of a passive investment strategy for Folketrygdfondet, shedding light on the dynamics encountered by a significant player within a relatively small market.

Engaging in this study has been challenging and educational. The process has increased my knowledge about the Norwegian stock market. Throughout this study, my skills in data processing have increased, and I have learned how to work with extensive datasets while deepening my understanding of the economic theories governing passive portfolio management.

I want to express my gratitude to Mats Engedal Bostad for providing the Python code used to calculate the constructed portfolio and to my supervisor, Joakim Kvamvold, for his guidance throughout this undertaking. His availability, invaluable insights, and provision of the data utilized in this master's thesis have been invaluable contributions to this research.

Trondheim, May 2023

Magnus Moen Sydtangen

Magnus Moen Sydtangen

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List of abbreviations

Explanations

FTF Folketrygdfondet

NOK Norwegian Krone

SPN Statens pensjonsfond Norge

SPU Statens pensjonsfond Utland

WO Weighted overlap

Chapter 1

Introduction

According to studies, the average active portfolio fund does not beat the average passive managed fund (Crane and Crotty 2018; Frino and Gallagher 2001). This is due to the difference between the best and worst active managed funds being much larger than the difference between the best and worst passive managed funds. In other words, the average return of a passively managed fund is higher than the average return of an actively managed fund. Due to this, there has been a discussion since 2010 if Statens pensjonsfond Norge (SPN) should change to a passive investment strategy (Finansdepartementet 2023). The last evaluation from the Ministry of Finance on the management of SPN was delivered on 30.03.2023, where the conclusion was that SPN should continue to be actively managed. The size of SPN is a factor that can make it difficult for SPN to be an index fund (Hanke and Schredelseker 2010) since it will generate high trading costs. SPN had an excess return of 40 billion NOK compared with the reference index from 2007 to September 2022.

Folketygdfondet (FTF) is the manager of SPN, and SPN is the largest owner on Oslo Stock Exchange (Folketrygdfondet 2023a). FTF has since 1967 handled the excess return of the national insurance ("folketrygden") (Folketrygdfondet 2023b). It received deposits from the excess return until 1979, the last year with an excess return for the national insurance. In 2006 are Statens pensjonsfond established, and both Statens pensjonsfond utland (SPU) and SPN becomes a subject to Statens pensjonsfond. Today, FTF is a special law company ("særlovsselskap"), which constitutes the management of the SPN. FTF is the management of the SPN, which is the fund's name. Since the beginning in 1967, FTF has become the largest institutional investor at Oslo Stock Exchange, owning

about 5% of the Norwegian stock market and 10% of the OSEBX. The reference portfolio to FTF contains 60% stocks and 40% bonds, where 85% are in Norway and 15% are in other Nordic countries.

This master's thesis investigates the consequences of a possible transition of SPN from an actively managed fund to a passively managed fund, employing simulations of historical data as the foundation for analysis. The study analyzes multiple case studies that explore the effects of altering trading restrictions within the fund. Furthermore, a comparison is conducted between the existing portfolio and the proposed passively managed strategy, using the same time period for accurate evaluation.

The scope of this master's thesis revolves around examining the potential transition of SPN, specifically its stock holdings in Norway, from an actively managed approach to a passive management strategy. The investigation will primarily focus on the period from 2014 to 2023. Employing simulations based on historical data, conducting several case studies where trading restrictions are altered.

First, the theoretical framework used to analyze the scope of the master thesis, the difference between active and passive portfolio management, the market impact model used, and information about how the index reviews are handled on OSEBX in Chapter 2. Further, the data used in this master thesis will be presented, with explanations of the adjustments done to the data and some descriptive statistics. At the end of Chapter 2, the method used to perform the calculation is presented. Chapter 3 will show the results from the trading restriction FTF has today, with the weighted overlap, trade cost, and portfolio value. In Chapter 4, the trading restrictions are changed to increase the weighted overlap, but trade cost and portfolio value are also studied for the different trade restrictions. The value of the actual portfolio of SPN is presented at the end of this chapter. In Chapter 5, the results are discussed and compared with the limitations of the model, and the data are presented in this chapter before the conclusion of the investigation is presented in Chapter 6.

Chapter 2

Literature review and method

In this chapter, the literature is presented. Further, the data used in the master thesis, along with the adjustments of the data and some descriptive statistics is presented. The method used to calculate the simulations is presented at the end of the chapter.

2.1 Literature study

In this section, the literature used in this master thesis is presented. First, the difference between a passive and active portfolio management is discussed, with the differences in α and weighted overlap. Second, the model for market impact and the index reviews conducted at OSEBX is be presented.

2.1.1 Passive and active portfolio management

Passive portfolio management has two different strategies: a buy-and-hold strategy and an index strategy (Focardi and Fobazzi 2004). In the buy-and-hold strategy, the portfolio of stocks is bought based on some criterion and held until the end of the investment horizon. This strategy is referred to as a passive strategy, but there are active elements in the portfolio's construction. An index strategy aims to create a portfolio with the exact return as an index by replicating the index's benchmark. The index strategy is often called passive since the portfolio manager performs no active choices. To have an index strategy, the manager buys and sells stocks to keep a portfolio close to the index. Over a time period, the passive investor should lose to the index due to the extra cost of maintaining the portfolio (Hanke and Schredelseker 2010).

There are three main strategies to replicate a reference index: full replications, the capitalization approach and the cellular method. Using the full replication method, the manager buys all the stocks with the same portfolio weights as in the index. The capitalization approach aims to replicate the index by investing in the largest stocks in the index, and the smaller stocks have an evenly small portfolio weight, with the goal of achieving the exact return as the index. In the third strategy, the cellular method, the manager defines risk factors where the stocks in the index are categorized.

In active portfolio management, it is the portfolio manager's subjective valuation of the market's future development (Focardi and Fobazzi 2004). The active portfolio managers invests in stocks they think are undervalued and sells stocks thought to be overvalued. In an efficient market, it is not possible to create excess returns unless the manager has an information advantage (Fama 1970). The information advantage can either be that the manager has information that other portfolio managers do not have or they are able to process the information better than the other managers.

Hanke and Schredelseker (2010) suggest that the passive portfolio's market share affects the gains and losses of the active and passively managed portfolios, respectively. With an increased part of the market share, a passive investor should give the active investor a higher return, while the passive investor are losing more.

Measurements of passive portfolio management

An index fund is trying to replicate the performance of the index (CEPF® 2023). To classify if the fund has active or passive portfolio management, Forcardi and Fobazzi (2004) suggest using alpha (α) and tracking error. α is defined as the average active return over some time period, where the active return is the difference between the actual portfolio return and the benchmark index return for a given period. The tracking error is defined as the standard deviation of the active return. Table 2.1 shows the limits for α and tracking error suggested by Focardi and Fobazzi.

Table 2.1: Measures of management categories from page 553 in (Focardi and Fobazzi 2004)

	Indexing	Enhanced indexing	Active management
Expected alpha	0%	0.5% to 2.0%	2.0% or higher
Tracking error	0% to 0.2%	0.5% to 2.0%	4.0% or higher

With an index strategy, the portfolio manager seeks to construct a portfolio with a risk profile similar to the index, so the expected α is zero, except for transaction costs. Tracking error should be zero in theory, but due to issues not discussed further in this thesis, tracking error have a small positive value. An active portfolio should seek to differ from the risk profile of the benchmark portfolio and have an expected α of more than 2% and a large tracking error larger than 4%. Enhanced indexing is a strategy between indexing and active management and is often represented by partly replication or optimized selection of stocks.

The total return of active managers is generally lower than the total return of the indexes (Harris 2003). Active managers often lose to the index due to brokerage commissions and management fees. Index investor should all else equal slightly unperformed compared to the index due to transaction cost, management fees, and rebalances. As a group, the expected return of an index fund is higher than the expected return of a fund with active management.

Weighted overlap

Weighted overlap (WO) are a measurement of the replication of the benchmark index. WO measures which degree the portfolio replicates the index. A portfolio weight equal to or higher than the benchmark gives 100% overlap. A portfolio weight lower than the benchmark give an overlap of below 100%. WO is calculated by summarizing the stock overlap with the benchmark. The WO is a measure of risk since a 100% overlap with the benchmark index give zero in relative risk. The weighted for a stock in a portfolio is calculated by:

$$w_{i,p} = \frac{V_i}{V_p} \tag{2.1}$$

V_i is the value of stock i, and V_p is the value of the portfolio. The reference weights are calculated in the same way as Equation 2.1. WO is the sum of the lowest value of the

stock benchmark and the weight of the stock in the portfolio.

$$WO(P, R) = \Sigma MIN(w_{i,P}, w_{i,R}) \tag{2.2}$$

The sum of the stock weight for both the portfolio and benchmark is 100%. The portfolio, unlike the benchmark, gives a weighted overlap that is less than 100%. A high WO indicate a more passively managed portfolio since the portfolio is close to the benchmark.

2.1.2 Market impact

The price must be moved when selling and buying shares to attract willing traders. Small transaction orders are easier to execute than large orders since the price has to be moved less than for large orders (Harris 2003). Large sellers need to lower the price to get buyers to buy. Meanwhile, large buyers must increase the bid price to buy the stock. Small sellers or buyers do not have this effect on the market. Generally, the cost of trading large orders increases with the number of shares that are bought. When the relative volume of the order is large compared to the stock's traded shares, the market impact increases.

In the paper of Frazzini et al. (2018) in Figure 6, the market impact of a buy/sell order depends on the fraction of the daily volume.

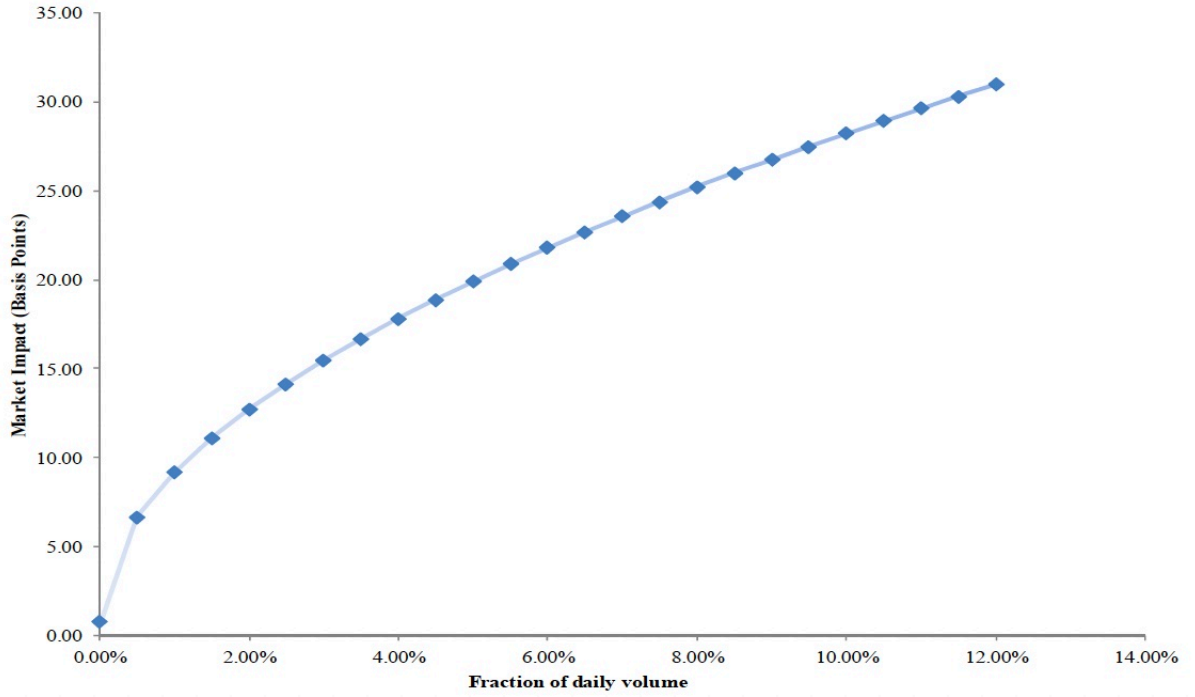

Figure 2.1: Market impact model from figure 6 in (Frazzini et al. 2018)

Figure 2.1 illustrates the market impact of a buy/sell given by the size of daily fraction volume. The model presented goes up to 12% of the daily volume traded. When the traded volume is 12% of the daily traded volume, the market impact is about 31 basis points. At the same time, an buy/sell order with a fraction of 5% of daily volume gives a market impact of 20 basis points.

Calculating the market impact

Frazzini et al. (2018) performed a study across 21 equity markets over 19 years. They measured the trading cost and the impact of the price on larger trades. In the background of this data, they created an empirical equation that matched the trading costs they experienced in the study. The trading cost is illustrated in Figure 2.1. The trading cost

was smaller compared to earlier findings. The equation is:

$$\begin{aligned} Trading\ cost = 0.23 \cdot Beta \cdot IndexRet \cdot buysell - 0.01 \cdot Time\ trend \\ - 0.62 \cdot Log\ of\ ME \\ - 0.13 \cdot Fraction\ of\ daily\ volume + 8.89 \cdot \sqrt{Fractionofdailyvolume} \\ + 0.28 \cdot Idosyncratic\ Volatility + 0.15 \cdot Vix \\ + 0.04 \cdot DGTW - adjusted\ return \cdot buysell \end{aligned} \quad (2.3)$$

where $Beta \cdot IndexRet \cdot buysell$ is the contemporaneous beta-adjusted market return, where $Beta$ is the stocks' predicted beta at the time of order submission, $IndexRet$ is the corresponding index return over the life of the trade, and $buysell$ is a dummy equal to 1 for buy orders and -1 for sell orders. $Time\ trend$ is a linear time trend. $Log\ of\ ME$ equals the log of 1 plus the market value of equity, where ME is in billions of USD. $Fraction\ of\ daily\ volume$ equals the trade's dollar size divided by the stocks' average one-year dollar volume. $Idosyncratic\ Volatility$ is the volatility of the residuals of a regression of one-year daily stock returns on the corresponding value-weighted benchmark. VIX is the monthly variance of the CRSP-value weighted index computed using daily returns. The $DGTW - adjusted\ return$ is the return of the stock minus the return on a portfolio of similar stocks matched on size.

The equation for the international market was chosen because of a study performed by Frazzini et al. (2012) in 2012, looking at each country's trading cost. This paper's average price impact for the Norwegian stock market was closer to the combined or international market compared with the US stock market. Due to that, the international model in the Frazzini et al. (2018) was chosen.

2.1.3 Index reviews

The OSEBX is Free Float Market Capitalisation weighted (EURONEXT 2023a). The two factors that are the weighted factors are:

- Number of shares
- Free Float factor

The OSEBX has semi-annual reviews, and each of these times, the number of shares are updated with the number of shares listed on the Review Cut-Off Date. The free float factor is the number of shares available in the market (Chen 2020). This factor is also updated with the right amount on the Review Cut-Off Date. When a stock gets a change in the number of shares or free float factor, the index weight is changed. From 01.01.2014 to 06.12.2022, which is the period of the data analysis, there have been 18 index reviews. The date for the index review has changed during the period in interest. From 2014 to 2021, it was always the first date with trades in June and December (Nilssen and Lilleberg 2021). Since 2021, the index reviews have been executed on the third Friday in March and September (EURONEXT 2022.) The index reviews are presented in Table 3.1.

2.2 Data

The data used to perform the simulation is presented in this section. The adjustments performed to the data are presented together with descriptive statistics on turnover and number of stocks in the index.

2.2.1 Data set

The data set is a panel data set with daily information about the stock price for all the companies on Oslo Stock Exchange from 01.01.2014 to 06.12.2022. The data set also provides information about the total market value, benchmark weights, average volume traded over the last 20 days, daily return for each stock, and the closing day share price. Data with the portfolio of SPN are used to compare the simulations with the actual portfolio, market value of each stock, portfolio weight, and amount of shares held. FTF provides the data set as a part of the background information for this master thesis.

2.2.2 Adjustments of the data

To simplify the analysis, the data were transposed with stocks on the rows and dates on the columns. When there are no observations for the specific date, the cell have a value of zero. This can happen if the closing price for all stocks is included when the stock is listed on the stock market, but before the stock is listed and after it has been removed from the index, the value of the cell is 0. The stock are sorted alphabetically after the ticker, and

the dates are sorted increasingly. Weekends and holidays affect the time period between the observations.

When a company is sold, merged, or unlisted from the index during the period, the event is registered on the first day of a transaction in the stock. Emissions and splits in the stocks are dated to the date when the amount of shares in the company is changed.

Modifications were made to the portfolio value of SPN. Several dates within the portfolio exhibited substantial deviations characterized by a decline ranging from 25% to 50% on one day, followed by an equivalent subsequent increase on the following day. Such fluctuations, which were not observed in the reference index (EURONEXT 2023b), were considered erroneous. Consequently, the value for each of those days was revised to match the value of the preceding day. The dates that underwent adjustment are provided in the list below:

- 01.01.2016
- 01.10.2016
- 01.01.2017
- 01.01.2018
- 01.01.2019
- 18.02.2019
- 14.10.2019
- 01.01.2020
- 01.01.2021
- 28.01.2021
- 27.10.2021
- 01.01.2022
- 04.05.2022
- 10.05.2022
- 18.06.2022
- 20.09.2022

2.2.3 Descriptive statistics

Descriptive statistics for the data are presented as the turnover and the number of stocks in OSEBX.

Turnover

Turnover is a measurement of the volatility of the shares on OSEBX (Lo and Wang 2000). The turnover is the amount traded divided by the outstanding shares.

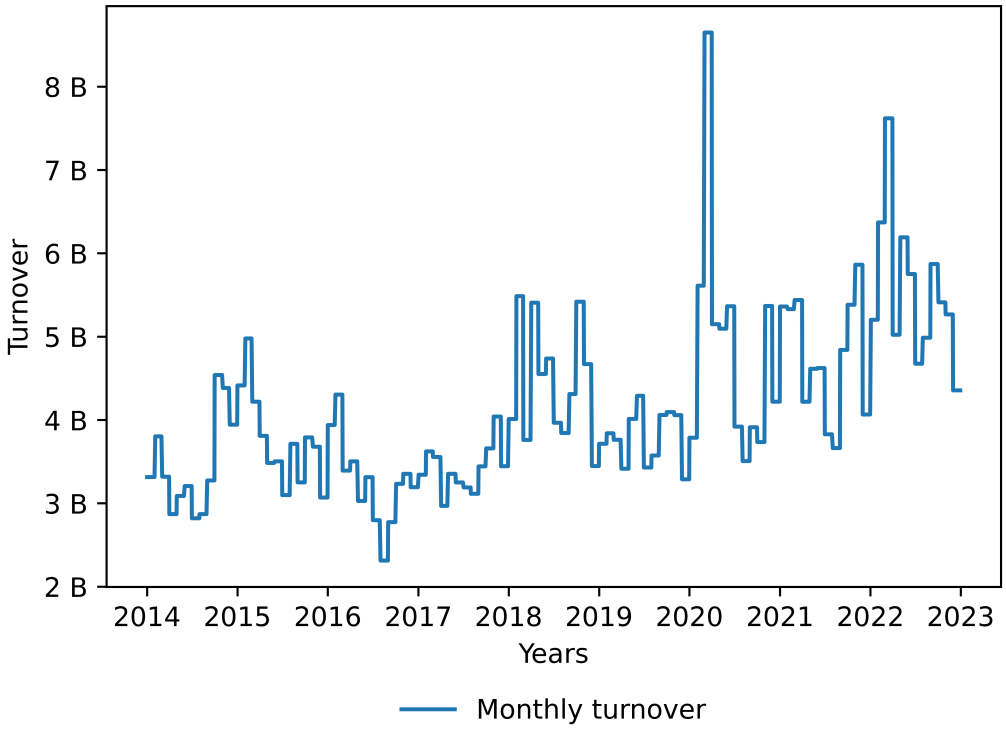

Figure 2.2: The monthly turnover is divided for each business day plotted for each day of the month in billions.

Figure 2.2 illustrates the liquidity of the OSEBX index through the monthly turnover presented in billions. As the figure illustrates, the portfolio's liquidity has increased since the mid-2017 and has larger periods with higher liquidity.

Stocks in and out of the index

Figure 2.3 illustrates the number of stocks in and out of the index.

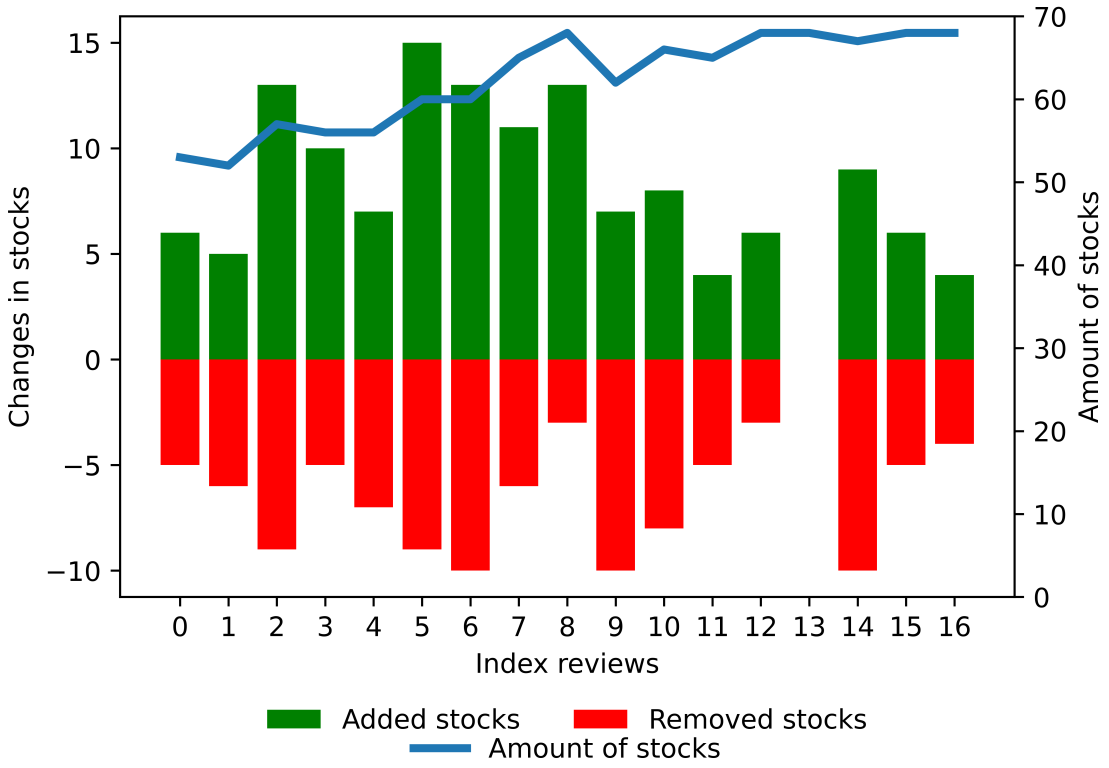

Figure 2.3: The stocks in and out of OSEBX and the total amount of stocks at OSEBX.

OSEBX is defined based on the factors described in section 2.1.3, and the number of stocks vary over time. The data do not consider stocks that are taken off the index for different reasons. In other words, it only looks at the changes in the index reviews. The date of the index reviews is presented in Table 3.1. For the first half of the period, there has been a steady increase in the number of stocks on OSEBX, which has slowed down in the second half, where the number of stocks is quite stable.

2.3 Method

This section presents the method used to calculate the synthetic and constructed portfolio. It focuses on how the trades are calculated, the market impact, and the portfolio rebalancing. In the end, the output of the model will be discussed.

2.3.1 The synthetic portfolio

The OSBEX index is updated two times each year. The index changes are given in Table 3.1. To have something to measure the simulation of the passive investment against, it is necessary to create a portfolio that replicates the index and which is updated daily. The synthetic portfolio makes it possible to perform orders between the two dates, and it is possible due to the rules that the OSEBX index follows a set of rules, as explained in section 2.1.3.

The weights of each stock in the synthetic portfolio are calculated by the weights of the stocks in each index review. In the period between the index adjustments, the synthetic portfolio is adjusted in line with the guidelines of the OSEBX. The synthetic portfolio is calculated with the equation:

$$\tilde{v} = \sum_{i=1}^{n} (P_{i,t} \cdot \tilde{q}_{i,t}) \tag{2.4}$$

$P_{i,t}$ is the price and $\tilde{q}_{i,t}$ is the weight of each stock i at time t. At t=0, the value of the portfolio invested in stock i is:

$$\tilde{v}_{i,0} = (P_{i,0} \cdot \tilde{q}_{i,0}) = w_{i,0} \cdot v_{i,0} \tag{2.5}$$

where $\tilde{w}_{i,0}$ is the published OSEBX weigth of the stock and $v_{i,0}$ is the value of stock at time t=0. Between each index-weight change, the portfolio value is calculated with the following equations:

$$\tilde{v}_{i,t} = \tilde{v}_{i,t-1} \cdot (1 + J_t) \cdot (1 + R_{i,t}) + \tilde{m}_{i,t} \tag{2.6}$$

where $J_{i,t}$ is given by

$$J_t = \sum_{i=1}^{n} \left(\frac{S_{i,t} + E_{i,t}}{P_{i,t-1} \cdot Q_{i,t-1}} \right) \tag{2.7}$$

and $R_{i,t}$ are given by

$$R_{i,t} = \frac{P_{i,t} \cdot Q_{i,t}}{(P_{i,t-1} - DIV_{i,t}) \cdot Q_{i,t-1}} \tag{2.8}$$

where $\tilde{v}_{i,t-1}$ is the value of stock i in the last period, J_t is a factor that takes into account stock-related events. $R_{i,t}$ is the stock dividend adjusted return. $\tilde{m}_{i,t}$ is the effect of spin-offs, mergers, and delistings of OSEBX in the time period. $S_{i,t}$ is the total value of all the

stocks if bought off the index in period t. Similarly, $E_{i,t}$ is the total value of the offering in the stock. $Q_{i,t}$ is the total shares in the stock, and $DIV_{i,t}$ is the dividends paid out in the period.

J_t is the percentage cash payout or deposits for the portfolio in period t. This is immediately reinvested into the portfolio in periods with cash payouts. When there are cash deposits, the stock's weight is reduced. If a company that is 1% of the portfolio is sold and delisted, the other stocks which the index is created from increase the weight with $\frac{1\%}{100\% - 1\%}$, so the value of the portfolio is unchanged.

In theory, the synthetic portfolio is always replicating the OSEBX index. Still, there are deviations from the OSEBX due to missing values in the data. In this master thesis, there is assumed that the synthetic portfolio is the exact replication of the OSEBX, which implies that the portfolio weights in the synthetic portfolio represent the optimal portfolio for the constructed portfolio. When the synthetic portfolio deviates from the constructed value, the value of the two portfolios develops differently. To handle this, a portfolio that calculates the optimal amount of shares for each stock. This calculates the number of trades performed for the constructed portfolio each day. This portfolio is not illustrated, but it is a tool for calculating the constructed portfolio. The optimal amount of shares for each stock in the portfolio is defined by Equation 2.9.

$$\hat{v}_{i,t} = \tilde{w}_{i,t} \cdot v_t \tag{2.9}$$

$\hat{v}_{i,t}$ is the value of stock i in the optimal portfolio at time t, $\tilde{w}_{i,t}$ is the stock weight in the synthetic portfolio, and v_t are the total value of the constructed portfolio at all time.

2.3.2 Constructed portfolio

The goal for the constructed portfolio is to maximize WO within the limitations of FTF. This section presents how the constructed portfolio is created, and more information about the calculation is also presented in appendix A.

Assumptions for the constructed portfolio

Restrictions for the portfolio are presented in Table 2.2, and the goal is to replicate the restrictions that FTF has to handle when managing the portfolio.

Table 2.2: Assumptions and restrictions for the model

Variables	Assumed value
Opening balance	88 billions
Limitations of trade volume	<10% of the traded shares in every stock
Shareholder limitation	Between 0% and 15%
Share in stocks	60%
Share in bonds	40%
Upper trigger limit for rebalancing	65% stocks
Lower trigger limit for rebalancing	55% stocks
The annualized interest rate for cash balance and loans	1%

The opening balance in Table 2.2 is determined with the value of part of FTF, which where invested in stocks on 01.01.2014. The stock part of the portfolio management by FTF is based on 85% in Norwegian stocks, and 15% are shares in the other Nordic countries. In this master thesis, the focus are on stocks registered on Oslo Stock Exchange, and the assumption is, therefore, that 100% of the stocks are in Norway. FTF participate in all issues of shares at the same rate as their ownership rate, and FTF can not short stocks, which means that the value of a company can not be a negative number.

Creating a portfolio that is as close to the synthetic portfolio as possible is an optimization problem, where WO is the measuring unit of how good the replication is. The traded volume gives the maximum number of shares allowed to buy, and the restrictions are set to 10% of the traded shares. A larger amount of the traded volume increases the trading cost and a very strong market impact, presented in section 2.1.2. As a result of the restrictions presented in Table 2.2, there are occasions where it is impossible to buy the total share order the day they are placed and, therefore, have the value in cash to the next day. On these occasions, the order is kept in cash or loaned to the next day, with an annualized interest rate of 1%. The interest rate is based on the average of Nibor yield for one week and one month, which is 0.98% and 1.05% in the time period (Referanser 2023).

The long-term portfolio weights are known, but what triggers the rebalancing of the portfolio is not known. Due to this, an upper and lower trigger value of 65% and 55% are chosen, respectively. The trigger value prevents the distribution of the portfolio from crossing the limitation of maximum 50% and 70% stocks (Lovdata 2022).

Calculation of trades

The deviation between the synthetic and calculated portfolios is calculated at the beginning of each day. The deviation is the trades the portfolio manager wants to do according to the trading rule and is prioritized on the background of the assumptions and restrictions in Table 2.2. An order to buy a stock is limited by the daily trade volume and the maximum allowed ownership in the stock, which is 15%. An order to sell a stock is limited by the daily trade volume, but the shareholding can not be negative.

Large cash transactions occur when there are large dividends, share issues, or taking a company off the stock market. All the transactions are assumed to occur at the beginning of each new day with trades. The distribution of the trade surplus is divided evenly between the stocks with unused trade capacity within the restrictions, even if the shareholdings are too large compared with the synthetic portfolio because this is the only opportunity to avoid cash holdings. Deviating from the synthetic portfolio is preferable because it could build up considerable cash holdings when stocks with low liquidity are bought. In the occasions when the transaction is too large to allocate into stocks after all the trade capacity in the stocks is used, the excess value is stored in cash with an annualized interest rate of 1%.

The Equations used to calculate the transactions within the limitations are presented in appendix A,

Calculation of the portfolio value

The trades are performed at the beginning of each new trade day, and the stocks have returns and other adjustments as dividends or share issues on the same day.

$$v_{i,t} = (v_{i,t-1} + t_{i,t}) \cdot (1 + r_{i,t} + n_{i,t}) \tag{2.10}$$

$$r_{i,t} = \frac{P_{i,t} \cdot Q_{i,t}}{P_{i,t-1} \cdot Q_{i,t-1}} \tag{2.11}$$

where $v_{i,t-1}$ is the shareholdings by the end of the last period, $t_{i,t}$ is the total amount of trades, $r_{i,t}$ is the non-adjusted return in the market value which includes the movement due to dividends and share issues and some M&A trades. $n_{i,t}$ is the effect of spin-offs, mergers, and delistings in the periods where it occurs.

The equation of the value in the stock at the end of the trading day is presented in Equation 2.10. The return on each stock is given by Equation 2.11 and is provided by the price of each stock and amount of shares at the end of this period divided by the cost of each stock and amount of shares at the end of last period.

Market impact

A large buy or sell order affects the stock price for most stocks. As presented in section 2.1.2, these are considered using the model from Frazzini et al. (2018).

The data used in this master thesis lacks information on all the variables presented in Equation 2.3, except for the fraction of daily volume. The market impact is therefore calculated using a simplified market impact model that only considers the fraction of daily volume.

$$\begin{aligned} Trade\ cost = &-0.13 \cdot Fraction\ of\ daily\ volume \\ &+ 8.89 \cdot \sqrt{Fraction\ of\ daily\ volume} \end{aligned} \tag{2.12}$$

This equation gave the Figure 2.4, presented below:

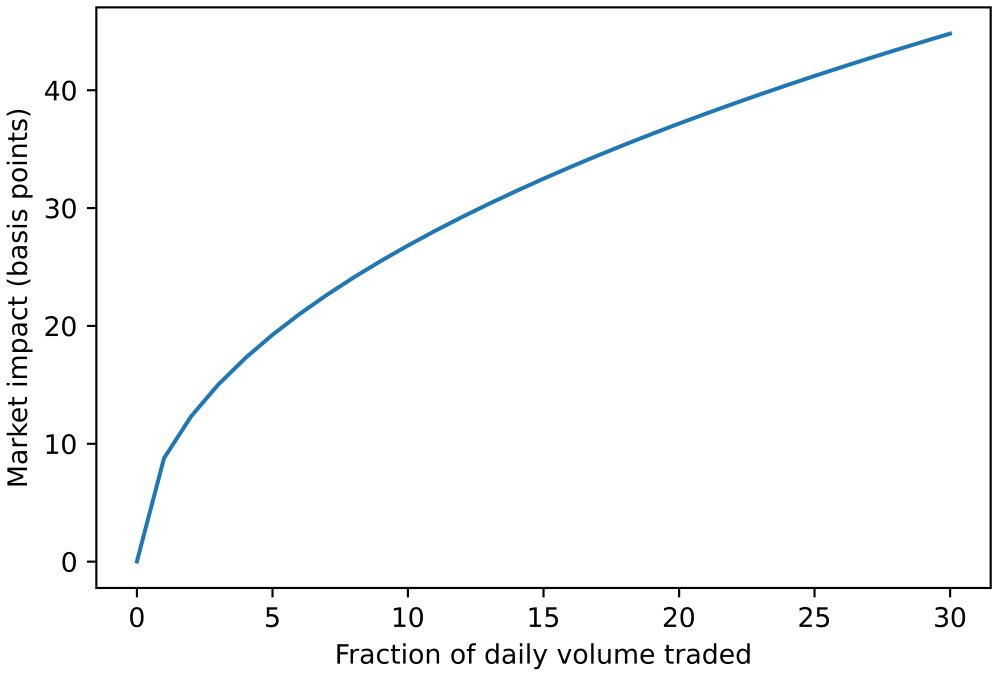

Figure 2.4: Equation 2.12 graphically illustrated.

Since Figure 2.4 is a simplification of Figure 2.1, the plotted values for Figure 2.1 are available. Therefore WebPlotDigitizer (*WebPlotDigitizer - Copyright 2010-2022 Ankit Rohatgi* 2023) where used to compare the plotted graph from Frazzini et al. (2018) and Figure 2.4. The values extracted from WebPlotDigitizer have some uncertainties since it uses the pixels to find the value of the graph. The data are presented in Table 2.3.

Table 2.3: The trading cost for a gien fraction of daily volume. The values in column 2 and 3 are basis points.

Fraction of daily volume	Data from figure 2.1	Data from figure 2.4
2%	12.6	12.3
4%	17.7	17.3
6%	21.9	21.0
8%	25.2	24.1
10%	28.2	26.8
12%	31.0	29.2

As Table 2.3 presents, the difference between the data fetched with WebPlotDigitizer from Figure 2.1 increases as the daily volume fraction increases. The simplification is a good

approximation of the market impact. Still, there is necessary to point out that it might be an error that seems to increase as the fraction of daily volume increases.

Rebalancing

The mandate from the Ministry of Finance contains a distribution between the two asset classes, which causes FTF to rebalance the portfolio when the bond and stock markets have developed too differently for a period. In the model, the rebalance occurs when the average shareholding in the past five days has passed the trigger values of under 55% or over 65% of the portfolio.

The absolute divergence between the synthetic and constructed portfolios is the rebalance transaction's size. The model is designed to quickly adapt to the synthetic portfolio within the given restrictions. Since a rebalance of the entire portfolio typically is about 5% of the portfolio value, the rebalance maximizes the allowed trades over several days. If the rebalance is not finished, maximal transactions are performed independently of the actual deviation from the synthetic portfolio. In most cases, this causes a reduction in WO.

2.3.3 Output of the model

The model returns two parameters that are used to analyze the data presented. These are the portfolio value and weighted overlap.

Portfolio value

The total value of the constructed portfolio is calculated with Equation 2.13:

$$v_t = \sum_{i=1}^{n} (v_{i,t}) \tag{2.13}$$

Weighted overlap

The weighted overlap are calculated by Equation 2.14:

$$VO_t = \sum_{i=0}^{n} (MIN(w_{i,t}, \tilde{w}_{i,t})) \tag{2.14}$$

WO is calculated daily as the weighted sum of the lowest value of the synthetic portfolio and the constructed portfolio for each company.

Chapter 3

Results and analysis

This chapter presents the results of the simulations using the trade restrictions FTF has today. First, the synthetic portfolio is presented before the different case studies with weighted overlap, market impact, and portfolio value. Three case studies have been performed: one with a trading restriction of 10%, 15%, and 30%. By increasing the trade restriction, the aim is to increase the weighted overlap and look at the effect of the portfolio value. At the end of the chapter, the SPN portfolio is presented.

3.1 The synthetic portfolio

The synthetic portfolio attempts to replicate the index between the index changes. Figure 3.1 illustrates the differences between the synthetic portfolio and the OSEBX index value development.

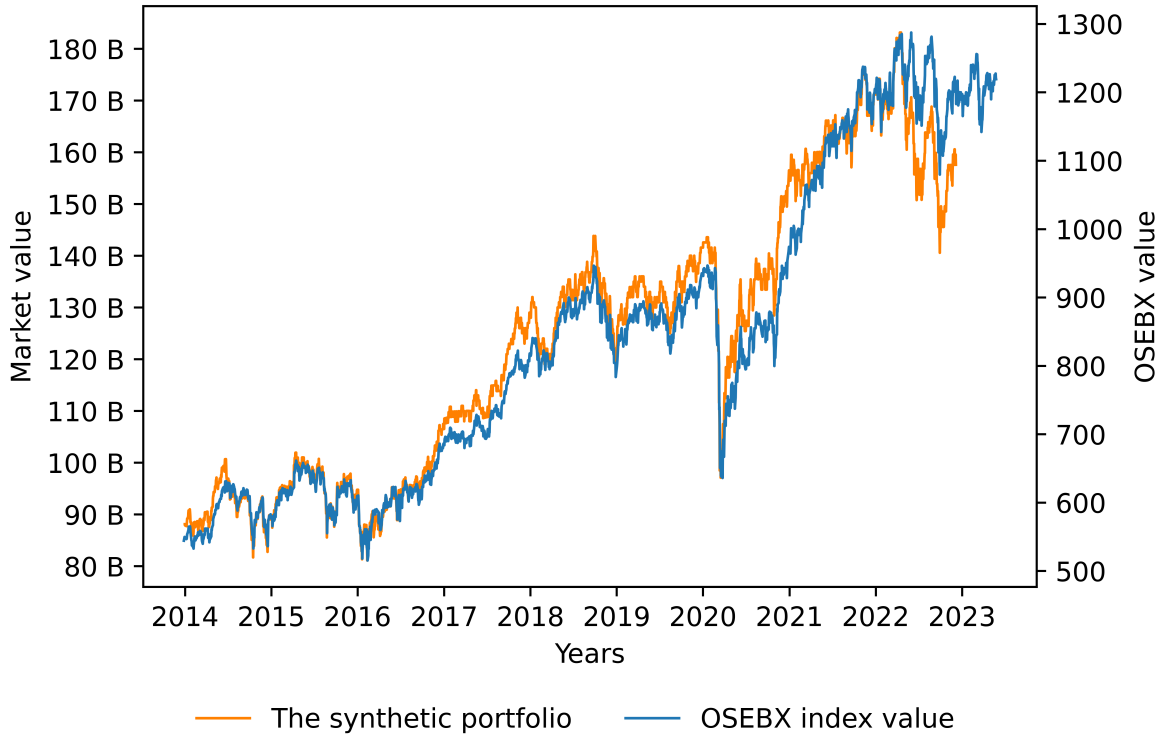

Figure 3.1: Development of the synthetic portfolio value and OSEBX index value.

Figure 3.1 have different values, so there is not possible to compare the value of the two graphs. The market value for the synthetic portfolio is on the left y-axis, and the OSEBX value is on the right y-axis. The development of the two graphs can be compared. The synthetic portfolio follows the development of the OSEBX index value. There are some deviations from 2020 to mid-2021 and in 2022. But overall, the synthetic portfolio illustrates a good replication of the OSEBX index value.

3.2 10% trade restriction

This section is looking at the 10% trading restriction, which is according to Table 2.2. This portfolio contain the same restriction that FTF has today in the active managed portfolio.

3.2.1 Weighted overlap

The weighted overlap is illustrated in Figure 3.2. From the beginning of the period in 2014, the synthetic and constructed portfolio is almost equal and, therefore, closer to

100%. The constructed portfolio is the simulation of the portfolio, which could be the new portfolio of SPN. From the second index review to the end of the data, the weighted overlap is most of the time between 95% and 98%. The reduced WO is due to the trading restriction, which specifies that there is only possible to trade 10% of the daily fraction volume. It also means that 2-5% of the constructed portfolio is overweighted or not in the index.

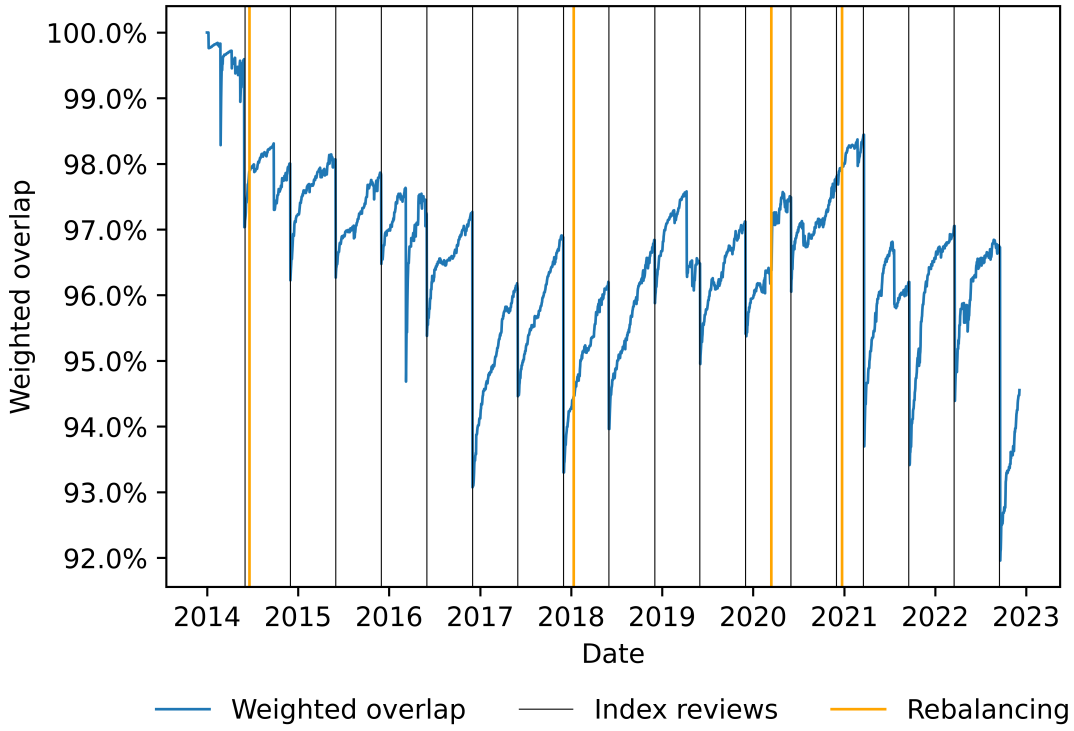

Figure 3.2: Weighted overlap for the trade restriction of 10%

The overlap between the synthetic and constructed portfolios is at the local minimum at the index reviews, illustrated by the black vertical lines in Figure 3.2. The volatility in the stocks will decide the recovery time of the weighted overlap. Since the constructed portfolio has a limit of buying 10% of the daily fraction traded in the stock, low liquidity will create a slower recovery of the weighted overlap than a stock with higher liquidity.

Table 3.1: Weighted overlap before and after index reviews

Index reviews	Date	Overlap before	Overlap after
1	02.06.2014	99.6 %	97.0 %
2	01.12.2014	98.0 %	96.2 %
3	01.06.2015	98.1 %	96.3 %
4	01.12.2015	97.8 %	96.5 %
5	01.06.2016	97.2 %	95.4 %
6	01.12.2016	97.3 %	93.1 %
7	01.06.2017	96.1 %	94.5 %
8	01.12.2017	96.9 %	93.3 %
9	01.06.2018	96.2 %	94.0 %
10	03.12.2018	96.8 %	95.9 %
11	01.06.2019	96.5 %	95.0 %
12	02.12.2019	97.1 %	95.4 %
13	01.06.2020	97.5 %	96.1 %
14	01.12.2020	97.7 %	97.8 %
15	19.03.2021	98.4 %	93.7 %
16	17.09.2021	96.2 %	93.4 %
17	18.03.2022	97.1 %	94.4 %
18	16.09.2022	96.7 %	92.0 %

Table 3.1 presents the varying effect of the index review has on the weighted overlap. The factor with the largest impact on the overlap is the number of changes in the composition of stocks. Stocks that enter the index will have 0% overlap, reducing the weighted overlap. Stocks that are left out of the index will not be counted anymore and will contribute to an indirect reduction in the weighted overlap since the constructed portfolio still have these stocks in the portfolio. Meanwhile, the synthetic portfolio does not have these stocks in the portfolio anymore. The trades performed by the model will increase the transactions within the limitations to increase the weighted overlap.

Dividends, equity financing, and spin-offs will affect the weighted overlap, which has to be fixed with buying and selling shares. Due to restrictions in daily traded stocks, there will not always be a possibility to reinvest the entire amount in new shares in the same stock or other stocks. Due to the absence of information on dividends, equity financing, and spin-offs within the data are it not a problem for the weighted overlap. A issue occurs when the low-liquid stocks have reached its daily trading limit, since the simulation model aims to have no cash at the end of the day. Then the model buys high-liquid stocks which will not increase the weighted overlap, but reducing the amount cash in the portfolio.

Rebalancing between stocks and bonds will have a significant impact, illustrated by the rebalances in Figure 3.2. A rebalance will cause all stocks to trade at the absolute maximum during the rebalancing period. The most liquid companies will therefore be underweighted when there is a rebalancing where stocks are sold or overweighted when there is a rebalancing where stocks are bought. This is illustrated by Figure 3.3. Low liquidity will increase the period where the rebalancing will be ongoing, and extended durability of the rebalancing will reduce the weighted overlap. A rebalance will typically be 5% of the value of the portfolio. The largest differences in each stock are presented in Table 3.2. The reason Aker BP is under-weighted in the constructed portfolio is due to the merger with Lundin Energy, which where fulfilled on 30.06.2022 (*Merger plan signed with Lundin Energy* 2022) and, therefore, not included in the index before the last index review of 2022. Part of the transaction was performed in shares, and therefore, there is a change in the index as presented in section 2.1.3. As the Table illustrates, most stocks over-weighted in the constructed portfolio were removed from the synthetic portfolio and are no longer a part of the index. One example of this is Evry ASA which where delisted when Tieto both the stock (Skaug and Brunborg 2019). On the other side, you have some of the largest and most liquid companies in the index, such as Equinor ASA, DNB ASA, Norsk Hydro, Telenor ASA, and Schibsted ASA where all are one of the 15 largest stocks in OSEBX. Aker BP ASA is the only one of the 15 largest stocks on OSEBX where the synthetic portfolio is larger than the constructed portfolio. At the same time, some of the less liquid stocks are represented with a negative portfolio difference. Stocks such as ArcticZymes Technologies, Arendals Fossekompani ASA, Bank Norwegian ASA, Cadeler, Hafnia Limited, and Kid ASA are represented in Table 3.2 and in appendix B. The list are in total 37 stocks.

Table 3.2: The difference in the constructed portfolio and the synthetic portfolio at 06.12.2022 for 10% trade restriction for stocks with a larger difference than 0.05% of the portfolio value. The portfolio difference is given in percentage. The market value of the constructed and synthetic portfolio is given in billion NOK.

Stocks	Portfolio difference	Market value constructed portfolio	Market value synthetic portfolio
AF Gruppen	0.170	1.216	0.719
Aker BP ASA	-2.341	6.888	9.423
Aker Carbon Capture ASA	0.075	0.150	0.000
ArcticZymes Technologies	-0.070	0.254	0.321
Arendals Fossekompani ASA	-0.163	0.045	0.300
Asetek	0.068	0.134	0.000
Atea ASA	0.065	1.187	0.864
Austevoll Seafood ASA	0.328	0.650	0.000
AutoStore Holdings Ltd	-0.679	0.836	1.783
Avance Gas Holding	0.062	0.123	0.000
BW Offshore Limited	0.127	0.252	0.000
Bank Norwegian ASA	0.084	0.167	0.000
Borregaard ASA	-0.685	0.403	1.439
Bouvet	-0.175	0.212	0.458
Cadeler A/S	-0.185	0.016	0.313
DNB ASA	0.175	20.389	16.384
EVRY ASA	0.122	0.242	0.000
Entra ASA	0.358	1.366	0.537
Equinor ASA	1.055	49.130	38.452
FLEX LNG Ltd	-0.072	1.097	1.013
Gaming Innovation Group Plc	0.099	0.196	0.000
Grieg Seafood ASA	0.211	0.419	0.000
Hafnia Limited	-0.150	0.620	0.750
Kid ASA	-0.065	0.162	0.237
Multiconsult	-0.125	0.063	0.254
Norsk Hydro ASA	0.132	11.902	9.515
Norwegian Finans Holding	0.812	1.609	0.000
Nycode Therapeutics	-0.216	0.095	0.427
Olav Thon Eiendomsselskap ASA	0.219	0.434	0.000
PGS ASA	0.098	0.194	0.000
Schibsted ASA	0.067	3.758	2.962
Telenor ASA	0.162	7.183	5.608
Ultimovacs ASA	-0.069	0.134	0.221
Veidekke ASA	0.145	1.337	0.857
Vr Energi ASA	-0.242	1.029	1.233
Wilh. Wilhelmsen Holding ASA	0.084	0.166	0.000
XXL	0.073	0.144	0.000

To compare the stocks as two groups, they are categorized into the 25% least and 25% most liquid stocks. The difference between the portfolio share of the constructed portfolio and the synthetic portfolio is illustrated by Figure 3.3.

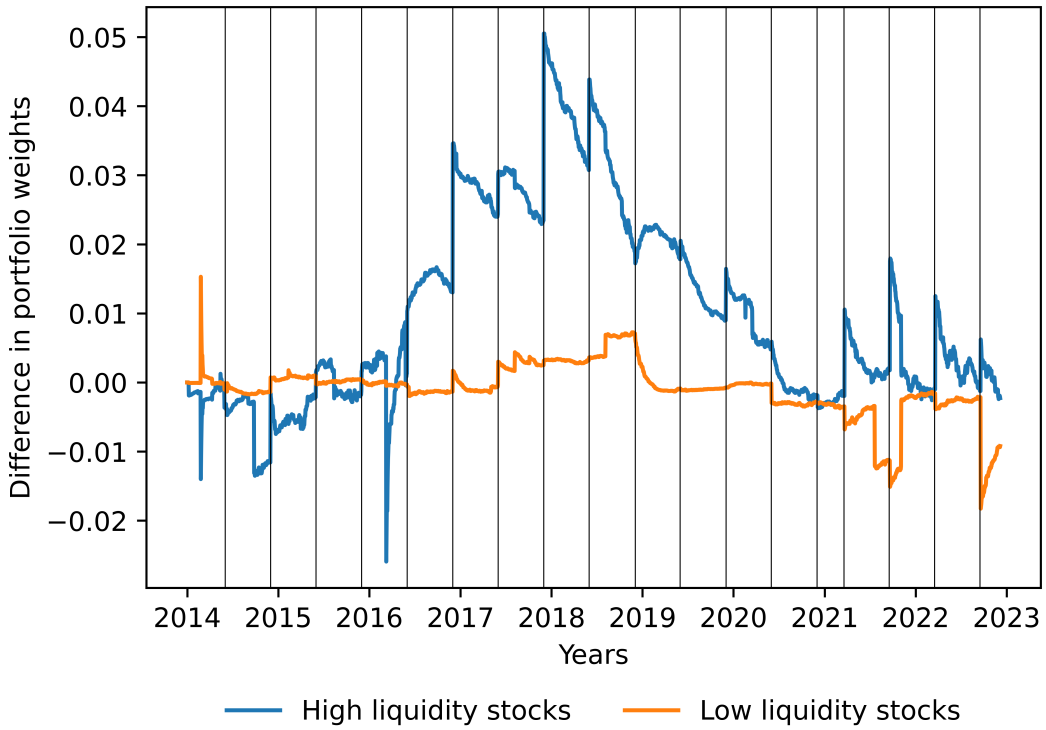

Figure 3.3: Comparison of the portfolio weight of 25% least and most liquid stocks for the 10% trade restriction.

The low- and high-liquidity stocks contain 31 stocks, presented in appendix B. As illustrated by Figure 3.3, the high liquid stocks are also the ones that vary the most if they are over- or under-weighed. There is a period between mid-2016 to 2021 where the most liquid stocks are over-weighted compared with the synthetic portfolio. At the most, the high liquid stocks are about 5% over-weighted, which is in late 2018. The low-liquid companies were 3.43% of the constructed portfolio in 2014, while in 2022, they were 1.78% of the constructed portfolio, with an average over the whole period of 1.25%. On the other hand, the 25% of most liquid stocks went from 79.95% in 2014 to 90.87% in 2022 of the constructed portfolio, with an average throughout the period of 86.03%.

Figure 3.3 illustrates that the large stocks are overweighted during the index changes. Due to the large increase in the difference between the constructed and synthetic portfolios

have a spike in the index change. This illustrates that when index changes occur, a lot of capital is stored in the high-liquid stocks and is reduced against the next index review, as the trading restriction allows for trades in the lower-liquid stocks.

3.2.2 Market impact

The market impact is calculated by using Equation 2.12. The equation considers the fraction of daily volume and returns the market impact. The market impact is presented in Table 3.3.

Table 3.3: Market impact for the portfolio with 10% trade restriction. Column 3, 4 and 5 are given in percentage.

Year	Trade weighted percentage of trades desired	Average market impact	Trade weighted market impact	Portfolio weighted market impact	Total trade cost in NOK
2014	0.5551	0.0809	0.1434	0.0315	2.30 billion
2015	0.5798	0.1065	0.1490	0.0331	2.55 billion
2016	0.5120	0.0996	0.1306	0.0257	2.16 billion
2017	0.5109	0.1202	0.1464	0.0428	2.43 billion
2018	0.5784	0.1245	0.1673	0.0637	4.40 billion
2019	0.5746	0.1115	0.1628	0.0566	4.32 billion
2020	0.6371	0.1001	0.1789	0.0579	5.85 billion
2021	0.6467	0.1368	0.1838	0.0795	11.9 billion
2022	0.5474	0.1312	0.1574	0.0654	10.62 billion

In column 2, the percentage of trades that are desired to be performed within the trade restrictions of the simulation. This is weighted for the number of transactions conducted, performed, weight-adjusted intraday, and then taken as the average of each day within the year. The equation used to calculate the desired and the actual trades are presented in appendix A.1.2 and calculated with Equation A.8 and A.9. In column 3, the average price impact is presented. The average is intraday and the average for each day in a year. The trade-weighted price impact is weighed for the amount of trades intraday and then used the average to find the value within one year. The last column is market impact weighted for the portfolio weight, which also is weighted for the portfolio intraday but for each day within the year, it is used as the average. The total trading cost over the time period is 46.60 billion NOK, in addition, there is a loss of the compounded interest rate on the market impact.

3.2.3 Portfolio value

The synthetic portfolio is a proxy of the index. Figure 3.4 illustrates that the constructed portfolio has a lower market value than the synthetic portfolio. The outgoing balance of the synthetic portfolio is 156.3 billion. At the same time, the outgoing value of the constructed portfolio is 145.19 billion. The difference in market value is from the moments discussed in section 3.2.1.

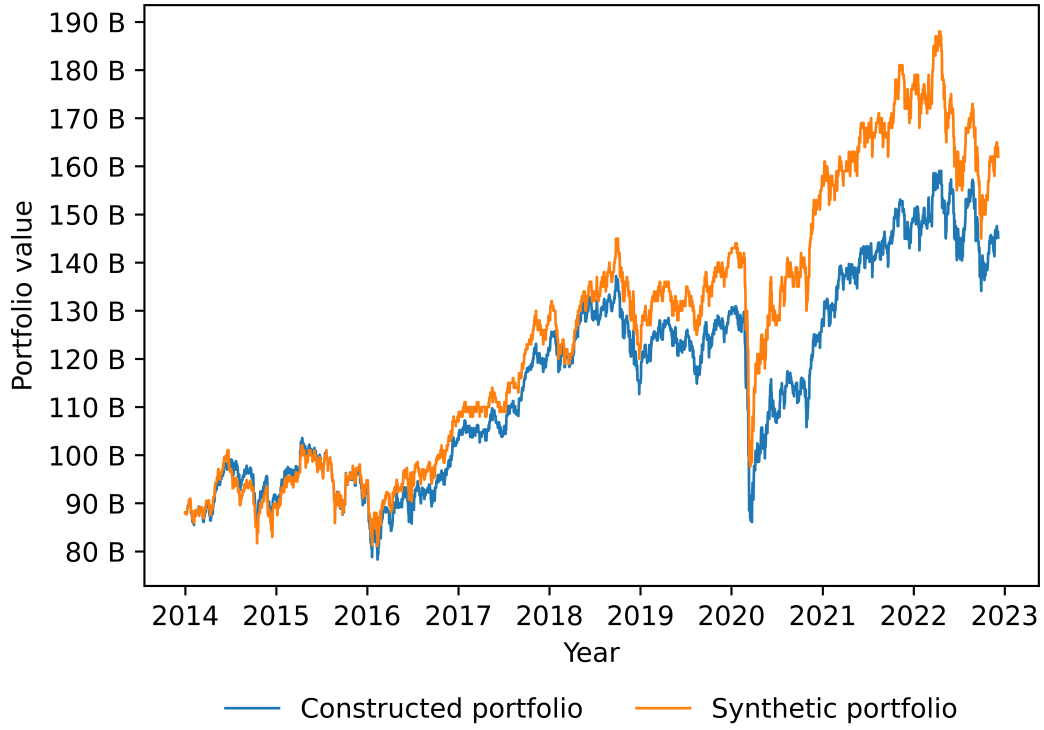

Figure 3.4: The difference in developing the constructed and synthetic portfolio value.

The constructed portfolio in Figure 3.4 are included trading cost, which is discussed in section 3.2.2. The average value of the portfolio is 115.63 billion. The figure illustrates that there are sometimes large deviations between the synthetic and constructed portfolios. On other occasions, there are minor differences. The difference from 2014 to the end of 2019 is relatively small. From 2020 to mid-2022, the portfolios' differences are significant before the difference is reduced. After the market value fell in March 2020, the mechanisms performed many transactions, which increased the trading cost. The difference in deviation is due to the different portfolio weights of the other stocks.

Even though the total trading cost equals 46.60 billion before the compounded interest, the difference would not be this value. Due to differences in the weights in the portfolio will, the return be different, whereas the constructed portfolio in the period has a higher return excluding market impact.

As illustrated by Figure 3.3, there is an overweight in the 25% of the high liquid stocks. The market value of the 25% most and least liquid stocks are plotted in Figure 3.5.

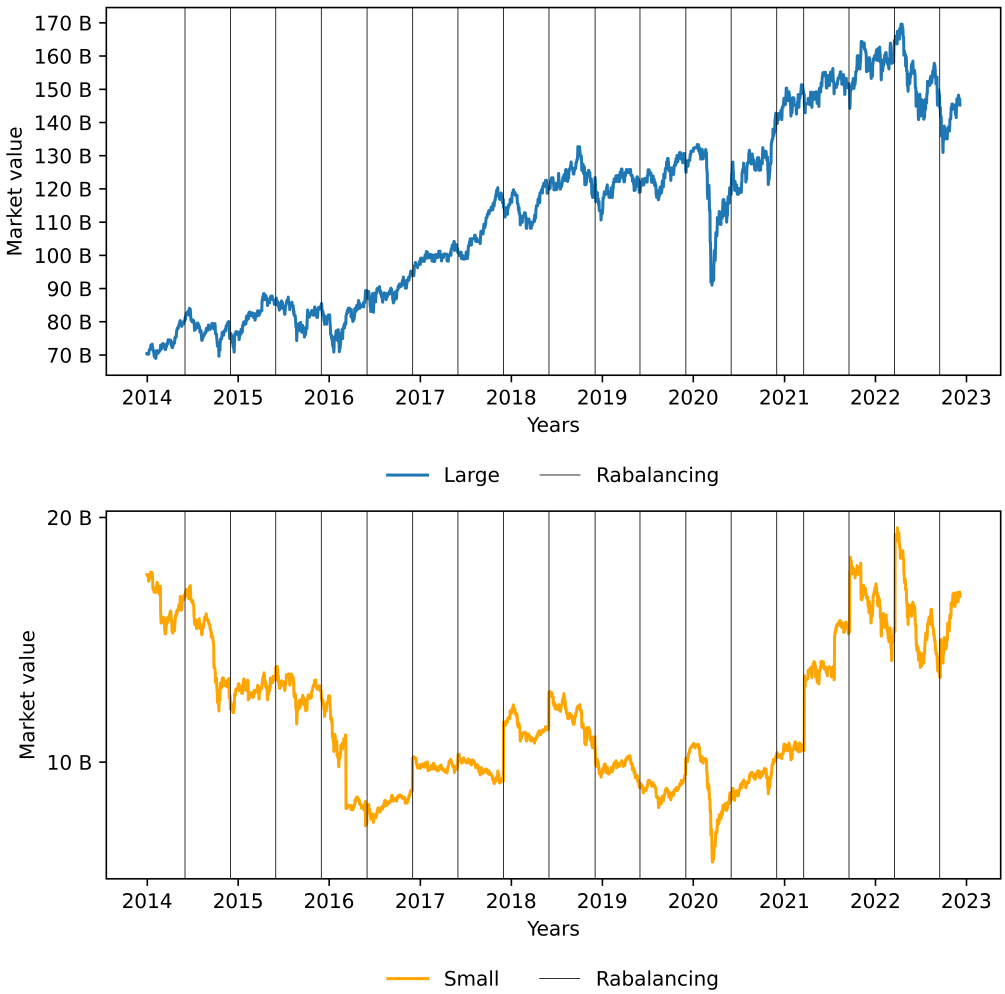

Figure 3.5: Market value of the 25% least and most liquid stocks in the synthetic portfolio.

The 25% most liquid stocks are a large part of the market value. At the same time, the least liquid stocks are a small part of the portfolio. The 25% most liquid stocks have been

a large part of the market development since 2014. Meanwhile, the low-liquid stocks have about the same market value at the end of 2022 as they had at the beginning of 2014. The least liquid stocks have doubled in value between 2020 to the end of 2021. This is both an increase in market value and more stocks added, which are low liquidity which gives the rise in market value.

3.3 15% trade volume

In this section, the trading restriction is increased to 15%. This is the only change in the restrictions in the model presented in Table 2.2.

Weighted overlap

With the SPN being allowed to trade 15% of the daily trades in one stock, the weighted overlap is presented in Figure 3.6.

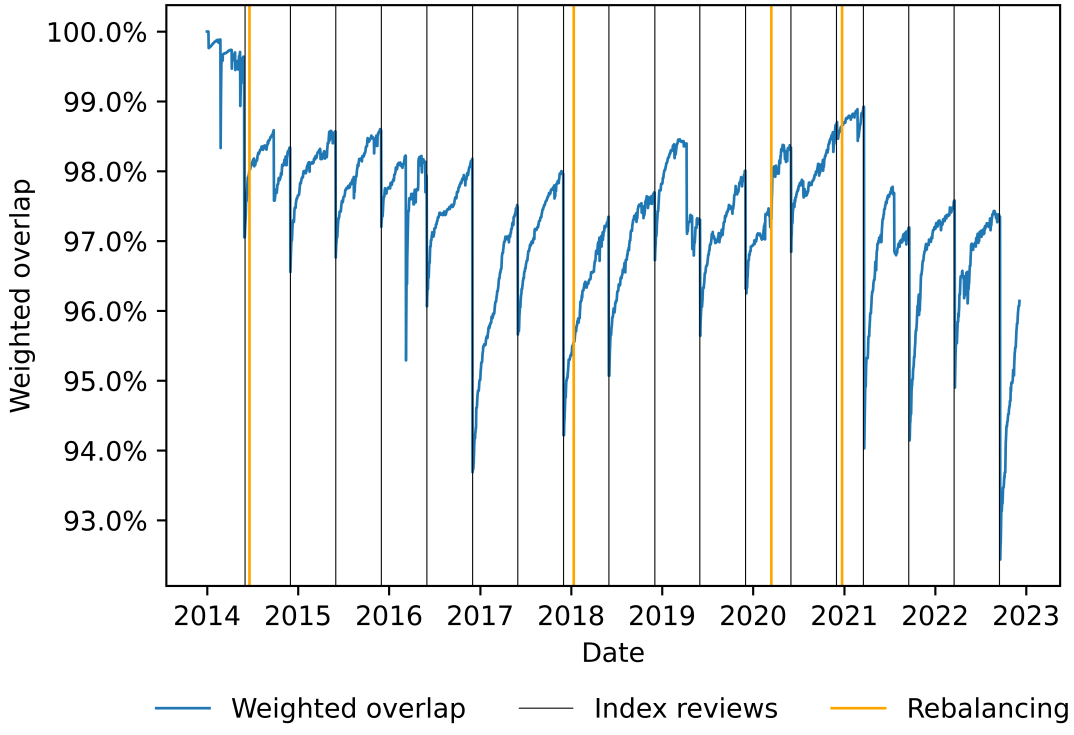

Figure 3.6: The weighted overlap for 15% trade restriction.

The average weighted overlap with 15% in trade volume is 0.9739, less than the original trade volume of 10%, which was 0.9657. The increase in weighted overlap is, on average,

0.82%. The weighted overlap has low values after the index review but increases rapidly to regain a high replication of the synthetic portfolio.

Table 3.4: The difference in the constructed portfolio and the synthetic portfolio at 06.12.2022 for 15% trade restriction for stocks with a larger difference than 0.05% of the portfolio value. The portfolio difference is given in percentage. The market value of the constructed and synthetic portfolio is given in billion NOK.

Stocks	Portfolio difference	Market value constructed portfolio	Market value synthetic portfolio
AF Gruppen	0.138	1.146	0.719
Aker BP ASA	-1.818	7.876	9.423
Aker Carbon Capture ASA	0.108	0.212	0.000
Arendals Fossekompani ASA	-0.152	0.066	0.300
Atea ASA	0.062	1.174	0.864
Austevoll Seafood ASA	0.285	0.561	0.000
AutoStore Holdings Ltd	-0.487	1.209	1.783
Avance Gas Holding	0.055	0.109	0.000
BW Offshore Limited	0.101	0.198	0.000
Bank Norwegian ASA	0.115	0.227	0.000
Borregaard ASA	-0.605	0.558	1.439
Bouvet	-0.144	0.273	0.458
Cadeler A/S	-0.181	0.024	0.313
DNB ASA	0.089	20.094	16.384
EVRY ASA	0.164	0.324	0.000
Entra ASA	0.181	1.009	0.537
Equinor ASA	0.565	47.862	38.452
Gaming Innovation Group Plc	0.098	0.193	0.000
Grieg Seafood ASA	0.194	0.383	0.000
Multiconsult	-0.115	0.082	0.254
Norwegian Finans Holding	0.741	1.460	0.000
Nycode Therapeutics	-0.192	0.142	0.427
Olav Thon Eiendomsselskap ASA	0.168	0.330	0.000
PGS ASA	0.071	0.140	0.000
Telenor ASA	0.099	7.014	5.608
Ultimovacs ASA	-0.050	0.170	0.221
XXL	0.066	0.130	0.000

The increased trading restriction has reduced the number of stocks with a larger difference from the synthetic portfolio than $5 \cdot 10^{-4}$. The portfolio differences are reduced. For example, the positive difference of Equinor ASA is reduced to 0.005. The list is also reduced to a total of 27 stocks.

In Figure 3.7, the 25% most and least liquid stocks are presented with the portfolio value development.

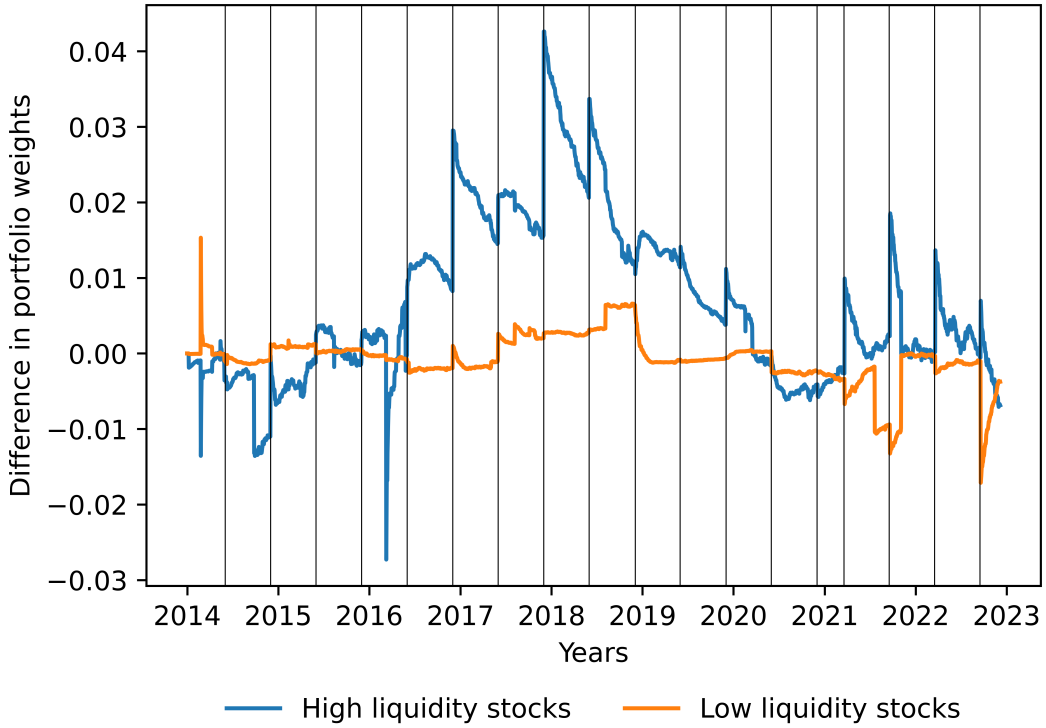

Figure 3.7: Comparing the portfolio weights of the 25% least and most liquid stocks for 15% trading restriction.

As the Figure illustrates, the constructed portfolio slightly differs from the synthetic portfolio for the stocks with low liquidity. The stocks with high liquidity have a more significant difference between the constructed and synthetic portfolios. The differences for the high liquidity stocks are especially great in the time difference between the first index review in 2016 to the first index review in 2020. Before and after this time period, the deviations from the synthetic portfolio are minor and of a temporary form.

3.3.1 Market impact

The market impact for 15% trade restrictions is calculated in the same way as Table 3.3.

Table 3.5: Market impact for the portfolio with 15% trade restriction. Column 3, 4 and 5 are given in percentage.

Year	Trade weighted percentage of trades desired	Average market impact	Trade weighted market impact	Portfolio weighted market impact	Total trade cost in NOK
2014	0.5612	0.0914	0.1745	0.0352	3.03 billion
2015	0.6130	0.1201	0.1878	0.0386	3.80 billion
2016	0.5089	0.1062	0.1563	0.0301	2.84 billion
2017	0.5120	0.1288	0.1772	0.0505	3.79 billion
2018	0.5980	0.1287	0.2048	0.0673	5.67 billion
2019	0.5943	0.1116	0.1979	0.0578	5.82 billion
2020	0.6380	0.0999	0.2109	0.0533	6.87 billion
2021	0.6137	0.1436	0.2077	0.0774	10.48 billion
2022	0.5257	0.1437	0.1839	0.0697	14.94 billion

The market impact with 15% trade restrictions has increased compared to the values in Table 3.3. The sum of the trading costs is 61.53 billion NOK, but the total cost will be larger due to compounded interest.

3.3.2 Portfolio development

Figure 3.8 illustrates the development of the portfolio value with a 15% trade restriction. Increasing the trade restriction by 5% reduces the portfolio value, and the differences between the synthetic and constructed portfolios are increasing.

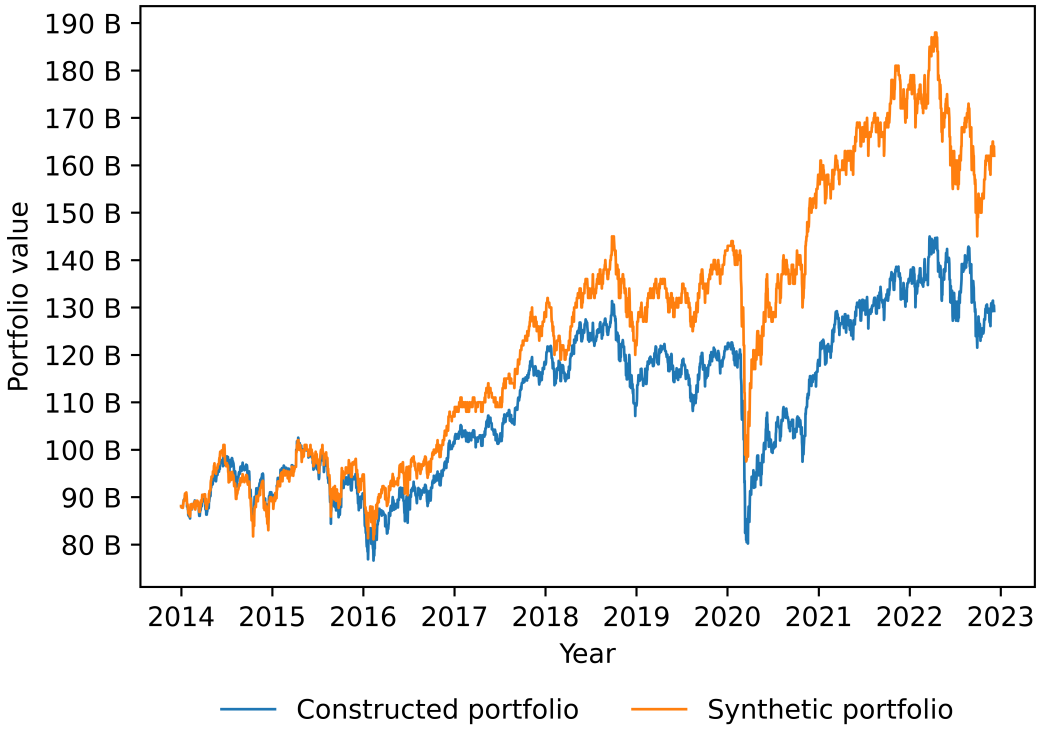

Figure 3.8: Portfolio development for 15% trade restriction.

The difference in value is not particularly visible for the given trade volume, but the portfolio value for 05-12-2022 for this trade volume is 129.26 billion NOK. The value of the constructed portfolio is smaller for the 15% trading restriction compared with the 10% trading restriction. The 15% trade volume is 1.6 billion lower than the 10% trade restriction. The average value of the constructed portfolio is 110.00 billion, which is 11.97 billion NOK lower than the average presented in section 3.2.3.

3.4 20% trade volume

In this section, the trading restriction is increased to 20%. This is the only change in the restrictions in the model presented in Table 2.2.

Weighted overlap

The weighted overlap for a maximum of 20% of daily trade volume is presented in Figure 3.9.

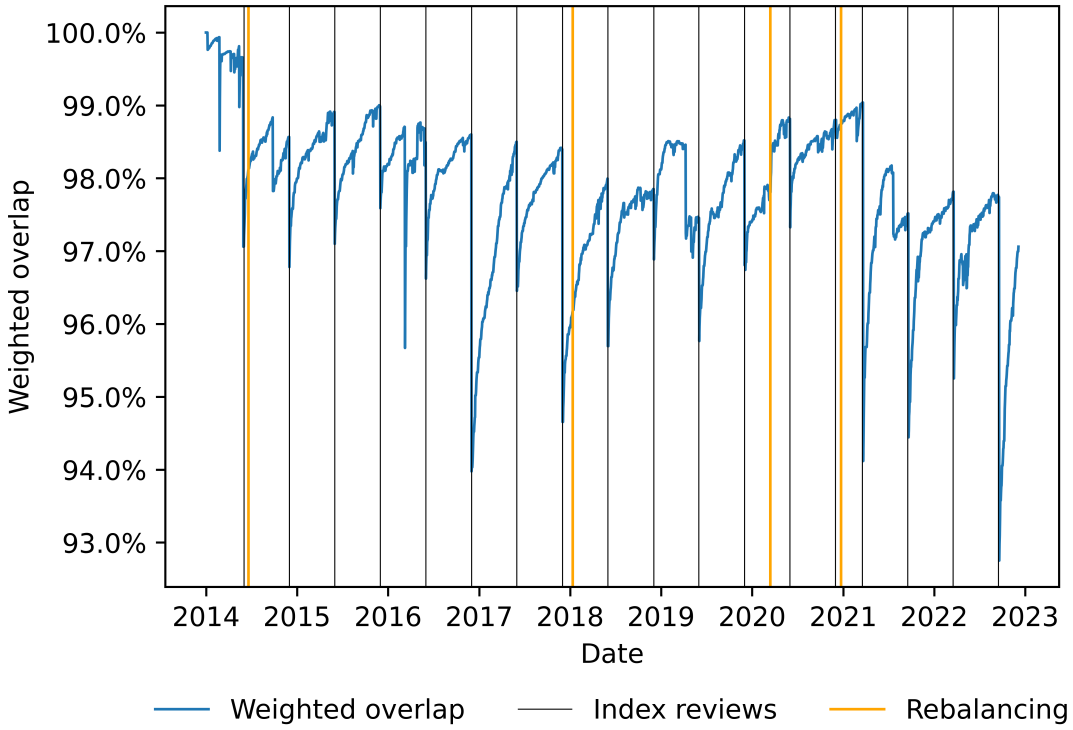

Figure 3.9: Weighted overlap for the 20% trade restriction.

The average weighted overlap for 20% trade volume is 0.9782. This is an increase both compared with the 10% and 15% trade restrictions. From the 15% trade restriction this is an increase of 0.43%, which is smaller than the difference between 10% and 15%.

Table 3.6: The difference in the constructed portfolio and the synthetic portfolio at 06.12.2022 for 20% trade restriction for stocks with a larger difference than 0.05% of the portfolio value. The portfolio difference is given in percentage. The market value of the constructed and synthetic portfolio is given in billion NOK.

Stocks	Portfolio difference	Market value constructed portfolio	Market value synthetic portfolio
AF Gruppen	0.107	1.083	0.719
Aker BP ASA	-1.297	8.886	9.423
Aker Carbon Capture ASA	0.134	0.264	0.000
Arendals Fossekompani ASA	-0.142	0.086	0.300
Atea ASA	0.061	1.168	0.864
Austevoll Seafood ASA	0.236	0.465	0.000
AutoStore Holdings Ltd	-0.318	1.539	1.783
BW Offshore Limited	0.073	0.143	0.000
Bank Norwegian ASA	0.149	0.293	0.000
Borregaard ASA	-0.525	0.714	1.439
Bouvet	-0.127	0.305	0.458
Cadeler A/S	-0.177	0.032	0.313
EVRY ASA	0.160	0.314	0.000
Entra ASA	0.131	0.910	0.537
Equinor ASA	0.201	47.063	38.452
Gaming Innovation Group Plc	0.098	0.192	0.000
Grieg Seafood ASA	0.176	0.345	0.000
Multiconsult	-0.106	0.100	0.254
Norwegian Finans Holding	0.718	1.411	0.000
Nycode Therapeutics	-0.167	0.190	0.427
Olav Thon Eiendomsselskap ASA	0.137	0.270	0.000
Telenor ASA	0.051	6.907	5.608
XXL	0.058	0.115	0.000

The amount of stocks in the 20% trading restriction, which has a difference of $5 \cdot 10^{-4}$, is reduced to 23 stocks. To retake a look at Equinor ASA, the portfolio difference is now reduced to 0.002.

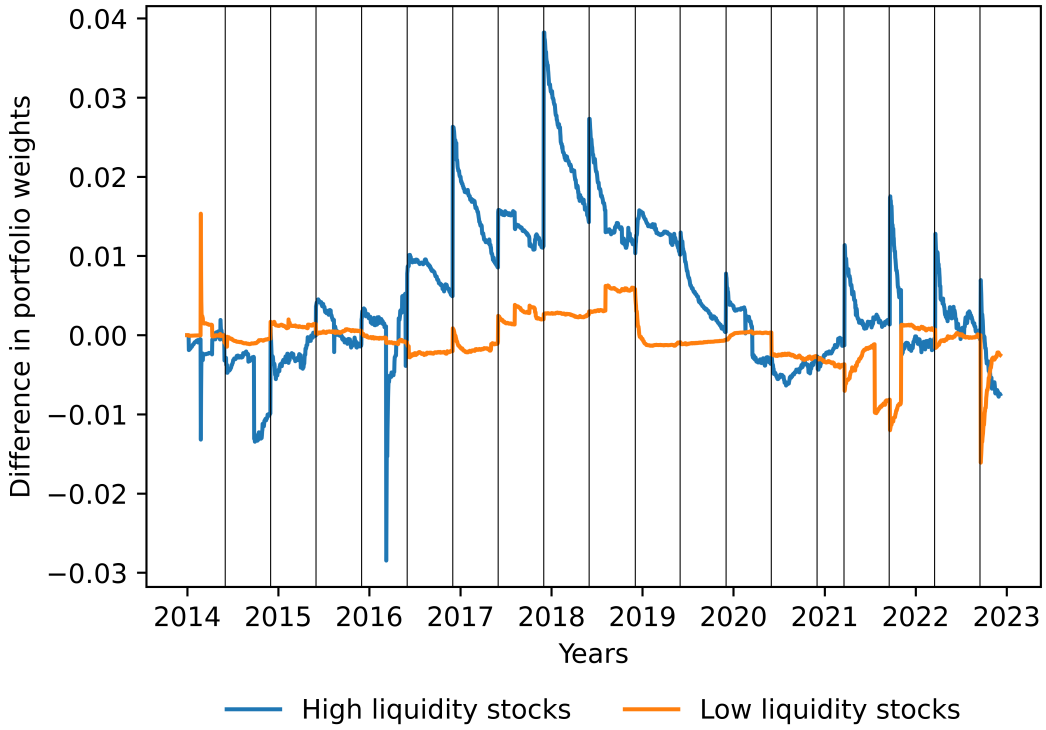

Figure 3.10: Comparing the portfolio weight of the 25 % least and most liquid stocks for 20% trading restriction.

From the first index change in 2016 to the beginning of 2020, the high liquidity stocks are overweighted in the actual portfolio. After the first index change of 2015, there are no long periods where the high liquidity stocks are underweight compared with the synthetic portfolio. The stocks with low liquidity have slight deviations from the synthetic portfolio value.

3.4.1 Market impact

The market impact for the 20% trade restriction is presented in Table 3.7. The data in the table are calculated in the same way as explained in section 2.1.2.

Table 3.7: Market impact for the portfolio with 15% trade restriction. Column 3, 4 and 5 are given in percentage.

Year	Trade weighted percentage of trades desired	Average market impact	Trade weighted market impact	Portfolio weighted market impact	Total trade cost in NOK
2014	0.5683	0.0985	0.1973	0.0372	3.81 billion
2015	0.6086	0.1191	0.2137	0.0384	4.38 billion
2016	0.5147	0.1145	0.1786	0.0352	3.55 billion
2017	0.5162	0.1286	0.2003	0.0504	4.89 billion
2018	0.5853	0.1243	0.2234	0.0691	6.18 billion
2019	0.5657	0.1102	0.2106	0.0572	7.15 billion
2020	0.6223	0.0979	0.2324	0.0471	6.63 billion
2021	0.6309	0.1433	0.2385	0.0715	17.28 billion
2022	0.5237	0.1481	0.2075	0.0710	18.57 billion

Compared with the previous market impacts for 10% and 15% trade restrictions in Table 3.3 and 3.5, the market impact has increased again with about 2% from the results for 15% trading restrictions. Which is a substantial increase in prices which again will increase the cost of maintaining the portfolio. The total trading cost from 2014 to 2022 is 72.44 billion NOK.

3.4.2 Portfolio development

The portfolio development due to the increased trade restriction is presented in Figure 3.11.

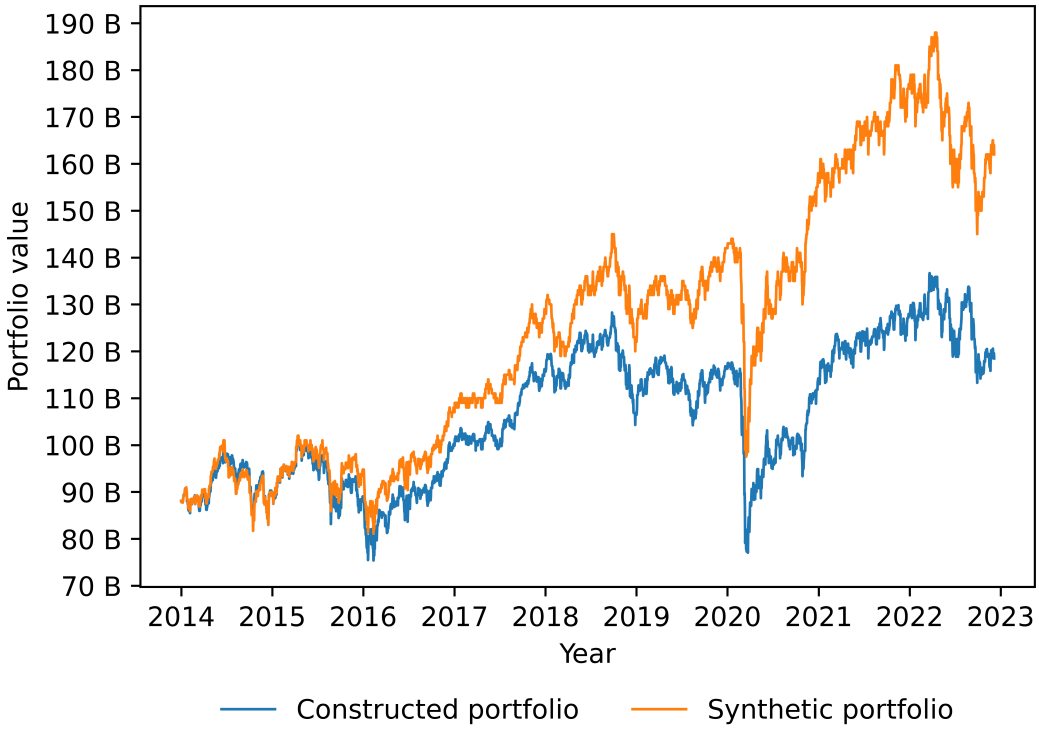

Figure 3.11: Portfolio development with 20% trade restriction

The portfolio value at the last date, 06.12.2022, is 118.47 billion NOK. The average portfolio value during the period is 106.56 billion NOK. The reduction from the 15% trade restriction is 3.44 billion NOK.

3.5 SPN portfolio

The actual composition of SPN is calculated according to the restrictions presented in Table 2.2 but has active management. An active manager can have more significant deviations from the index, or in this case, the synthetic portfolio, by making active choices in which stocks will give increased returns in the periods ahead.

3.5.1 Weighted overlap

The weighted overlap for SPN compared with the synthetic portfolio is presented in Figure 3.12.

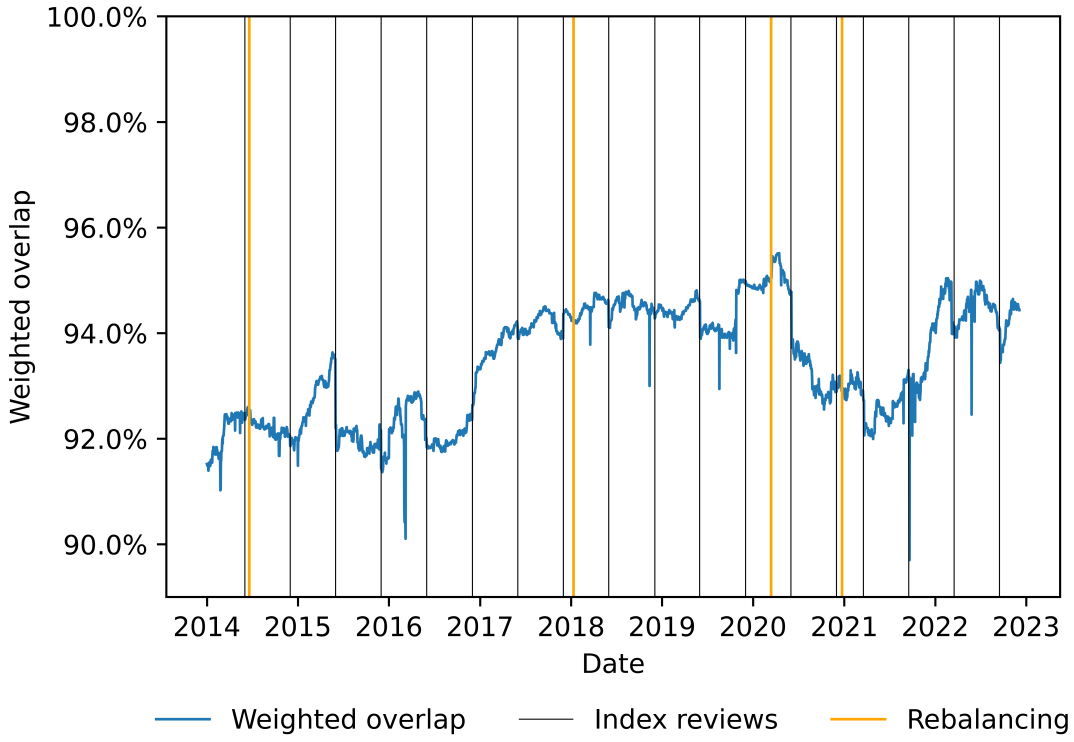

Figure 3.12: The weighted overlap of SPN portfolio today

The average weighted overlap for the actual portfolio is 93.42%. As the Figure illustrates, there are lower deviations in the weighted overlap compared with Figures 3.2, 3.6, and 3.9. The reason behind the deviations is that the management of SPN today is not trading after a strict trading rule. The portfolio managers are using time to adapt to the changes in the index and are trying to predict the changes so they can adjust to the new index before it happens. In addition, the managers in FTF can make strategic choices in the portfolio, meaning they can omit stocks with bad prospects or buy more stocks with good prospects. 18 stocks are a part of the index, which is not included in SPN from 2014 to 2022. The stocks are listed below.

- Axactor ASA
- B2 Holding ASA
- BergenBio ASA
- Cadeler ASA
- Carasent
- Cloudberry Clean Energy ASA
- Ensurage Micropower
- Fjord1 AS

- Funcom N.V
- Gaming Innovation Group Plc
- Idex
- NEXT Biometrics Group ASA
- Nycode Therapeutics
- PCI Biotech Holding ASA
- Questerre Energy Corp
- Targovax AS
- Vow AS
- Vow Green Metals AS

Some of these stocks are also in the list of those with low liquidity in appendix B. One reason why the stocks are not included may be that it is hard to buy the stock without getting high trading costs. It could also be for strategic reasons that these stocks are not included in the portfolio of SPN. The Figure below illustrates the deviation between the 25% high- and low-liquid stocks for SPN.

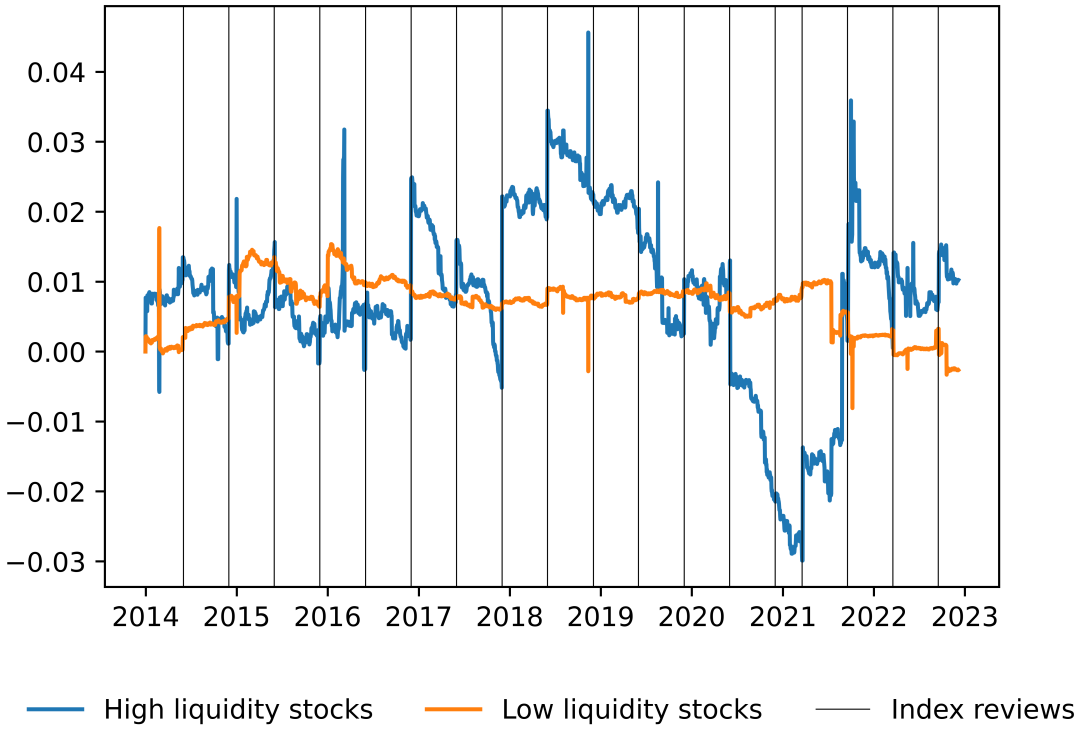

Figure 3.13: Difference in portfolio weights for SPN and the synthetic portfolio.

As illustrated by Figure 3.13, the difference between the high- and low-liquid stocks is minor until the last index review in 2017. Between the index review of 2017 and mid-2019,

the larger stocks are over-weighted in the portfolio. The stocks with high liquidity are under-weighted from mid-2020 until the last index review in 2022.

3.5.2 Market impact

The annualized market impact for SPN are presented in Table 3.8

Table 3.8: Market impact for the portfolio of SPU.

Years	Total trade cost in NOK
2014	8.32 million
2015	6.66 million
2016	10.09 million
2017	50.26 million
2018	72.64 million
2019	251.91 million
2020	368.52 million
2021	114.91 million
2022	400.87 million

The market impact of the SPU is included in the portfolio presented below, the total market impact is from 2014 to 2022 is 1.28 billion which is lower than the yearly market impact for all of the simulation for passive portfolio management.

3.5.3 Portfolio development

The portfolio value of SPN during the period between 01.01.2014 and 06.12.2022 are illustrated by Figure 3.14.

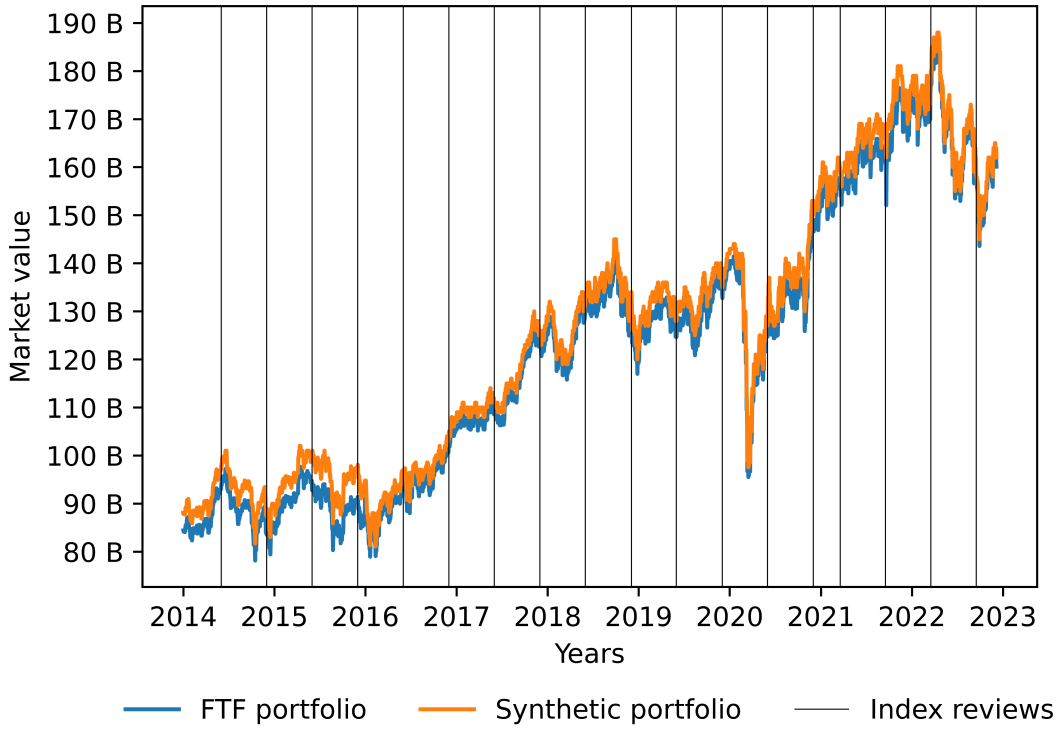

Figure 3.14: The market value of the portfolio of SPN.

The portfolio value at the last date is 160.10 billion NOK. At the same time, the synthetic portfolio has a value of 162 billion NOK. The average value of SPN is 121.82 billion. Meanwhile, the average value of the synthetic portfolio is 125.15 billion NOK. So the deviation at 06.12.2022 is smaller than the average difference between SPN and the synthetic portfolio. Also, Figure 3.14 illustrates that the portfolio value of SPN is a reasonable replication of the synthetic portfolio. There are some deviations from 2015 to 2016, but other than this, the difference in the portfolio is not visible in this figure.

Chapter 4

Discussion

In this chapter, the results presented in chapter 3 will be compared and discussed in light of the scope of this master thesis.

4.1 Optimizing the weighted overlap

The average value is increased when the trade restrictions are changed to increase the weighted overlap. The dip in the weighted overlap is in the same size order due to index reviews having the same changes regardless of the starting point. The inclination from the dip in the weighted overlap is how fast the weighted overlap recovers after index reviews and is decided by the trade restriction and the volatility. The weighted overlap for 15% and 20% trade restrictions has a higher rate of increase than the weighted overlap with 10% trade restrictions. This contributes to a higher replication of the index. The average weighted overlap for 10% trade restriction is 0.9657, which means that 96.57% of the synthetic portfolio stocks are in the constructed portfolio. The average weighted overlap for the 15% trade restriction is 97.39%, considerably higher than for the 10% trade restriction.

Table 4.1: Comparing of the 4 cases presented in the master thesis.

Cases	Average weighted overlap	Average portfolio value	Average trading cost per year	Average weight of the 25% most liquid stocks
10%	96.57%	115.63 billion	5.18 billion	86.03%
15%	97.39%	110.00 billion	6.84 billion	85.67%
20%	97.82%	106.65 billion	8.05 billion	85.50%
SPN	93.42%	121.82 billion	142.22 million	85.25%

The deviation between the constructed and the synthetic portfolio is decided by changes in the free float of shares. Large stocks buy back their shares; therefore, the number of free-float shares is reduced by the following index review. At the same time, most low-liquid stocks are also smaller companies with smaller profits, reducing the possibility of buying back shares. Therefore, the low-liquid stocks will more likely issue new shares to fund new money to fund the operation. When a stock issue new shares, it will be underweighted compared to the index change. This can explain the over-weight in large companies. Meanwhile, the small stocks are under-weighted. One exception is Aker BP, one of the most valuable stocks on OSEBX but funded the buy of Lundin Energy by issuing new shares.

Increasing the maximum trade volume will reduce the time the shares are wrongly weighted in the constructed portfolio, but at the same time, this will increase the market impact. Table 4.1 presents the market impact for the different cases. As expected, the market impact is increasing as the trade restriction increases. Since the trades often are not pushed to the total of the trading restriction, the market impact should not increase linearly, which also is the case. For more discussion about the market impact, see section 4.2.

The stocks with a difference above 0.05% are reduced when the trading restriction increases. The larger stocks, Equinor ASA and Telenor ASA, are decreasing faster than those phased out of the synthetic portfolio. Due to this, the largest stocks will be phased out more quickly than the companies with lower liquidity.

The background of the lower trade restriction has a higher return than the higher trade restriction due to the overweight in large stocks and higher market impact, which have been standing for most of the return as illustrated by Figure 3.5. With another market situation, there might be other stocks that would be a larger part of the market return, and therefore would the return be different as well before the market impact. At the same time, the average weight in the 25% most liquid stocks has been lower for SPN than for any other portfolio when it has the highest average portfolio value. This shows the power of timing the market can do for the portfolio value.

4.2 Market impact

As presented in chapter 3, the market impact is increasing for the increasing trade restriction. The trade-weighted market impact for the simulations are presented in chapter 3 is illustrated in Figure 4.1.

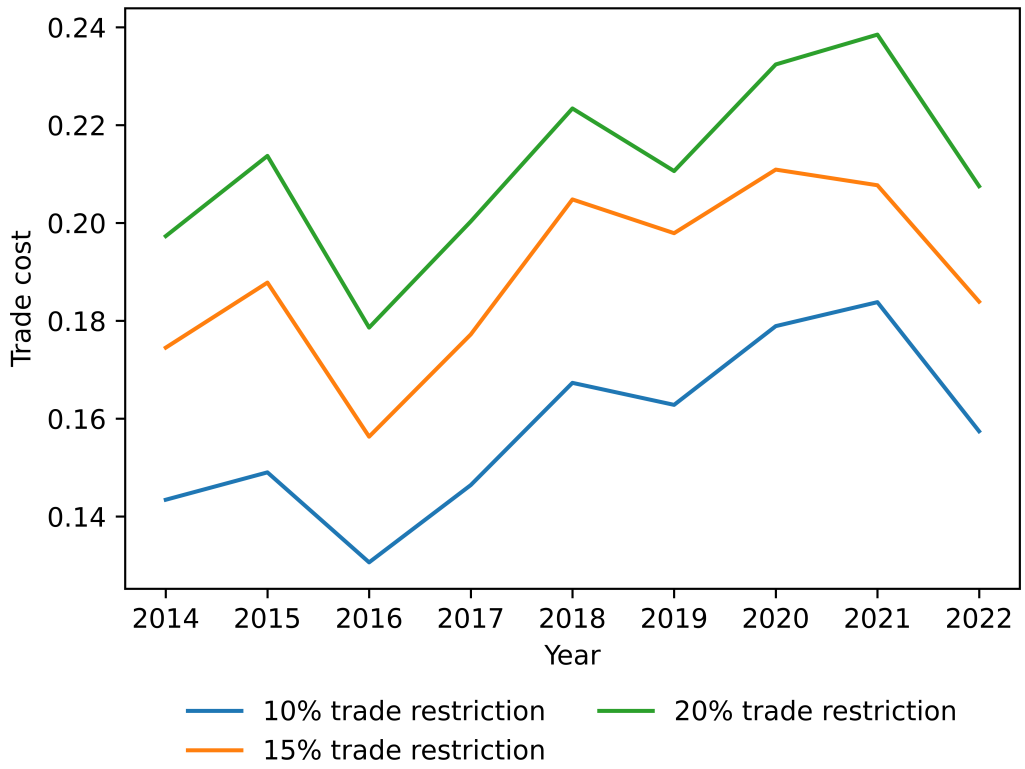

Figure 4.1: The market impact from Tables 3.3, 3.5 and 3.7 plotted in the graph.

As illustrated by the comparison in Figure 4.1, there is larger volatility in the market impact for the 20% trade restriction than for the 10% trade restriction. This is also visible for the other trade restriction. This means that the difference in market impact between the different trade restrictions is not constant. Also, moving from the trade restriction from 10% to 15% gives a larger increase than moving from trade restriction 15% to 20%. Figure 2.4 are converging, which means the growth for the market impact is decreasing as the fraction of daily volume increases, but it is also not necessary to use the full trading restriction when it is grown.

Some of the market impacts for the simulations can be assumed to be included in the data set due to the market effect that SPN has, presented in Table 2.3. However, the market

effect is strictly limited compared with the market impact of the simulations since the market impact of SPN is significantly lower than the simulations. The passively managed portfolios have, at the same time performed more trades, especially in less liquid stocks. Maxing the trade restriction in the low-liquid stocks is increasing the market impact. Table 4.1 presents the average annual market impact. For the 10% trading restriction is 3.9% of the portfolio value each year. For the 20% trading restriction, the market impact is 6.0% of the portfolio value each year. With such high market impacts each year, it won't be easy to follow the return of the synthetic portfolio, which also is illustrated by the Figures 3.4, 3.8 and 3.11. On the other hand the market impact of SPN is 0.1% of the portfolio value each year. The market impact reduces the portfolio's value since it is subtracted daily. This is over time affecting the market value of the portfolio.

These observations show that it is essential to establish a trade restriction that will not be too large to serve the intended design of the portfolio. Limitations of the market impact are described in section 4.5.2.

4.3 Portfolio development

The constructed portfolio's market value strongly depends on the market impact. The constructed portfolio is mainly below the synthetic portfolio, which means that the constructed portfolio is worth less than the synthetic portfolio.

The market value development of the portfolios will be strongly affected by the maximum trading limit of the portfolio and, due to that, the market impact of the portfolio. All cases with different trading restrictions are overweighted for the 25% most liquid stocks. Since the most liquid stocks accounts for the majority of the growth in market value illustrated by Figure 3.5. The low liquidity stocks increased from 2020 to 2021, which may explain the increased difference between the synthetic and constructed portfolios. When this increase is reduced, the constructed portfolio has a relative increase to the synthetic portfolio. Due to this, the difference between the constructed and synthetic portfolios is lower at the end of the period.

The portfolio value of SPN follows the synthetic portfolio closely, and there is possible to

see that the weight of the high-liquid stocks has a larger difference between the high and low points. By comparing Figure 3.5 and 3.13, there is overweight in large stocks when the large stocks have a high return, and reducing the weights in the high liquid stocks when the lower liquid stocks that have a high return. Due to this, SPN outperforms the 10%, 15%, and 20% trading restrictions regarding portfolio value which is illustrated by Figure 4.2.

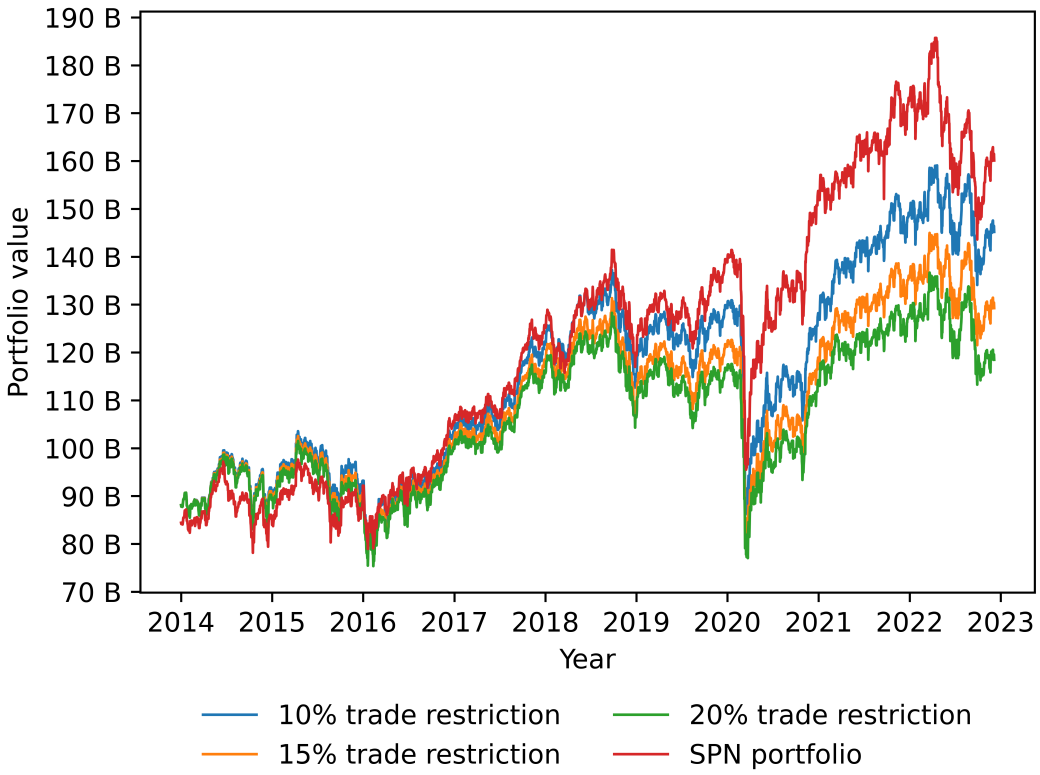

Figure 4.2: The portfolio values for the different cases

4.4 Comparison of the actual portfolio

The portfolio of SPN has a significantly lower weighted overlap with the synthetic portfolio compared with the other cases with passive portfolio management, illustrated by the Figures of the weighted overlap. This is summarized with the Table 4.1. The weighted overlap is 3% lower for SPN than for the 10% case, which is the passive management with the lowest weighted overlap. Despite the low weighted overlap, the SPN has the highest average portfolio value, which is 6.13 billion higher than for 10% trading restrictions. Some of this difference would be included in market impact of which already is included

as discussed in 4.2. Due to this, some of the market impact calculated for the simulations for the passive portfolio management the market impact will be lower than calculated in this thesis. This effect would increase the portfolio value of the simulations, and maybe reduce the differences but the difference between the portfolio values is still going to be significantly.

SPN does not follow a strict trading rule, they can predict the index changes and incorporate the stocks included in the following review. Also, they can take bets on stocks with a higher expected return than the index, so the distribution of the portfolio weights will differ from the synthetic portfolio, which is why weighted overlap is lower than the portfolios with a strict trading rule. The weighted overlap for SPN is not low taken into considerations that it is a actively managed fund. Among other features which differ from the strict trading rules, FTF has excluded 18 stocks, where some of the stocks are low-liquid stocks. This is one strategic bet which has paid them well since the cost of buying shares is high due to low liquidity, but also that the return since 2014 has been lower for the low-liquid stocks than the high-liquid stocks.

SPN has large deviations from the portfolio, as illustrated by Figure 3.13. SPN has the same pattern in the overweight of the large stocks. Still, the underweight between the first index review in 2020 and the second index review in 2022 is significantly larger than for the passively managed portfolios. This is where the deviation between the constructed and synthetic portfolio for the 10% trading restriction increases. The underweight in high-liquid stocks causes SPN to follow the value of the synthetic portfolio more closely than the passively managed portfolios.

4.5 Limitations

This section addresses the limitations in the data set and provides information about the limitations in the model.

4.5.1 Limitations in the data

Limitations in the data are, amongst others, that the calculation is based on historical prices and that the values used to calculate the values are the closing prices. Also, there

might be errors in the data that have not been corrected.

The data contain historic prices

The data consists of historical values on the stocks in the index. The trades in the model deviate from the historical trades, which would most likely have caused changes in the recorded price development. This reduces the previsions level of the model. This implies that the model still replicates the actual development well. On the other hand, the SPN portfolio is the real portfolio value, which contains historical prices and the actual market impact.

The data only contain information about the companies in the index. Historical prices are used to calculate further trades with stocks that are no longer a part of the index. One example is Evry ASA, where the stock is delisted, and trade is no longer possible. As illustrated by chapter 3, the model still sells the stocks for all the different trade volumes for the same price as the last trading day.

Missing data on intraday volatility

The data provided in this master thesis do not contain information about intraday volatility. Since the only information in the data is the closing price, there might be significant intraday changes, which can affect the price for which the shares are bought. For example, suppose the stock price rises a lot during the day and falls back the yesterday's closing price at the end of the day. In that case, the shares will be bought at a higher market price and, therefore, also give a lower return compared to what is presented in Figure 3.4, 3.8 and 3.11. The same effect will also appear the other way, so it is impossible to conclude how this will affect the portfolio's total value.

No information about dividends

The simulations for does not contain information about dividends paid to the shareholders. The dividends would have increased the portfolio value because it is cash that the manager has to distribute on all of the stocks in the portfolio. So the values for the simulations on 10%, 15%, and 20% trading restrictions would probably have a higher value.

Incorrect data

The data are most likely to contain errors that have not been corrected and will give incorrect values for the values in the simulation. The values for SPN have some errors that have been updated, but there are still values that may be incorrect and, therefore, either increase or decrease the portfolio value.

4.5.2 Limitations in the model

The simulation performed in this master thesis is simplified to be adapted to the data provided and to reduce the complexity of the simulations. The limitations of the model are presented in this section.

Use of a synthetic reference portfolio

The constructed portfolio is compared with a synthetic reference portfolio. Some rules from Oslo Stock Exchange determine the OSEBX, and there is possible to calculate the index changes to a certain degree. Still, it is not possible to create an exact replication.

Assumption that trades happen at the start of the day

Each transaction is assumed to occur at the beginning of the day to the market value of the last trading day. This will not be realistic in the real world, especially when the trading orders are larger. The market depends on factors that happen during the closing time of the Oslo Stock Exchange, and the market can open up or down from the last day's closing price. The effect of this is not, since it can be both positive and negative dependent on market development.

Limitation of the market impact model

The market impact model used in this master thesis is a simplified model of the model presented by (Frazzini et al. 2018), which gives a lower value than the actual market impact function, which is illustrated in Table 2.3. Therefore the actual market impact will be higher given that the market impact function 2.3 is used. The market effect of SPN is not adjusted for in the simulations presented, if this would have been included

it would increase the portfolio value of the simulations slightly. Also, the market impact function had a maximum daily fraction volume of 12%, which means that there is not guaranteed that Equation 2.3 is valid for a daily fraction volume higher than 12%. For trades as large as 20% of daily volume, there might be hard to buy the shares without paying a considerable market impact, so especially for the large trading restriction, the market impact will be very unreliable.

Assumption of unlimited liquidity in the obligation market

The assumption is that the liquidity in the obligation market is unlimited, which means that in the rebalancing process, it is possible to rebalance the total holding in the obligation market without any market impact. This is an assumption that is not possible to accomplish in reality. As in the stock market, there will also be market impacts in the obligation market, which will increase with increased trading volume. Due to these effects, the rebalancing would probably have taken more time and, therefore, not have the same impact on portfolio return.

Strict following of the synthetic portfolio

The model follows the synthetic portfolio in all cases. A passive investor could deviate from the synthetic portfolio to create a more optimal composition. One example is buying companies likely to be included in the index at the new index review.

Chapter 5

Conclusion

The purpose of this master thesis was to investigate the possibility of SPN being passively managed, its consequences, and what this may cause. The simulations performed in this thesis showed that the passive management of SPN will reduce the replication of the OSEBX and the return from SPN. Most of the reason for this is the trade cost. Due to the size of SPN would, strict trading restrictions, which are used in this master thesis, cause large trading cost, which is between 3.9% and 6.0% annually, dependent on the size of the trading restriction.

The simulation is a simplification based on historical data. If SPN were managed as a passive portfolio, other players in the market exploit this and increase the cost for SPN when SPN would need to make large changes due to index reviews or rebalancing the portfolio.

Based on the moments discussed in this master thesis, passive management of SPN would not be recommended.

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Appendix

Chapter A

The equations used to calculate the model

The equations used to calculate the model are presented in this appendix.

A.1 Calculation of deviations

The following equation calculates the difference between the synthetic and constructed portfolio:

$$\Delta v_{i,t} = \hat{v}_{i,t-1} - v_{i,t-1} \tag{A.1}$$

$\Delta v_{i,t}$ is the difference in value between the synthetic and constructed portfolio. $\hat{v}$ is the value of the constructed portfolio .v is the closing value of the constructed portfolio and time t. The values from period t-1 are used to calculate the deviations due to the investment decision being made one day after the movement yesterday. A positive $\Delta v_{i,t}$ means that the investor wants to increase the investment in the stock. Since there is no trading restrictions incorporated in this model, the synthetic and constructed portfolio are equal:

$$\sum_{i=1}^{n} (\Delta v_{i,t} = 0) \tag{A.2}$$

A.1.1 Incorporating trading restrictions

The deviations presented are the trades the model tries to execute to be equal to the synthetic portfolio. The trading restrictions are presented in table 2.2. For each stock, the wanted trades γ, is given by the following equation:

$$\gamma_{i,t} = d_{i,t} \cdot z_{i,t} + (1 - d_{i,t}) \cdot c_{i,t} \tag{A.3}$$

equation A.3 took into account the deviations between the synthetic and the constructed portfolio and used the dummies ($d_{i,t}$) to denote whether the stock is under-weighted or over-weighted in the constructed portfolio. The dummy variable is 1 if $\Delta v_{i,t} \geq 0$ and 0 if $\Delta v_{i,t} \leq 0$. For stocks under-weighted in the constructed portfolio, $\gamma_{i,t}$ equals $z_{i,t}$. For under-weighted stocks, the equation is:

$$z_{i,t} = MIN(\Delta v_{i,t}, \dddot{A}_{i,t)}, (P_{i,t} \cdot q_{i,t}) \cdot \ddot{A}_{i,t} - v_{i,t-1}) \tag{A.4}$$

$\dddot{A}_{i,t}$ are the maximum percentage of daily trades, and $ddotA_{i,t}$ is the maximum amount of the stock that is allowed to own. Due to these restrictions, this contributes that the maximum of trades that can be performed in an under-weighted stock is the smallest of the:

1. The deviation between the synthetic and constructed portfolio.
2. Maximum trade according to the maximum percentage of daily trades.
3. Trades that contribute to the ownership exceed 15% in one stock.

For over-weighted stocks, the equation is:

$$c_{i,t} = -MIN(-\Delta i, t, -\dddot{A}_{i,t}, v_{i,t-1}) \tag{A.5}$$

The maximum amount of shares that are possible to be bought is affected by these restrictions:

1. Deviation between the synthetic and constructed portfolio.

2. Maximum trade according to the maximum percentage of daily trades.

3. The number of shares owned past period, so the ownership is not negative.

A.1.2 Allocation of the trades

When a deviation occurs between the number of sales and buys, there is a need to be handled. In this master thesis, this problem is handled by taking the smallest of the equation for the purchase completion degree and sales completion degree. The purchase completion degree is defined by the following:

$$g_t = \frac{MIN(\sum_{i=0}^{n}(c_{i,t}), \sum_{i=0}^{n}(z_{i,t}))}{\sum_{i=0}^{n}(c_{i,t})} \tag{A.6}$$

The sales completion degree is defined by the following:

$$h_t = \frac{MIN(\sum_{i=0}^{n}(c_{i,t}), \sum_{i=0}^{n}(z_{i,t})}{\sum_{i=0}^{n}(z_{i,t})} \tag{A.7}$$

Suppose the trading restrictions say it should buy stocks for 10 million and sell stocks for 30 million. Then it is 20 million with desired trades, which is performed since desired buying transactions do not exist. In this case, 100% (10 of 10 million) of the buys are performed. Meanwhile, only 33% (10/30 million) of the sales are completed. Actual trades for purchase transactions in the stock are calculated as follows:

$$y_{i,t} = \gamma_{i,t} \cdot g_t \tag{A.8}$$

Actual trades for sales transactions in the stock are calculated as follows:

$$y_{i,t} = \gamma_{i,t} \cdot h_t \tag{A.9}$$

If equation A.8 or A.9 are defined if the stock is bought or sold.

Chapter B

The 25% least and most liquid stocks

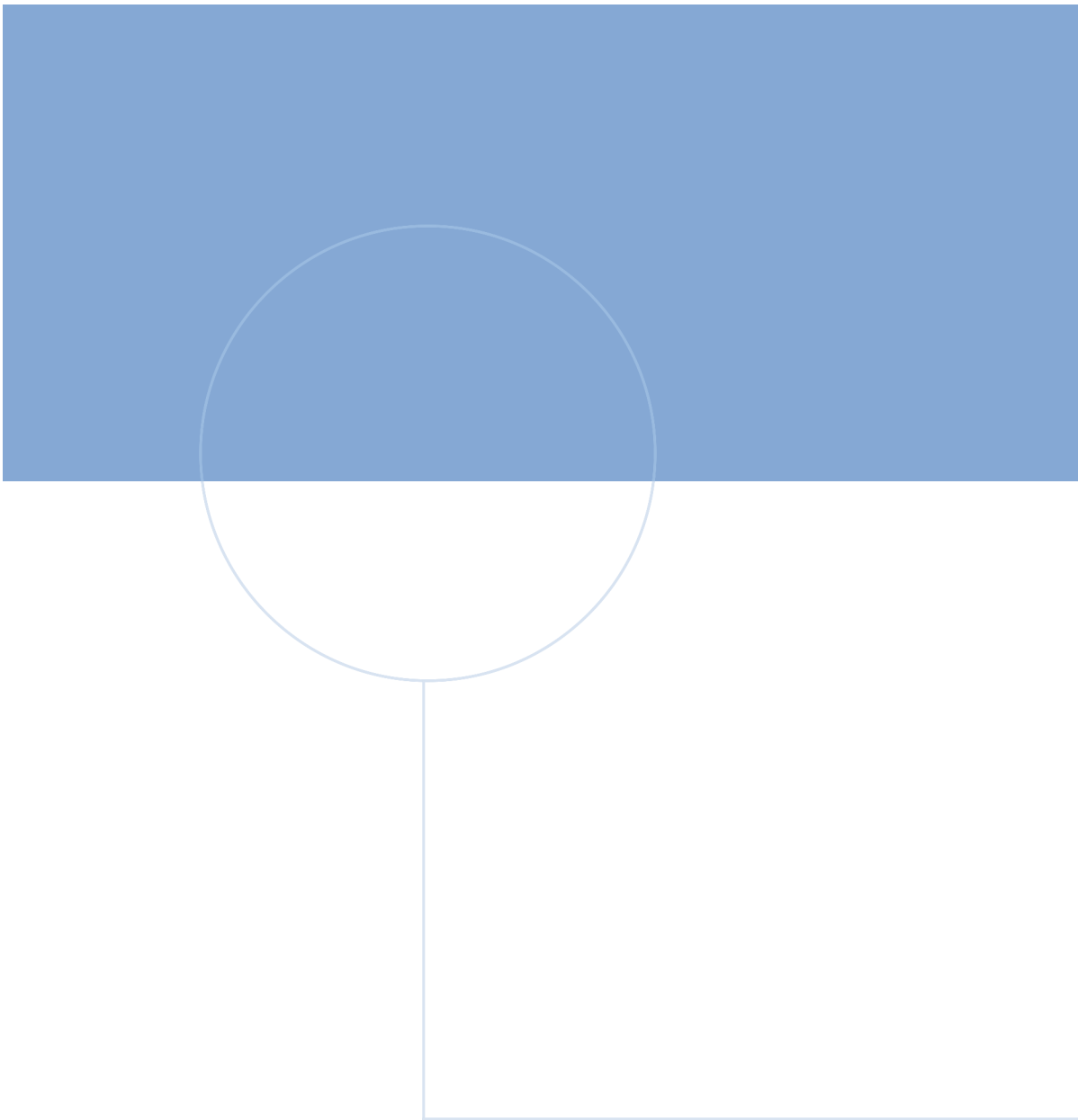
The 25% low liquidity stocks are presented in the list below:

- ABG Sundal Collier ASA
- Algeta
- American Shipping Company ASA
- ArcticZymes Technologies
- Arendals Fossekompani ASA
- BWG Homes
- Bank Norwegian ASA
- Cadeler A/S
- Carasent
- Ekornes
- Eltek
- Fjord1 AS
- Hafnia Limited
- Hafslund Produksjon Holding AS
- Kid ASA
- Medistim
- Multiconsult
- Norwegian Property ASA
- Nycode Therapeutics
- Odfjell SE
- Olav Thon Eiendomsselskap ASA
- Q-Free ASA
- RenoNorden
- SAS AB (publ)
- Solon Eiendom ASA
- Treasure ASA
- Ultimovacs ASA
- Vow ASA

- Vow Green Metals AS
- Vår Energi ASA
- Weifa AS

The 25% most liquid stocks are presented in the list below:

- Adevinta ASA
- Aker ASA
- Aker BP ASA
- Aker Solutions ASA
- BW LPG Limited
- Bakkafrost
- DNB ASA
- DNO ASA
- Elkem ASA
- Equinor ASA
- Frontline Ltd
- Gjensidige Forsikring ASA
- Golden Ocean Group
- Grieg Seafood ASA
- Lerøy Seafood Group ASA
- Mowi ASA
- NEL
- Nordic Semiconductor ASA
- Norsk Hydro ASA
- Norwegian Air Shuttle ASA
- Orkla ASA
- PGS ASA
- REC silicon ASA
- SalMar ASA
- Schibsted ASA
- Storebrand ASA
- Subsea 7 S.A.
- TGS-NOPEC Geophysical Company
- Telenor ASA
- Tomra Systems ASA
- Yara International ASA



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